Determination of agro-management practices for enhancing seed yield and quality in Peas (*Pisum sativum* L.)

BY

MUHAMMAD IRFAN ASHRAF

M.Sc. Hons. Agri.

94-ag-1069

A thesis submitted in partial fulfillment of the requirements for the Degree of

DOCTOR OF PHILOSPHY

IN

HORTICULTURE

INSTITUTE OF HORTICULTURAL SCIENCES
UNIVERSITY OF AGRICULTURE,
FAISALABAD, PAKISTAN.

2010

Oh Lord,
Make me
An Instrument of Your Peace
Where, there is Hatred
Let me sow Love
Where, there in Injury, Pardon
Where, there is Doubt, Faith
Where, there is Despair, Hope
Where, there is Darkness, Light
And where, there is Sadness, Enjoy

DEDICATED To

HOLY PROPHET MUHAMMAD (Peace be upon him)

The Greatest pillar of Knowledge, Peace and tranquility for humanity

To

My beloved Father & (Late) Mother who though not alive to see the fruits of prays and well wishes, they always rendered for my success and prosperous future life. I am extremely helpless to inform them the success but can only cordially pray for their souls are rest at the highest ranks of paradise.

ACKNOWLEDGEMENTS

Over and above the entire substance, I firmly and solemnly offer thanks to **Allah Almighty**, who blessed me to over-come all concurrent hardships and the tests in the accomplishment of the study and of this manuscript.

I present my humble gratitude from the deep sense of heart to the **Holy Prophet Muhammad (Peace Be Upon him)** that without him the life would have been worthless. All praises be to the **Holy Prophet Muhammad (Peace Be upon him)**, the city of knowledge, the illuminating torch and rescuer of humanity from going astray, whose teaching enlightened my heart and flourished my thoughts.

I wish to express my deepest sense of gratitude to the fatherly and sympathetic attitude, untiring advice and noble benevolence of **Professor Dr. M.A. Pervez**, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. His expert supervision and excellent caliber graced me with an unparallel boon in achieving the dignified goal.

Besides, I am really under indelible obligations to **Professor Dr. Muhammad Amjad,** Director, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, for his critical insight, scholarly guidance and keen interest which enabled me to finalize this manuscript. I also extend cordial appreciation to **Professor Dr. Rashid Ahmad**, Chairman, Department of Crop Physiology, University of Agriculture, Faisalabad for his inspiring guidance, valuable comments, constructive criticism and willing assistance, as and when sought for, to achieve the conclusive goal. I am highly thankful to **Dr. C. M. Ayyub**, Associate Professor, Institute of Horticultural Sciences for his sincere cooperation and considerable assistance at every occasion during the execution of this research.

I offer obligations to **Professor Dr. Shamshad Ahmad** (Late), Department of Agronomy, **Ch. Muhammad Sadiq** (Subject Specialist) Institute of Horticultural Sciences and **Professor Dr. Muhammad Ashraf Randhawa (Retd.)**, Department of Plant Pathology for their technical guidance, constructive, valuable suggestions and kind Corporation during the tenure of my study. My highest regards for my father

Ch. Muhammad Ashraf and my dear uncle **Ch. Muhammad Akram** (Twins) for their cooperation and assistance in completion of the study. I extend my sincere gratitude to dear friends, **Munawar Ahmad Noor** (Ph.D Scholar), **Abdul Manan** (Ph.D Scholar) and **Muhammad Wajid Khan** (M.Sc, Scholar), **Shakeel Ahmad** for their moral support, encouragement and cooperation in compilation of this manuscript. I am highly appreciative to all my colleagues and well wishers for their support, constructive criticism and friendly behavior, they rendered during the whole span of this study work.

I present my special thanks from core of my heart, to my Brothers, loving Sisters and cute niece (**Aneeqa**) who are constant reminder that these people who still inspire my world. I will never ever forget their sacrifices, love and devotion to me and the comfort I get from them. Big thanks to all teaching staff, field staff and other members of the Institute of Horticultural Sciences for field work and helping in the preparation of this thesis.

(MUHAMMAD IRFAN ASHRAF)

LIST OF TABLE

LIST OF FIGURES

ABSTRACT

Studies were conducted to evaluate the impact of agro-management practices on two Peas cultivars named Climax and Meteor during the year 2005-09. The study was executed to find out best management practices, packing material and storage environment for better yield and quality seed production of Peas. There were six trials for determining irrigation, nutrition, seed maturity, seed storage and packing material for the Peas crop. Agro-management practices had significant effect on plant growth and yield attributes. These practices included, good seed bed preparation, proper seeding methods, proper irrigation, effective plant nutrition, timely harvest, proper storage conditions and accurate packing material. Peas are a good source of vegetable protein which is highly digestible. Although its nutritional aspects have been proved yet the factors which contribute towards seed yield and quality require a series of research projects for their detailed study. Seed is a basic unit in crop production as it influences the yield directly and indirectly by impacting the contribution of other inputs.

Different irrigation frequencies like, I_0 (Irrigation as needed by the crop; 13 irrigations applied), I_1 (Irrigation up to flowering; 8 irrigations applied), I_2 (Irrigation up to pod filling; 10 irrigations applied) and I_3 (Irrigation up to seed filling; 12 irrigations applied) were investigated. Each irrigation of (7.5 cm) was applied with 10 days intervals. Their impacts on growth, Yield and quality attributes were studied. Seed vigour tests were also performed. Irrigation frequency up to seed filling stage was observed to be better for yield and quality of Peas seeds as compared to other irrigation frequencies.

Nutrition to the seed crop improved seed yield and quality. Seed yield and quality of seed Peas crop was also influenced by varying plant nutrition requirements during its growth period. Out of various phosphorus and potash levels studied, phosphorus @ 120 kg $ha^{-1}$and potash @ 100 Kg ha^{-1} gave better results for Climax as compared to other levels of phosphorus and potash.

Different best results combinations of the above experiments are made to observe their performance and the best one are selected for Peas crop. The

combinations of T_0 (Irrigation up to seed filling) T_1 (Irrigation up to seed filling + P120 kg ha^{-1}) T_2 (Irrigation up to seed filling + K100 kg ha^{-1}) T_3 (Irrigation up to seed filling + P120 kg ha^{-1}+ K100 kg ha^{-1}) were studied. T_3 (Irrigation up to seed filling + P120 kg ha^{-1}+ K100 kg ha^{-1}) gave high seed yield in Peas as compared to other combinations.

Peas seed crop was harvested at proper maturity stage. Maximum seed viability and seed vigour was achieved if harvested at correct stage of maturity. Peas seed harvested at different moisture % levels like, M_1, (45%), M_2 (40%) M_3 (35%) M_4 (30%) M_5 (25%) M_6 (20%) and M_7 (15%) respectively. Determination of optimum seed harvest time by seed moisture content is used as a general recommendation for farmers as a clue to determine the optimum time of harvest to maximize seed yield and quality. Peas crop harvested at 25% moisture contents, gave better results as compared to other levels of moisture percentage.

Seed storage is a basic requirement for Peas seed crop. In Pakistan particularly the seed of legume crops like Peas suffer from storage problem. Three packing material, gunny bags, plastic bags, paper bags and various temperatures, 0°C, 15°C, 20°C, and 25 °C were studied. 50% humidity was kept constant in storage. Best material and temperature are pertained for storage. Seeds were stored for six months. Seeds stored at 5°C in gunny bags gave better performance with respect to seed quality and vigour.

TABLE OF CONTENTS

TABLE OF CONTENTS

CHAPTER-I

INTRODUCTION

Peas (*Pisum sativum L.*) a grain legume and a member of the leguminoseae family is a native of central or Southeast Asia. It grows well in cool weather in the presence of ample moisture. It is widely cultivated in temperate regions for its fresh green seed. Peas are an excellent human food, either eaten as a vegetable or used in preparation of soup. The peas are full of nutrition because its grain is rich in protein (27.8%), complex carbohydrates (42.65%), vitamins, minerals, dietary fibers and antioxidant compounds (Urbano *et al.*, 2003).

Peas ranks 4^{th} in the world on a production basis (441.53 thousand tons) among grain legumes after soybean, groundnut and French beans and is grown on an area of 528.71 thousand hectares in the world (FAO, 2009).

In Pakistan, Peas is an important crop of the Punjab Province, Which plays a major role in farmer's economy. It is the most common crop and enjoys a great commercial demand due to its nutritive value. Total production of peas per unit areas both in terms of green pods and for seeds can hardly be over-emphasized. The dried peas contain 24.6 percent protein as compared to wheat which contains only 9.4 % In Pakistan, it is cultivated on an area of 10 thousand hectares with a total production of 82 thousand metric tons (Anonymous, 2008).

Seed requirements for crop raising are met through annual imports of the vegetable seeds. The local seed availability is very meager, however, its production has increased over time. In Pakistan annual peas seed requirement is 588 tons and due to the non-availability of quality seed, the country is spending about Rs.159.00 million on the import of peas seeds annually (Anonymous, 2008). Good quality seed is one of the important inputs required to obtain high yield by maintaining optimum plant population. Seed is both a vital and expensive commodity; it must not be wasted through unnecessary seed-bed losses or due to low quality, which may result in reduced plant population, followed by low yield. Therefore, high quality seed is indispensable for better crop production.

The achievement of a plant population which provides the optimum yield as compared to seed costs, desires high attention. If the correct crop inputs and husbandry methods are used then the chances of obtaining high yield may become greater. High quality seed is one of the most important inputs required to obtain high yield by helping the optimum plant population to be established. It is necessary to calculate the seed rate required for the desired plant population.

In some developing countries like Pakistan the availability of high quality seed is a problem. There may be insufficient seed producing organizations to meet the seed requirement, or farmers use their own seed obtained as a residue from their commercial crops and they do not grow any specific seed crops. During seed production no physiological and agronomic care is taken and during post harvest processing they do not take care of its as a seed crop. Mechanical processing can cause mechanical injuries to the seed. Hot and wet weather during seed production and storage affects seed quality adversely (Copeland and McDonald, 1995). Farmers do not grow particular crops for seed purposes only, so they do not apply physiological and agronomic crop husbandry techniques which are necessary for a seed crop rather than commercial crops for grain, such as appropriate sowing times, harvesting times and fertilizer requirements. Care for seed quality is limited to avoid contamination without seed crop husbandry techniques or any other post harvest processing or storage techniques to improve the quality.

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended peas varieties, good seed bed preparation, proper seeding methods, effective plant nutrition, weed control, timely harvest, disease and insect control. Because of the influence of climatic conditions, soil type, cultural practices, crop response from fertilizer may not always be accurately predicted. Soil test results, field experience and knowledge of specific crop requirements help to determine the nutrients needed and the rate of application (Hadavizadeh, 1989).

Seed quality can be increased by careful management of seed crops during production in the field, harvest, post harvest, processing and storage. Nutrition to the seed crop may improve seed quality (George *et al*., 1980). This increases the reserves of the seed and increases the resistance to deterioration during adverse storage environments and adverse field conditions at seed emergence time. In this research attempts have been made to improve seed quality by providing proper nutrients to the peas seed crop such as nitrogen, phosphorus and potassium.

Phosphorus is an important nutrient for high quality seed production of peas. Its effects on plants are complex. It plays very important physiological role in plant growth. Phosphorus deficiency triggers many morphological, biochemical and molecular changes in plants (Raghothama, 1999). It affects on nodulation, nitrogen fixation and plant growth in legume crops. It provides the desired amount of adenosine tri-phosphate (ATP) for nitrogen fixation. It plays a vital role in the plant cell nucleus. It is essential for cell division, and is therefore, particularly important in the meristems of the plant. The concentration of the phosphorus in dividing cells can be more than a thousand times that in mature cells. Phosphorus also plays an important role in enzyme actions for conversion of water and carbon dioxide to sugars and starch in the process of photosynthesis. Phosphorus supply may also affect seed quality. Padrit *et al.* (1996) found that phosphorus application to the seed crop of peas had improved seed vigour and quality.

Potassium is not directly involved in the synthesis of protein, carbohydrates or other main substances but it activates the essential biochemical action involved in the synthesis of these substances. It is retained mainly in cell sap and regulates the osmotic pressure and maintains the turgidity of the plant. It also plays a part in the essential processes of photosynthesis and respiration and shifting of carbohydrates from one plant part to another. It moves very freely from soil to plants and also within the plant (Mengel and Kirkby, 1997). However, sufficient information is not available on the response of Peas grown for seed crop.

Peas seed crop should be harvested at proper maturity stage. Maximum seed viability and seed vigour may be achieved if seeds are harvested at the correct stage of maturity. Peas seed should be harvested as soon as possible after attaining an acceptable level of seed moisture. Letting seed remain in the field after they are dry enough for safe harvest reduces quality. Reproductive development ends at physiological maturity, when the seed reach maximum dry weight. The rate of loss depends on the temperature and humidity of the field environment. Efforts have been made to find out the optimum seed harvest time (Copeland and McDonald, 1995) with reference to seed moisture contents and dry weight (Harrington, 1972). Under good field drying conditions, seed moisture will decrease from 13 to 15 percent in 6 to 8 days (Delouche, 1974). The problem is how to identify this stage of maximum quality. This study is an effort to determine the moisture percentage in seed for the optimum time of harvest to maximize peas seed yield and quality.

Efforts have also been made to find out the optimum seed harvest time (Copeland and McDonald, 1995). Seed moisture contents and seed dry weight (Harrington, 1972). Determination of optimum seed harvest time by seed moisture contents is used as a general recommendation for farmers as a clue to determine the optimum time of harvest to maximize seed quality.

Last but not the least efficient seed storage is a basic requirement for peas seed crop. The environmental conditions and duration of seed storage affects seed quality. There are not enough good seed storage facilities because of lack of sufficient funds (John and Asianics, 1994). In Pakistan particularly the seed of the winter crops, such as some legume crops like peas and cereal crops like wheat, suffer from storage problems. Seeds of these crops have to be stored throughout the whole summer season till the next sowing season in winter. Summer is very hot, especially in the Plains. The temperature begins to rise rapidly from April onward, reaching a maximum in June. At this time, a daily maximum temperature normally exceeds 40°C Average maximum temperature is highest (45.5°C) in upper Sindh Province. Summer temperature is slightly milder in the coastal belt and in the mountains. Maximum temperature begins to decrease in July with the onset of monsoon rains. Evaporation is the highest in summer, before monsoon from May to June. Pan evaporation in the plain areas varies from 1300 mm in northern Punjab Province to 2800 mm in Sindh Province, Mostly in Pakistan, the rain falls (70-80%) in the monsoon during July, August and September (Qureshi and Barret, 1998). The seeds have to face these unfavourable environmental conditions during the storage period. The three most important factors which affect the viability of seed during storage are temperature, oxygen and seed moisture contents or relative humidity of the storage environment (Roberts and Abdallah, 1968). Hence there is a need to develop improved methods of seed production and storage that are within the financial and technical capabilities of farmers. The study will also be carried out to find out best packing material and storage conditions for quality Peas seed. Hence this study may solve the storage problem as stated above. In the research efforts have been made to produce high quality seed in order to improve physiological aspects such as germination capacity and vigor of peas seeds.

The peas crop was selected for this study because:

i) It is an important commercial vegetable crop and knowledge of the optimal conditions for germination and seedling establishment is essential for successful cultivation.

ii) Mature seed of high viability is readily available in quantity throughout the year in most parts of the world.

iii) The ripple seed is quiescent rather than dormant and germinates rapidly and relatively uniformly, if placed under favourable conditions.

iv) There are no special requirements such as exposure to light to fluctuating temperature and there is not hard seed coat to be removed.

v) The Peas plant is specifically useful in physiological and biochemical studies, as in this research physiological aspects have been dealt with.

vi) Peas seed size, shape and colour provide easy handling during the limited time available for the research work.

vii) In developing countries such as in Pakistan peas is a winter crop which faces seed quality problem as discussed above? Hence it is desirable to solve these problems by conducting research on Peas seed quality.

1.1. MAIN OBJECTIVES OF THIS STUDY:

1. To study the effects of irrigation on growth, yield and quality of peas seeds.
2. To determine a suitable dose of P and K fertilizer for enhancing the productivity of peas.
3. To produce high quality seed, by harvesting the seed at appropriate moisture contents.
4. To find out best packing material and optimum conditions for seed storage.

CHAPTER II

REVIEW OF LITERATURE

Peas are grown as a winter vegetable in the plain areas of Pakistan and as a summer crop in the hilly areas (Khan *et al.*, 1988). The low quality of seed stock is one of the most crucial and important factors, for low yield. This is responsible for losses around 30-40% in production. In Pakistan the acceptable minimum seed germination percentage is 65% (Bhatti and Soomro, 1994), while in the UK it is 80%. In Pakistan vegetable seed is obtained either saved by farmers themselves by bartering with neighbors or farmers in different villages, or purchased from local grain stalls. This seed has not been produced under a certification system (F.A.O., 1984-85). Although the government is encouraging the seed industries, both multinational and Pakistani, to develop seed business in the country, but need to improve the quality and yield of peas by developing good management practices on scientific level.

A lot of research work has been carried out on various aspects related to peas production but little work has been carried out on management practices related to quality peas seed production. However literature pertaining to present peas study is reviewed under the following headings.

2.1. Effect of Irrigation on the seed crop

2.2. Effect of nutrition on the seed crop

- 2.2.1. Nitrogen
- 2.2.2. Phosphorus
- 2.2.3. Potash

2.3. Effect of balanced mixture of nutrients to the seed crop

2.4. Effect of seed maturity on the seed crop

2.5. Effect of seed storage conditions on seed quality

2.6. Seed Testing

2.1. Effect of Irrigation on the seed crop

World wide the aggressive exploitation of natural resources endangers water resources, biodiversity and soil quality. Scarcity of water is the most severe constraint for development of agriculture in arid and semi-arid areas. Under these conditions, the need to use the available water economically and efficiently is unquestionable. Based on the actual crop need, the irrigation management has to be improved so that the water supply to the crop can be reduced while still achieving high yield. Already more than 1.2 billion people in over 110 countries are affected by the social and environmental effects of the land degradation in dry areas (Schuster, 2003), which leads to declining biological and economic productivity (Erickson, 2003). Pakistan is also one of the above mentioned countries that are facing challenges in its agricultural systems caused as a result of climatic changes. Acute shortage of irrigation water and drought are adversely affecting crop production in general and vegetable production in particular.

Differences in plant architecture might be expected to influence the ability of the crop canopy to use available soil moisture and thus affect water use efficiency. Under reduced soil moisture, lower water use efficiency of leafless or semi-leafless peas might be the result of the more open crop canopy (Heath *et al*., 1994).

Acosta-Gallegos (1988) found that, in common bean, many morphological traits were negatively affected by moisture stress; these included loss of leaf area, which can be the result of reduced number of leaves, reduced size of younger leaves and inhibition of the expansion of developing foliage. Halterlein (1983) reported that short periods of drought negatively reduced both quality and yield of beans. Water stress during flowering and pod filling reduced yield, seed weight and accelerated maturity of dry beans (Singh 1995). Ramirez-Vallejo and Kelly (1998) also found that water stress reduced seed yield from 22 to 71%. When water stress was imposed during the flowering stage, the reduction was greater (Miller and Burke 1983). Stoker (1974) suggested that reduction in yield in dry beans subjected to water stress was caused mainly by abscission of flowers and young pods. Beans respond to water stress by leaf aging, stomatal closure, and shedding of leaves, flowers and young fruits (Adams *et al*., 1985).

Chickpeas and field peas have a relatively short growing season and use less water than many other broadleaf crops such as sunflower or safflower (Johnson *et al*., 2002).

Hsio *et al*., (1985) reported that water stress reduces growth via an effect on cell expansion. A more severe and prolonged period of stress reduces growth by reducing photo synthetic metabolism. Irrigation is usually required for producing profitable yield of high quality peas seed. Efficient irrigation demands to apply the correct amount of water at the correct time. A number of irrigation practices and strategies are recommended for peas seed to make every drop of water count. Water stress initiated during vegetative or early reproductive growth of soybean usually reduced yield by reducing the number of seeds per unit area (Brevedan and Egli, 2003) while stress during seed filling reduced seed size (De Souza *et al*., 1997) Seeds per unit area and yield could be reduced by short periods of stress during flowering and pod set (Vieira *et al*., 1992). Fougereux *et al*., (1997) reported that physiological quality of peas seeds depends on various factors affecting the plant including water supply. Water stress during the flowering period did not reduce seed quality but reduced seed yield slightly. Peas seed yield was closely related to pod number per unit area, which was also strongly related to water stress. The number of peas per pod was unaffected by water stress (Martin and Jamieson 1996). Moisture stress during seed development can substantially decrease the amount of viable peas seed production (Raymond and Jeffrey, 1987).

Peas yield increase resulting from supplying supplemental water was attributed to more pods per vine (Maurer *et al*., 1968; Salter, 1962; Smittle and Bradley, 1966) and more peas per pod (Maurer *et al*., 1968; Salter, 1962).

Most research on irrigation management for peas production has dealt with sensitivity to moisture stressed specific growth stages (Hukheri and Sharma, 1980; Pumphrey and Sehwanke, 1974; Salter and Williams, 1967). Peas yields often are increased by irrigation during vegetative and reproductive growth, when soil moisture is otherwise limiting (Guatam and Lenka, 1968; Hukheri and Sharma, 1980; Zain *et al*., 1983). However, few studies have examined the effects of irrigation on spring peas seed yield (Stoker, 1977; White *et al*., 1982; Zain *et al*., 1983) and quality (Biddle and King, 1978; Nichols *et al*., 1978).

Baigorri *et al.,* (1999) stated that peas seed yield was strongly dependent on water availability, especially at flowering and pod filling. Similarly, Martin and Jamieson, (1996) reported that water stress during the last half of the growing season (pollination, pod and seed formation periods) was a major factor in reducing seed yields in temperate dry areas. Water stress during seed filling decreased seed yield and seed quality. Changing irrigation strategies for peas seed production by irrigating during seed filling improved, physiological quality of the seed lots without decreasing seed yield. Irrigation usually required producing profitable yield of high quality peas seeds (Raymond and Jeffrey, 1987).

Seed yield and viability could be reduced by environmental stress. Little information is available concerning the effect of environmental stress on seed quality. Unfavourable environmental conditions during seed development and maturation reduced viability and vigour (Tekrony *et al*., 1980). Delouche (1980) reported that stress severe enough to interrupt seed development, resulted in light, shriveled seeds. Accelerating ageing showed that seeds from field plots where moisture was with held during pod filling were low in vigour (Yaklich, 1984). Soybean seeds that experience hot, dry weather during maturation exhibited reduced laboratory germination and field emergence. Severe drought that occurred throughout seed filling reduced yield and seed number at a faster rate than seed mass, germination or vigour and maintained the development of at least some viable and vigorous seed (Dornbos *et al*., 1989). Smiciklas *et al*., (1989) mentioned that drought stress could lower seed quality and germination of seeds of soybean if applied during various stages of flowering and seed development. Drought stress during seed production of soybean usually reduced seed yield (Reicosky and Heatherly, 1990). The major portion of this yield reduction was related to fewer seeds being produced (Dornbos *et al*., 1989 and Heatherly, 1993) but some yield loss was also associated with a reduction in weight per seed (Heatherly, 1993). Vieira *et al*., (1991) reported yield of 35-41 % when drought stress was imposed during seed filling in green house experiment but found no effect on germination. Drought stress resulted in significantly inferior quality seeds as compared to well watered control plants. Irrigation during the full reproductive period was required to realize both maximum seed yield and maximum germination of harvested seed (Heatherly, 1993).

Environmental stress during seed production can affect subsequent seed quality. Stress occurring after physiological maturity, but before harvest can cause reduction in soybean seed germination and vigour (Tekrony *et al*., 1980; Vieira *et al*., 1991 & 1992). There was a significant reduction in yield and yield components of soybean following drought stress. There was no effect of drought stress on seed germination or seed vigour as measured by accelerated ageing germination and the cold test. Slight changes in 3rd germination and conductivity occurred for some drought stress treatments. Seed germination and vigour were significantly reduced for small, flat, shriveled and undeveloped seeds that only occurred following defoliation. The data suggested that drought stress had no effect on seed germination or vigour, unless the stress was sever enough to produce shriveled, flat, undeveloped seeds (Vieira *et al*., 1992).Water stress during seed filling could reduce soybean yield by creating leaf senescence and shortening the seed filling period. Moisture stress reduced yield by reducing seed size and number.

Moisture stress accelerated leaf senescence and reduced seed size on the depodded plants but the effect was less than on the non depodded plants. Water stress during seed filling could reduce yield by accelerating decline in leaf photo synthetic activity and increasing remobilization of C and N to the seed (De Souza *et al*, 1997). Nichols *et al*, (1978) working with potted peas plants observed no effect of drought stress on seed conductivity or germination. Raymond *et al.,* (1988) found reduced peas seed quality when water was with held during seed filling. Thy concluded that applying the final irrigation at 500 degree days after blooming (after 2 weeks) was necessary to produce viable seed yields similar to those obtained with continuous irrigation through early senescence. Ibrahim (1990) stated that drought stress reduced seed yield via reduction in seed number and this was related to reduce branching. It was frequently observed that seed size was increased in water stressed plants. Heatherly (1993) observed that drought stress resulted in reduced germination of harvested soybean.

Yadav and Chuhan (1997) conducted field experiment during 1984-86 at Morena, Madhya Pradesh. Peas were sown in rows 25 cm or 50 cm apart, given 0, 25, 50 and 75 kg P_2O_5/ha and irrigated 50 and 70 days after sowing (DAS). Seed yield was the highest with irrigating 50 DAS (1.90 t/ha in 1985 and 2.30 t in 1986) which increased with upto 25 kg P_2O_5 and was higher with 25 cm than 50 cm row spacing. Protein production and uptake of nitrogen and phosphorus were positively correlated with yield.

Dubey *et al*., (1999) conducted field experiment during summer seasons of 1993 and 1994 at Kukumseri, Himachal Pradesh, India. Peas cv. Arkel was irrigated at 4, 8 and 12 days intervals and given 0, 40, 80 and 120 kg P/ha. Yield increased with decreasing irrigation interval and generally increased with increasing P rate.

Rathi *et al*., (1993) said that peas cv. JP-885 were grown in a sandy loam and given no irrigation. The phosphorus was given @ 0, 20, 40 and 60 kg/ha. Nitrogen and phosphorus contents in the seed was highest with irrigation and protein contents was highest with irrigation + 60 kg P2O5/ha. Deficient irrigation reduced seed yield more than excessive irrigation.

2.2. Effect of nutrition on the seed crop

The nutrient status of the seed crop (mother plants) could affect not only flowering and seed yield but also seed quality. A recent study of changes in the mineral composition of aging peas pods (p. Hocking, unpublished) suggested that nutrients build up at relatively different rates during growth of the seeds and were then mobilized from the pods with different degrees of efficiency during senescence. At stages later when pods lost approximately 50% of their dry matter comparable losses of nutrients were 10% for calcium, 27% of manganese, 32% for copper, 34% for ferri ion, 37% for zinc, 48% for potassium and 82% for phosphorus. These mobilized minerals were captured by the seeds, and pods must contribute the minerals substantially to the developing seed (Pates and Flinn, 1977).

The fertilizer application for peas crop should ensure adequate levels of all nutrients. Optimum fertilization was essential for top quality and yield. Hadavizadeh (1989) found in greenhouse experiment that increased nitrogen supplied to peas plants resulted in increased in seed yield, seed nitrogen, seed protein contents and seed size. In greenhouse experiments increased nitrogen supply to peas plants improved the seed vigour as determined by electrical conductivity, germination percentage and seedling dry weight, using standard germination and cold test. The effect of nitrogen application was more than the application of phosphorus and potassium. Padrit *et al*., (1996) found that nitrogen application to the seed crop of peas significantly increased seed vigour in terms of electrical conductivity, after accelerated aging germination percentage was also increased and hollow heart percentage was decreased.

Kanaujia *et al*., (1997) evaluated the effect of P, K and rhizobium on growth, yield and quality of peas cv. Lincolin and stated that the growth and nodulation increased significantly with increasing levels of P and K (0, 30, 60, 90 kg/ha) alone. Best dose of P and K reported was 60 kg/ha, which increased seed yield and quality significantly.

Phosphorus is needed in relatively large amounts by legumes for growth and nitrogen fixation and has been reported to promote leaf area, biomass, yield, nodule number, nodule mass, etc., in a number of legumes (Berg and Lynd, 1985, Pacovskoi *et al.*, 1986, Kasturikrishna and Ahlawat, 1999). Kohli *et al*., (1992) studied the response of peas to phosphorus given different doses i.e. 0, 30 and 60 kg P_2O_5/ha. Phosphorus significantly increased number of peas/pod and total green pod yield, at the highest phosphorus rate. Hadavizadeh (1989) found in a greenhouse experiment that increasing phosphorus application led to increase of seed vigour.

Amjad *et al*., (2004) conducted an experiment on peas crop providing phosphorus @ 0, 23, 46 or 69 kg/ha^{-1} and potassium @ 0, 50, 100 or 150 kg/ha^{-1}. They observed that seed yield, 1000 seed weight and percentage of large sized seeds increased significantly with increasing level of P_2O_5.

When a peas seed crop was supplied with different treatments of different rates and combinations of nitrogen phosphorus, potassium, zinc and Rhizobium inoculation, the nitrogen + phosphorus + potassium + zinc combination gave the highest seed yield, but the highest return was obtained with application of 46 kg phosphorus/ha (Singh *et al.*, 1992). Patel *et al*., (1998) stated that peas cv. Arbel showed significantly increased plant height, number of branches, leaves per plant, number of pods per plant, grains per pod and pod yield. When applied 20 Kg N/ha +80 Kg P_2O_5/ ha + 40 Kg K_2O/ha. Bogdevich *et al*., (1996) tested three rates of different nutrients applied alone or in combination i.e. (nitrogen), (phosphorus and potassium), (nitrogen and trace elements (micro nutrients)), (phosphorus, potassium and trace element) to the peas crop. Intermediate rate of nitrogen and trace elements gave smaller increase in yield but the yield was the highest with high rate of nitrogen without trace elements.

Naeem (2003) reported that when nitrogen applied @ 80 kg/ha^{-1} and phosphorus @ 120 kg/ha^{-1} produced maximum length of pod and maximum number of pods per plant in peas.

2.2.1. Nitrogen

Nitrogen is contained in all proteins, nucleic acids and in all protoplasm. It is taken up by the plant through its roots as ammonium or as nitrate ions. In the plant the nitrate is rapidly converted to ammonium ions which combine with carbohydrates formed during photosynthesis to form amino eventually proteins. The protein is used in the growth of the leaves and increases their green surface area, thus increasing photosynthesis and stimulating further growth. In many crops the total leaf area is proportional to nitrogen supply. If the nitrogen supply is excessive the leaf cells become very large and thin walled and can easily be injured by wind, rain, frost, fungi or insects. Stems may also become weak. Excessive nitrogen also tends to keep the leaves green longer and thus to delay maturity. Nitrogen deficient plants remain dwarf and have pale yellow leaves containing little chlorophyll. Fermandes and Rossiello (1995) have stated that nitrogen enhanced metabolic processes that influences the physiochemical environment at all stages of plant growth and development. It interferes with the uptake of cations and could enhance or repress the activity of several enzyme systems. It also affects the growth patterns, protein content and quality of seeds. Nitrate-N nutrition increased cation uptake, carbohydrate contents in tissues and alkalization of root free space. N-assimilation is involved in the allocation of dry matter and energy, which caused different growth rates of plants parts. Application of nitrogen to the mother plant increased the protein contents of cereal grain (McNeal *et al*., 1971) and peas (Lysenko, 1979) and has been correlated with improved germination and greater seedling vigour (Schlesinger, 1970; Ries and Everson 1973; Lowe and Ries, 1973).

The rapidity of growth of seedlings is an important factor in commercial production and might be used as a parameter for vigour (Perry, 1972) Seeds from plants supplied with additional nitrogen might be more vigorous than control seeds. In wheat and other grasses there were strong correlations between an increase in grain protein contents associated with nitrogen fertilizer and the production of more vigorous seedlings (Ries and Everson, 1973; Ene and Bean, 1975. Application of nitrogen fertilizer increased the quality of proteins to a greater degree than all other amino acids (Trachuk, 1966).

During the seedling development, endogenous levels of reserves may become limited and by the time seedlings produce their second true leaves intraspecific competition for available nutrients may occur between the seedlings. Seeds initially higher in proteins, carbohydrates and other assimilates would be expected to have an advantage at this stage. Nitrogen increased seed protein content in peas and may be correlated with improved germination and seedling vigour (Schlesinger, 1970; Ries, 1971). Boyd *et al*., (1971) have reported a relationship between seed size and vigour which may be increased by nitrogen application. There is general agreement that nitrogen fertilizer has the most important effect in increasing number of flowers, seed yield and quality of a wide variety of plant species. Streeter (1978) reported that the nitrogen contents of soybean decreased when nitrogen became limiting towards the end of the flowering season and during seed formation.

Negi (1992) stated that when peas cv. Lincoln were fertilized with 20 kg N/ha. It increased seed yield (1.66 tons/ha in 1989 and 3.32 tons/ha in 1990) compared with control yields of 1.18 and 2.42 tons/ha, respectively. Application of 60 kg P_2O_5 also significantly increased seed yield (1.73 tons/ha in 1989 and 3.28 tons/ha in 1990) compared with control of 1.04 and 2.08 tons/ha, respectively.

Nitrogen supply strongly influences photosynthesis and as a result the assimilate supply available to the developing seeds. Nitrogen affects the production of carbohydrate by increasing the leaf area available to intercept radiation and the rate of gross photosynthesis (Thorne *et al*., 1979) Sucrose generally considered to be the major carbohydrate reaching the seed and in cereals has been shown to be the precursor of endosperm starch granules (Duffus, 1979), Proteins, carbohydrates and other seed reserves were depleted during germination by the process of hydrolysis and translocated to the embryonic axis to provide a substrate for seedling growth. Possibly seeds produced by supplying additional nitrogen to the mother plant and thereby having higher endogenous reserves had more rapid development of seedlings.

Lawn and Brun (1974) have reported significant effects of nitrogen fertilizer on soybean crop, supplied at the end of flowering.

Bogdevich *et al.,* (1996) tested (phosphorus and potassium), (nitrogen and trace elements), (phosphorus, potassium and trace elements) to the peas crop. Intermediate rate of nitrogen and trace elements gave smaller increase in yield, was higher with higher rate of nitrogen without trace elements.

Biological nitrogen fixation is an important source of nitrogen for plant growth and development requirements. Some times this source is enough to meet the plant requirements of nitrogen. If the factors affecting nodule activities (such as soil temperature, soil moisture, soil gaseous status, soil pH, soil salinity and soil nutrients like phosphorus and molybdenum) are inadequate or not favourable for enzymatic activities then the amount of nitrogen fixed through this source becomes insufficient to meet the plant requirement. Nodule activity generally increased from seedling stage and during vegetative growth and reaches a maximum at reproductive growth (flowering), but then decreased rapidly during seed filling (Hardy *et al*., 1971). This means that at the time of seed filling when the crop has its greatest requirement for nitrogen it may be beneficial to provide extra nitrogen.

2.2.2. Phosphorus:

Phosphorus is the most common limiting nutrient in many agricultural areas. Its effects on plants are complex. It acts on nodulation, nitrogen fixation and plant growth in legume crops. Phosphorus provides the desired amount of adenosine tri-phosphate (ATP) for nitrogen fixation. It played a vital role in the plant cell nucleus. It is essential for cell division, therefore particularly important in the meristem of the plant. The concentration of phosphorus in dividing cells can be more than a thousand times that in mature cells. Phosphorus also play an important role in enzyme actions for conversion of water and carbon dioxide to sugars and starch in the process of photosynthesis.

Parsad *et al*., (1989) conducted an experiment during Rabi (winter) season to study the effect of application of P_2O_5. They studied P_2O_5 @ 0, 40, 80 and 120 kg/ha with and without rhizobium inoculation of seeds. P_2O_5 resulted in significant increase in growth, nodulation growth and yield, compared with control. The highest green pod yield was obtained with combination of 120 kg P_2O_5/ha and rhizobium inoculation.

Phosphorus supply may also affect seed quality. Rao *et al*., (1983) observed that plants deficient in phosphorus produce seeds having slower germination than normal seed. Mother plants given additional phosphorus produced seed which tended to germinate more quickly than those of control plants. Hence phosphorus is important in the production of quality seed. Birecka and Wlodkowski (1961) found that seed from phosphorus deficient plant of peas and yellow lupin (*Lupinus luteus* L.), produced less vigorous seed than those from plants supplied with adequate phosphorus. Koostra and Harrington (1969) found that seed solute leaching was due to impairment in the effectiveness of membranes within the cytoplasm. Perhaps some of the membrane lipid changed in cucumber and peas seed also occur during moist storage. They found that there was a marked fall in the phosphorus contents of the membrane lipids after only one week of moist storage.

Gupta *et al*., (2000) studied the effect of P applied @ 0, 25, 50 and 75 kg/ha^{-1} and lime @ 0, 50, 100 and 150% on peas cv. Bonneville, for growth and yield characteristics. They observed that increasing P levels increased seed yield and yield parameters such as pod length, number of grains per pod and pod weight. Kohli *et al*., (1992) studied the response of peas to phosphorus given different doses i.e. 0, 30 and 60 kg P_2O_5/ha. Phosphorus significantly increased number of peas/pod and total green pod yield, at the highest phosphorus rate. Shukla *et al*., (1993) presented a table of correlation coefficient for 5 garden peas cultivars, grown in 2 climates, in Himachal Pradesh in response to 3 rates of P application (45, 60 and 75 kg P_2O_5/ha). The results showed that plant highest, shelling percentage, number of pods/plant and seed/pod were maximum with 75 kg P_2O_5/ha compared with control and other doses of P_2O_5.Tawaha and Turk (2004) observed the effect of phosphorus fertilizer with placement method (banded or broadcasted) and seeding rate (30, 60 and 90 seeds m^2) in field peas. Phosphorus fertilization and seeding rate had significant effect on most of the traits measured. Increase in seeding rate from 30 to 90 seeds/m^2 and increase in P fertilization from 17.5 to 52.5 kg/ha^{-1} increased 50% seed yield. Posypanov *et al*., (1994) found in a pot experiment with peas plants that the critical phosphorus contents for nitrogen fixation with boron and molybdenum was 25 mg P_2O_5/kg soil which increased atmospheric nitrogen fixation and seed yield.

2.2.3. Potassium:

Potassium is not directly involved in the synthesis of protein, carbohydrates or other main substances but it activates the essential enzyme actions involved in the synthesis of these substances. Potassium is retained mainly in cell sap, regulates the osmotic pressure and maintains the turgidity of the plant. Potassium also plays a part in the essential processes of photosynthesis, respiration and shifting of carbohydrates from one part to another. For example transfer of sugars from the leaves to the swelling roots of sugar beet where they accumulate as sucrose, to the tubers of potatoes where they are converted mainly to starch or to the seeds of peas, cereals and beans where they are converted to starch and protein. Potassium moves very freely from soil to plants and also within the plant, and its excessive absorption to the plant may interfere with the absorption of other ions. For example, excess of potassium absorption may cause magnesium deficiency.

Haeder (1990) found in an open-air pot trial, with semi-leafless fodder peas given 4.5, 16 and 28 mg potassium/100 g soil, seed yield was increased with the increase of potassium rate given to the plants respectively with increase of starch percentage as well. El-Habbasha *et al*., (1992) tested three treatments of potassium as foliar spray (0, 2 and 3 times with 15 days intervals) given to a peas seed crop in the field. Spraying potassium 2-3 times decreased plant height, increased number of leaves, branches, and shoot dry weight. Two sprays of potassium increased the seed yield by 42.2 and 24.1% as compared to the control in the first and second seasons, respectively. Three spray of potassium doubled the seeds yield. Length of peas pods, seed size, number of seeds/pod, total carbohydrate and nitrogen of peas pods were increased by potassium spray. Costa and Paulino (1992) found that in a green house pot experiment using ultysol with Pigeon peas (*Cajanus cajan* L.), fertilized with potassium increased biomass production, nodulation and phosphorus, nitrogen uptake over control values. Hanolo *et al*., (1994) conducted a field trial with potassium given at rates of 0, 50, 100, 150 and 200 kg KCl/ha to a peas seed crop. Plant growth and seed yield increased as the potassium rate increased.

2.3. Effect of balanced mixture of nutrients to the seed crop

The balanced nutrition of a plant has a profound influence on seed quality. George *et al*., (1980) reported that seed quality, as reflected by germination percentage, of the tomato cultivar “Money maker”, was affected not only by the amount of nitrogen, phosphorus and potassium but also by the balance of the minerals.

The nutrient status of the mother plant can affect not only flower and seed yield but also seed quality. The availability and balance of macro nutrients may play an important role in the production of high quality seed and vigour seedling. In phosphorus treated plants the ratio of phosphorus and potassium to nitrogen would be high whilst the reverse may be true in plants given extra nitrogen. The hypothesis that a high phosphorus and potassium to nitrogen relationship within the mother plants led to the availability of trace elements may also play an important role.

Patel *et al*., (1998) stated that peas cv. Arbel showed significantly increased plant height, number of branches, leaves per plant, number of pods per plant, grains per pod and pod yield. When applied 20 kg N/ha + 80 kg P_2O_5/ha + 40 kg K_2O/ha.Cutcliffe and Munro (1980) studied the effect of NPK on the yield of dark skin peas at 9 different locations during 3 successive cropping seasons. Dolomite limestone was also applied in furrows with the seed @ 400 kg/ha. They reported that germination was in the range of 85-95%. Vine length tended to increase and maturity was slightly advanced by increasing both N and P rate. Browning and George (1983) investigated the effect of mother plant mineral nutrition on seed yield and quality in legumes. Peas and *Phaseolus vulgaris* were grown in pots in green house with various combinations of N and P. Higher seed yield was obtained when N and P were used in combination @ 80 kg/ha and 120 kg/ha, respectively. Gangwar *et al*., (1998) stated that requirement of N, P and K for the production of 1 ton of vegetable peas seed was 8.25, 1.03 and 5.65 kg, respectively. The percentage utilization of soil available N (% organic carbon), P_2O_5 (Olsen-p) and K_2O (ammonium acetate-K) was 36.59, 13.83 and 11.81, respectively. The contribution from fertilizer as a percentage of its nutrient content was 188.82, 20.79 and 46.57 for N, P and K, respectively. Vimala and Natarajan (1999) studied that peas cv. Bonneville was treated with 32 combinations involving 4 rates of N (30, 60, 90 and 120 kg/ha) and P (40, 80, 120 and 160 kg/ha) with and without bio-fertilizers. They said that plant highest increased with increasing rate of N and P. Increasing the phosphorus rate also increased the number of branches per plant. The number of days taken for 50% flowering increased with increasing rate of nitrogen.

Pochauri *et al*., (1991) studied that to increase the area under vegetative peas production for the fresh market; increased quantities of seeds are required. In 2-year trials with garden peas cv. Lincolin, plants received N @ 0, 37 and 75 kg/ha, P_2O_5 at 0, 75 and 150 kg/ha, K_2O @ 0, 50 and 100 kg/ha as calcium ammonium nitrate, super phosphate and murate of potash, respectively. A basal dose of FYM was also applied. The highest yield was obtained in case of plants receiving N: P_2O_5: K_2O @ 75:150:50 kg/ha.

Bhopal (1991) conducted a 2-year trial to observe the response of garden peas to N and P application. Plants of the semi dwarf cultivar Lincolin received N @ 0, 20, 40 or 60 kg/ha and P_2O_5 @ 0, 30, 60 or 90 kg/ha with K_2O @ 30 kg/ha applied as a basal dressing. One half of N applied at sowing time in mid-November and the remaining after one month. The mean green pod yield for the two years increased with increasing rate of N upto 40 kg N/ha and then decreased at 60 kg N/ha. Vigorous vegetative growth was observed at the highest N rate. The yield also increased with increasing P rate upto 60 kg/ha and then decreased with highest P rate.

Kostov *et al*., (1989) applied 50, 100 and 150 kg P_2O_5/ha to winter peas cv. No.11.50. They reported that 100 kg P_2O_5/ha was most effective in increasing the seed yield. Whereas, 50 and 150 kg P_2O_5/ha did not increased the seed yield.

Shahien (1996) worked on peas cv. Victory Freezer which were irrigated at 4, 6 and 8 day intervals and given 20 m^3 cattle manure/fedden by broadcasting. The crop was also given 20 or 40 kg N/ha + 30 or 45 kg P_2O_5/ha. He said that dry seed yield, net assimilation rate and NPK uptake increased with frequency of irrigation and with application of manure.

2.4. Effect of Seed Maturity on seed crop

Maximum seed viability and seed vigour may be achieved if seeds are harvested at the correct stage of maturity. If harvesting is delayed seed quality may be declined due to adverse environmental conditions such as high temperature, high humidity, rainfall, over drying, attacks by diseases, pests or damage by birds and animals. The ideal harvesting time is before loss of mature seeds from shattering, lodging and mechanical seed damage (Copeland and McDonald, 1995). A seed crop should be harvested soon after achieving the maximum seed quality. Physiological maturity (PM), mass maturity (MM) and harvest maturity (HM) are three important terms which are closely related to seed quality. Physiological maturity was probably first defined by Shaw and Loomis (1950) as the stage in seed development when the seed reaches its maximum dry seed weight and yield. This same stage was also termed as relative maturity by Aldrich (1943), morphological maturity by Anderson (1955) and more recently mass maturity by Ellis and Pieta-Filho (1992). Since the moisture contents of the seed is often too great for mechanical harvesting and threshing at PM, further desiccation must occur before direct harvesting is possible. Harvest maturity is defined as the first time the seed moisture declines to a harvestable level in those crops harvested at dry seeds and /or fruits (TeKrony and Egli, 1997). It is widely accepted that PM represents the end of the seed filing period and the maximum yield for any crop harvested as dry seed weight. Harrington (1972) proposed that developing seed attained maximum quality (vigour) at PM, after which deterioration started and seed germination and vigour decline, with the rate of dependent upon the storage environment. This hypothesis was supported by research for more than two decaded by many physiologists for many crop species such as Powell *et al*., (1984) and Ellis *et al*., (1987). More recently, it has been reported that maximum seed quality (vigour) does not occur until some time after PM (Ellis and Pieta-Filho, 1992; Zanakis *et al*., 1994). They concluded that maturity seeds of soybean and corn did not attained maximum ability to survive storage (Potentional longevity) until sometime after PM. Hence they now refer to this stage as mass maturity, rather than physiological maturity (Ellis and Pieta-Filho, 1992). In such case seed quality (vigour) may continue to increase even after the seed have reached maximum seed dry weight (mass maturity).They achieved physiological maturity and maximum seed vigour at same later stage, after maximum, seed dry weight (mass maturity) but before harvest maturity, the stage at which a grain crop is harvestable i.e. usually 10-15 % seed moisture contents (fresh weight basis). Ferguson (1993) found that in different cultivars of combining peas maximum seed quality were attained 14 to 19 days after the stage of maximum seed dry weight. High seed yield were only achieved if the crop is harvested when the number of ripe inflorescences is at a maximum, as florets per inflorescence, seeds per floret, and seed weight are considered to remain constant over the harvest period and are not influenced by harvest date. Castillo *et al*., (1992) found that peas seeds harvested at 15% seed moisture contents had nearly double the number of hollow heart seeds than those harvested at 25% moisture contents. Seeds harvested at 40% moisture contents had over 90% germination and were high in vigour as shown by low electrical conductivity and low hollow heart frequency, and little loss of germination after controlled deterioration. Field emergence was lower in seed harvested at 15% seed moisture contents than in seed harvested at 25% seed moisture contents. Nascimento (1994) found that yellow peas seeds from a late harvest had higher electrical conductivity than green or greenish-yellow seeds. Green seeds had a higher 1000-seed weight and performed best in an accelerated aging test, suggesting the highest viability after storage.

A seed crop should be harvested when it reaches to maximum seed quality. Some physiologists have said that at the end of the seed filling period, seed attained the maximum seed quality. At the end of the seed filling period, the seed achieved maximum seed dry weight and this stage has been termed as physiological maturity, initially by Shaw and Loomis (1950). Harrington (1972) also suggested that maximum seed quality (viability and vigour) is attained at physiological maturity (the end of the seed filling period) and that after that viability and seed vigour decline. This opinion is accepted by many physiologists for many different crop species (Chen *et al*., 1972; Maguire, 1977; Delouche, 1980; Powell *et al*., 1984). Ellis *et al*., (1987) have reported that maximum seed quality in peas, chick peas and lupin was found to be reached at physiological maturity, at 45% moisture contents in soybean and 30% moisture in faba bean and lentil.

In different cultivars of combining peas maximum seed dry weight and seed quality did not decrease before harvest maturity (Ferguson, 1993). Sanhewe and Ellis (1996) observed that maximum seed quality (potential longevity) was attained at 13-23 days (at 30/24°C) or 34 (at 27/21°C) days after completion of the seed filling stage. Similarly, in soybean (*Glycine max* L. Merill) seed quality continued to increase after attaining maximum seed dry weight (TeKrony *et al*., 1980; Zanakis *et al*., 1994). Ellis and Pieta Filho (1992) have concluded that, to describe the stage of maximum seed dry weight as the term of physiological maturity is misappropriate and suggested that instead of it “Mass maturity” may be used. Physiological maturity explains the physiological quality of seed; hence the term should be used to explain this and not any physical property like dry weight of the seed. Ferguson (1993) concluded that Harrington's hypothesis may be rejected in case of combining peas just after one year field research. Castillo *et al*., (1992) found that peas seeds harvested at 15% seed moisture contents had nearly double the number of hollow heart seeds than those harvested at 25% moisture contents. Seeds harvested at 40% moisture contents had over 90% germination and were high in vigour as shown by low electrical conductivity and low hollow heart frequency, and little loss of germination after controlled deterioration. Field emergence was lower in seed harvested at 15% seed moisture contents than in seed harvested at 25% seed moisture contents. Hosnedl and Ruzickova (1988) found that during peas seed ripening assimilation of seed deposits was completed at up to 50-55% seed moisture contents, and the sequence gradually started from the pods at the bottom to the top of the plant. The germinating capacity of the seeds increased rapidly as the moisture contents of the seeds dropped to 65% and the standard germination percentage was achieved at seed moisture contents below 55%. The electrical conductivity was decreased significantly as seed moisture contents decreased below 28%. The increase in seed quality improvement depended on the environmental conditions of plants, pods and seeds experienced during drying. Demir *et al*., (1994) assessed seed quality of snap bean (*Phaseolus vulgaris*) by germination and emergence rates, seed length and seed dry weight, which were maximum when seed moisture contents had decreased to 45-50%. However it was concluded that the optimum harvest time for seed production was when seed moisture contents reached 14%. Further delay resulted in physiological aging and seed loss through shedding. Nascimento (1994) found that yellow peas seeds from a late harvest had higher electrical conductivity than green (earliest) or greenish-yellow seeds (earliest harvest). Green seeds had a higher 1000-seed weight and performed best in an accelerated aging test, suggesting the highest viability after storage. Nkang and Umoh (1997) harvested seeds of soybean at physiological, agronomic and two weeks after agronomic maturity and examined the effects of different temperatures and relative humidity on seed longevity. Optimum storage conditions were found to be at temperature of 25-30°C and relative humidity of 55-65%. Harvesting at agronomic maturity gave the best seed quality as shown by highest germination after storage for six months. Periago *et al*., (1996) reported that in peas seeds the chemical composition, nutritional protein value, mineral composition and antinutritive factors depend on the seed development stage and cultivar. Nutritional protein value increased with peas maturity whereas free amino acids and non protein nitrogen decreased. Mature peas have the highest copper, zinc and manganese contents. Estimates of mineral availability showed that immature peas are a better source of calcium, zinc and phosphorus than mature peas. Ellis *et al*., (1993) found that beside the hypothesis of Harrington in cereals and vegetable crops, maximum potential longevity was not attained by developing seed crops until some time after mass maturity. In the cereals seed quality declined after the maximum dry weight had been achieved, this decline being quantitatively similar to that expected in post harvest air-dry storage. In capsicum and tomatoes, however, no substantial decline in seed quality was detected after maximum dry weight achievement. This difference between the two crop groups is comparable with results of post harvest seed storage longevity at air-dry and very high seed moisture contents.

Maturity and storability of seed are important but the exact relationship between these variable is not elucidated. Viability equations developed predominantly from storage experiments under various temperatures (Ellis *et al*., 1980) were used to estimate seed deterioration and longevity under more beginning conditions. The post-harvest treatments often include methods and temperature of drying, storage moisture contents, storage conditions and duration (Peasrce *et al*., 2001).

As maturity advances in this indeterminate species, the seed yield potential increases because the total number of pods produced increases. The percentage of pods that dehisce and the amount of seed shattering increases as later-developing pods mature (Anderson, 1955). The anatomy, development, and maturation of birds foot trefoil pods have been extensively studied. The anatomical configuration of pod tissues is related to the dehiscence mechanism. Dehiscence occurs along the ventral and dorsal sutures of the carpel margins and along the median vein of the pod. Pod dehiscence is caused by different rates of moisture loss from these tissues.

Relative humidity has been reported to be the most critical factor influencing pod dehiscence and seed shattering (Anderson, 1955; Metcalfe *et al*., 1957). Mature pods shattered freely when relative humidity was below 40% (Anderson, 1955). At low temperatures and high relative humidity, the rate of shattering was less than at high temperatures and lower relative humidity (Metcalfe *et al*., 1957; McGraw and Beuselinck, 1983). Pod moisture contents were influenced by ambient relative humidity, which was a critical factor that determines when pods will dehisce. The critical pod moisture concentration for shattering was between 101 and 104 g kg-1 (Metcalfe *et al*., 1957). Under sunny conditions, pod temperature can be 5°C higher than the ambient air temperature, resulting in a change in the relative humidity at the surface of the pod (Metcalfe *et al*., 1957). Gershon (1961) found no correlation between relative humidity and birds foot trefoil pod dehiscence for plants grown under greenhouse conditions, but relative humidity and pod dehiscence were correlated when grown in the field. This was likely due to differences between the humidity in the field and that in the greenhouse (Grant, 1996).

The rate of shattering increases as the rate of water loss from the pods increases, but pods do not shatter as readily when pod drying proceeds slowly. Although dependent upon environmental conditions, when desiccants and plant growth regulators were used to manage vegetative growth, seed shattering was reduced and seed yield increased (Wiggans *et al*., 1956). Summations of average daily temperatures have been used to determine when pod dehiscence and shattering will occur (Gataric *et al*., 1990). These findings suggest that factors other than relative humidity and pod moisture contents alone may modify the pod shattering response.

The effects of agronomic practices on seed shattering are not as well defined as the physical factors that trigger pod dehiscence. Grant (1996) suggested that earlier harvest was only partially effective for reducing seed losses due to shattering because fewer mature pods were present in the indeterminate flowering crop. Estimates for proper harvest time have been based on the rate of appearance of pods and pod color (Anderson, 1955; Winch and MacDonald, 1961; Winch *et al*., 1985; Pieroni and Laverack, 1994) and the rate of development of reproductive structures (Li and Hill, 1989). Pod color can vary from dark green or dark green-purple to green-white and then to golden-brown (MacDonald, 1946; Anderson, 1955; Winch and Mac-Donald, 1961). Maximum seed yield was obtained with harvest at the time pod color changed to golden-brown, pod moisture contents decreased from 650 to 250 g kg-1 and initial seed shattering had begun.

Optimal harvest time was suggested to be when 70 to 78% of the pods picked at random throughout the field were mature (Winch *et al*., 1985). A delay in the seed harvest time to allow more developing umbels to mature can result in yield decreases of 50% (Winch and MacDonald, 1961) to 67% (Anderson, 1955).

Demir and Ellis (1992a) studied changes in seed quality in pepper (*Capsicum annum* L.) during seed development. They tested seed quality by the seed storage longevity test and seedling growth. Maximum seed dry weight occurred 49-53 or 53 days after anthesis in two seasons. Maximum potential longevity and seedling dry weights were observed in seed harvested at 10-20 and 17-21 days after physiological maturity respectively. The onset of germination ability and desiccation tolerance occurred just before or at physiological maturity. They concluded that maximum seed quality is attained some time after physiological maturity. Demir and Ellis (1992b) has also reported that in tomato (*Lycopersium esculentum*) physiological maturity was attained 35-42 days after anthesis. They tested maximum seed quality by seedling size and normal germination, which were not achieved until 24-40 days and 23 days after physiological maturity respectively.

Demir (1994) has assessed the changes in seed quality during seed development on the mother plant in okra (*Hibiscus esculentum* L.). Physiological maturity was attained 31 days after anthesis, when the seed moisture contents were 71%. Maximum germination and resistance to accelerated aging emergence was observed in seed harvest 21 days after physiological maturity. Maximum seed quality was found when maturation drying on the mother plant in the field had reduced the seed moisture contents to 12% in okra pod. He concluded that for the sake of seed quality and seed loss due to splitting of okra pods, seed harvesting should occur at 45-52 days after anthesis and at around 12-16% seed moisture contents.

2.5. Effect of seed storage conditions on seed quality:

Garden peas are propagated by seeds. Seed are also used in crop improvement and for long- term conservation of genetic diversity. Seed show orthodox storage behavior. Seed longevity is primarily controlled by genetic means and regulated by storage conditions. Peas seeds stored at 10°C and 50 percent RH remain viable for five years but when stored at subzero temperature (-20°C) seed remained viable for 33 years (James *et* *al*., 1967). The benefit of early harvesting peas to obtain bright seed with strong, uniform colour can readily be lost due to unfavorable storage conditions. An important and often overlooked consideration in seed storage is the quality of seed placed into storage. Seed germination provides a good indication of seed condition. Vigorous, premium quality seed store well even under relatively adverse conditions, while poor quality seed deteriorates rapidly even under favorable conditions. Initial seed condition, however, has a profound influence on subsequent storability. To achieve low moisture levels in seed, the ripe crop stands at risk of weather damage as it dries. Such risk needs to be considered in harvest and storage planning. According to Dickie and Pritchard (2002) different aspects like optimal storage temperature and desiccation tolerance, longevity of seeds in storage, seed size and “fleshiness” as well as ecological habitat of the mother plant must be taken in consideration when determining the storage category and optimal storage conditions for a crop species. Mills and woods (1994) found that in peas (*Pisum sativum* L.) and white bean (*Phoseolus vulgaris* L.) deterioration assessed by electrical conductivity and germination percentage, the occurrence of fungi was increased by increasing the moisture contents and storage temperature of the stored seeds. According to Guberac *et al*., (1997) relative air humidity and high storage temperature are negatively correlated with peas seed longevity and germination. Temperature and moisture contents of the seed are major factors in determining viability in storage. Seeds that can be stored in a state of low moisture contents (MC of 1-8 %) and at low temperature are called orthodox (Dayan, 1997) and their viability under certain storage conditions conforms to some general rules; for each 1% decrease in seed moisture contents the storage life of the seed is doubled. For each 5.6ºC decrease in seed storage temperature the storage life of the seed is doubled. The arithmetic sum of the storage temperature in degrees F and the percent relative humidity (RH) should not exceed 100, with no more than half the sum contributed by the temperature (Bewley and Black, 1985; Desai *et al.,* 1997). Orthodox seeds are best stored in a state of low moisture contents and at low, generally subzero temperatures. Recalcitrant seeds species are usually found in tropical, sometimes in temperate, areas (Kolotelo *et al*, 2001). Their seeds are generally larger than orthodox ones, sensitive to low temperatures and must, to preserve their viability, be stored with high moisture contents (Bewley and Black, 1985; Desai *et al*, 1997*;* Rae and Ingram, 1999; Dickie and Pritchard, 2002). It is important to store the seeds in waterproof containers/dehumidified atmosphere. If the storage relative humidity (RH) is high seed gain moisture and if they are later brought out to a higher temperature they could deteriorate because of their high moisture contents. For small batches of seeds, e.g. in *gene banks*, seeds could be kept immersed in liquid nitrogen (Bewley and Black, 1985).

The environmental conditions and duration of seed storage affect seed quality. Optimum environmental conditions may prolong the storage period and seeds do not deteriorate so rapidly. If environmental conditions during storage are good. High temperature and relatively humidity cause faster deterioration of seed. Moreover during seed storage pathogen, insects and other seed damaging animals such as mice might also adversely affected seed quality. The moisture contents of seed also affect its storage potential. The storage life of seed is doubled for each 1% reduction in its moisture contents upto an optimum percentage. Further decrease in moisture contents will be harmful for seed life, because all metabolic reactions will stop. The three most important factors which affect the viability of seed during storage are temperature, oxygen content and seed moisture contents or relative humidity of the storage environment (Roberts and Abdalla, 1968). Usually seed is stored from harvesting until sowing. This can be a short or a long time but it is important to store seeds under conditions that cause the minimum reduction of potential germination and vigour. Sometimes seed may be stored for more than one season because it is uneconomic to multiply each seed stock annually. It is also not possible to estimate seed yield. Demands for seed may fluctuate. Good seed stocks are valuable and can be difficult or costly to produce. Seed for storage must be free from mechanical damage, pest damage or infestation, free from disease (pre or post harvest disease), must be mature at the time of harvest and well processed. Generally the storage life of seed can be doubled for each 5.5°C reduction in seed store temperature, within the range of 0°C to 45°C. The sum of the percentage relative humidity plus the temperature in degrees Fahrenheit should not exceed 100. The activity of the majority of storage pests is reduced below 50% relative humidity and their reproduction stops at 35% relative humidity. Important diseases of stored seed cannot thrive on seed stored at relative humidity below 65-70%. For satisfactory long term storage a cold store with temperature and relative humidity not exceeding 10°C and 50% respectively is required. For storage of up to one year the temperature and relative humidity should not exceed 25°C and 50%. For low cost storage, seed may be stored in the coolest place possible in small quantities in desiccators or storage jars using calcium chloride or silica gel to remove moisture from the atmosphere in the container. One main problem in seed storage is that there is a negative correlation between temperature and relative humidity. By decreasing the temperature the relative humidity is increased. Hence 4°C is the optimum temperature for seed storage providing that facilities are available to control the humidity. If seeds are stored below 0°C then there is a possibility of seed damage due to freezing and similarly if the seeds are kept extra ordinarily dry, they may be damaged by handling. In soybean, optimum storage conditions were found to be at temperatures of 25-30°C and relative humidity of 55-65% (Nkang and Umoh, 1997). It is also good if seeds are kept in waterproof bags and the bags kept in open air before transmission for sowing, to let them attain normal temperature otherwise they might get mechanical injuries (Raymond, 1980). Mills and Woods (1994) found that in peas (*Pisum sativum* L.) and white bean (*Pisum valgaris* L.) deterioration assessed by electrical conductivity and germination percentage the occurrence of fungi was increased by increasing the moisture contents and storage temperature of the stored seeds.

During storage, seed deterioration processes involve many metabolic/chemical reactions, including loss of intracellular integrity which depends mostly on the nobilities (diffusion) of involved molecules. If the cytoplasm of dry seeds (low moisture contents) exists in a glassic state (a highly viscous liquid condition that can be expected to immobilize cell constituents) it showed down metabolic reactions and the deterioration rate in stored seeds. A loss of the glassy state might be related to the loss of viability as the seed ages (Wendell and Carl, 1994). Seeds covered in pods or unthreshed or remaining in ears and stored, may be protected from the relative humidity and temperature of the store by their natural covering i.e. pods or ears. Thus their deterioration might be slowed and seeds may show longer longevity than threshed loose seeds. Pods or ears may prevent the seeds from diffusion of moisture. Zanakis *et al*., (1994) found that the germination of soybean (*Glycine max*) by remaining covered in pods after soaking in water for 24 hours at 20°C and tested for germination percentage, which were found better than that of threshed seeds. The pods protected the seeds from imbibition damage. Weathering (rainfall) caused reduction of germination percentage from 85 to 58% (31% decrease) in threshed seeds and 91.4 to 78.1% (14.6% decreased) in unthreshed seeds (Knights, 1993).

Under field conditions the legumes pods might be a barrier to the weather for the enclosed seeds. The endocarp of the mature soybean pod regulates moisture migration to the seed. It seems probable that differences in the pod might influenced moisture migration to the enclosed seed and thus influenced seed deterioration. It has been observed that certain cultivars maintain their seed quality in the field even after a lengthy delay of harvest. It might be assumed that moisture was not being absorbed as readily through the pods and that the enclosed seed could maintain their quality because their moisture contents were under identical condition. The moisture influx of soybean seeds appeasrs to be controlled by pods, that control the uptake of moisture and which act as a mechanism to slow the seed deterioration (Yaklich and Cregan, 1981).

Organization of cellular membranes is at its peaks by the time a seed reaches physiological maturity (Abdul-Baki, 1980). Seeds undergo a structural disorganization process during the drying period before harvest; the lower the water content, the greater the disorganization. As a result seeds temporarily lose their integrity (Bewley & Black, 1994). During the initial phase of the soaking process, the capacity of a seed to reorganize the cellular membrane system and repair physical and/or biological damage that may have occurred, will influence the quantity and nature of the lixiviates released into the environment (Simon & Raja Harun, 1972; Bewley & Black, 1994; Vieira & Krzyzanowski, 1999). Thus, seeds with less physiological potential as a result of the deteriorative process have a reduced capacity for membrane reorganization and a greater loss of solutes to the environment, resulting in decreased seed reserves and reduced germination uniformity and speed.

Ferguson (1988) observed that soybean seeds stored at 10ºC (temperature normally utilized in a cold chamber) had a reduced physiological potential when evaluated by germination and accelerated aging tests; however, this reduction was not detected by the electrical conductivity test.

With the objective of investigating the effect of storage temperature on seed deterioration in soybean, Vieira *et al*., (2001) evaluated six seed lots with distinct physiological potentials. They observed that at 10ºC, germination obtained after accelerated aging was reduced for all stored lots, while electrical conductivity data did not vary during the same period. Seed samples stored at 20ºC presented rapidly decreasing values for standard germination and accelerated aging tests, accompanied by increased electrical conductivity values. When seed samples were transferred from 20ºC to 10ºC after six months storage, accelerated aging test results showed that there was a continuing decline in vigor but that the electrical conductivity values remained stable. This fact led the authors to question the use of electrical conductivity as an indicator of deterioration and seed vigor in soybean after storage at low temperatures. In a more recent study, Fessel (2001) sought to confirmed the influence of storage at 10ºC on electrical conductivity results and verified that this test was also not indicated for evaluating seed vigor in soybean under cold storage. On the other hand, seed deterioration at 10ºC does not seem to be directly related to loss of membrane integrity, which may be due to its repair or reorganization during storage at lower temperatures.

Although there are several studies on the effect of storage temperature (10ºC in particular) on electrical conductivity test results in soybean, more detailed studies are needed for other species, especially to verify the influence of low storage temperatures (Hampton & TeKrony, 1995).

Seeds of many species of legumes are capable of retaining germinability for many years in storage. According to these authors; the cultivated peas is not one of these long-lived species, retaining 70 to 100% germinability for only three years. However, recent work has shown otherwise.

Deterioration in seed quality of field peas (*Pisum sativum* L. `Titan') and white beans (*Phaseolus vulgaris* L. 'Seafarer') during storage for 147 days was studied at temperature-moisture levels typical of storages in Manitoba. Time required for development of off-odors and visible mold, fat acidity value (FAV), conductivity (seed electrolyte leakage), germination, occurrence of particular fungi and their association with off-odors, and other parameters of seed quality were assessed. Spoilage increased as temperature and moisture increased, as shown by rate of development of off-odor, and

FAV, conductivity and germination levels. Off-odors developed more rapidly in the peas than in the beans at the same temperature and comparable initial moisture contents. In beans, Eurotium species (*Aspergillus glaucus*) levels after 147 days were low except at high moisture contents. In peas, Eurotium levels after 147 days were low except at high moisture contents. In peas, Eurotium levels were higher but peaked at intermediate moisture. Beans suffered severe germination loss under less extreme conditions than peas. There were strong associations among most of the storage quality parameters studied, except for some fungi that occurred at low levels. In peas stored at an initial temperature of 31°C and 14.5% m.c. or in beans at 22°C and 14.2% m.c. Moisture contents/temperature/time storage guidelines were derived from the laboratory data and related to data collected from farm bins in Manitoba. The guidelines are intended for estimating storability of the two crops during the first 5 months after binning in climatic zones typical of western Canada and the northern U.S.A.

The discovery of the glassy state in seeds has provided insight into the understanding of storage stability and we have carried out studies to investigate its role. The change of glass transition behaviour during accelerated aging was examined. The glass transition temperature (Tg) of soybean axes decreased during aging, and eventually the seed tissue lost the ability to enter into the glassy state, which was followed by a subsequent decrease in seed viability. The effect of the glassy state on deteriorative reactions was also studied for soybean seeds (Sun and Leopold, 1995). Deteriorative processes, such as the release of free radicals and sugar hydrolysis, were effectively inhibited during storage in the glassy state (Sun and Leopold, 1995, 1997).

2.6. Seed Testing:

There are two types of test that can be used to estimate seed quality (Isely, 1957) i.e. direct and indirect tests. Direct tests imitate the field environment in some way and measure the ability of seeds to emerge under simulated field stress conditions e.g. the cold tests. Indirect tests measure specific physiological components of seeds e.g. the leachate electrical conductivity test. However indirect tests fail to evaluate all the physical and physiological factors. Woodstock (1973) has divided these tests into physiological and biochemical tests. Physiological tests measures some aspects of germination or seedling growth while biochemical tests evaluate a specific chemical reaction (e.g. enzymatic activities or respiration) related to the expression of germination. McDonald (1975) added one additional group, physical category that included seed size and density. Other invigorators have classified these tests into stress and quick test groups (Pollock and Roos, 1972). Quick tests (e.g. tetrazolium test, electrical conductivity test) are those in which some chemical reaction associated with seed vigour is monitored, and this is usually a more rapid test than a stress test. Stress tests depend on subjecting seeds to one or more environmental stresses before measuring some aspects of germination (e.g. hypocotyls length).

2.6.1. Germination percentage test:

A germination percentage test gives estimation about field survival of progeny plants from the seed and results can be used to differentiate between different seed lots. The standard germination test is conducted under controlled laboratory conditions. Hence there is no guarantee that the seeds will also give almost the same emergence percentage in the field. Under field conditions testing is normally unsatisfactory, because repetition is not possible. In the laboratory it is possible to provide generally similar conditions as in the field, but these can be controlled constantly during the whole testing period, so that the most regular, rapid and complete germination may occur in most seeds of the testing sample. 1985 established rules for seed testing defined the germination percentage test as "The emergence and development from the seed embryo of those essential structures, for the kind of seed being tested, which indicate the ability to develop into a normal plant under favourable conditions in soil".

The categorization of normal and abnormal seedlings is based on internationally agreed definitions. Normal seedlings are those seedlings which are capable of becoming a normal plant in the field, comprising at least one main root and a normal shoot. Abnormal seedlings in contrast are not able to develop into a normal plant in the field because one or more essential structures are missing, e.g. no main root, no coleoptile, broken mesocotyl, deformed small seedlings. There are standards of this evaluation according to species, in which essential structures for normal and abnormal seedlings are prescribed. There are also prescribed materials, methods, environmental conditions, duration, and dormancy breaking method, to conduct the germination test, (I.S.T.A., 1966). For Peas (*Pisum sativum* L.) sand or double filter paper is recommended as the germination substrate. The temperature during the test is 20°C, while no light is necessary. The first and final count days are the 5th and 8th day of the test. For fresh and dormancy seeds diffusion of light into the seeds is recommended.

2.6.2. Emergence percentage test:

A field emergence percentage test gives information about seed vigour and gives more accurate data to predict the storability of the seed lot tested. If the field conditions are optimal, the results of the laboratory germination test usually correlate well with field emergence (Abdella and Roberts, 1969; Perry, 1977; Egli and Tekrony, 1979), but under suboptimal field conditions, the laboratory germination results often overestimate the actual field emergence of seed lots (Tekrony and Egli, 1977; Johnson and Wax, 1978; Yaklich and Kulik, 1979; Naylor, 1981). There can be considerable differences between the laboratory germination of a seed lot and its emergence in the field. Matthews (1977) found that soil infection, seed inborn diseases, soil conditions such as low temperatures, and both high and low soil moisture adversely affected seed emergence.

2.6.3. Accelerated aging and Controlled deterioration (C.D.) test:

In this test a technique is used in which rapid aging of seeds occurs. The seeds undergo a stress of high temperature (40-45°C) and high relative humidity (100%) for a particular period (2-8 days depending on the species). Seeds are then removed from the stress and are tested for viability and vigour by germination percentage, electrical conductivity and field emergence tests. High vigour seeds can tolerate the aging stress, but low vigour seeds are affected severely, and lose viability. The technique of this test is being used to predict the storage longevity potential of different crop species. Bishni and Delouche (1980) have reported that a cold test and accelerated aging test are good enough to predict the deterioration and field emergence of cotton. In sunflower (*Helianthus anuus* L.) the results of accelerated aging and field emergence tests have been found to be correlated to each other (r = 0.81) (Anfinrud and Schneiter, 1984). This test is inexpensive, simple, useful for all species and no extra know how is desired for correct evaluation, but the results may depend on moisture contents (McDonald, 1977) and differences between seeds in the rate of water absorption from humid atmospheres (Ellis and Roberts, 1980; Matthews, 1980).

The controlled deterioration (CD) test was introduced by Matthews (1980). It is more advanced than the accelerated ageing test of Delouche and Baskin (1973). In this test seeds undergo a set period (24-72 hours) of rapid, controlled aging at high temperature (40-50°C) and the moisture contents of the seeds is kept between 15 to 20%. Seed lots which still give low electrical conductivity, high germination and field emergence after the test are deemed as high vigour seed lots, otherwise low vigour seed lots. This test is more suitable for detracting vigour differences in small-seeded vegetative species (Matthews, 1980, Matthews and Powell, 1981). The results of controlled deterioration, water stress and laboratory emergence tests have been found to be significantly correlated with seedling emergence in peas (Bustamante *et al*., 1984). This test is much more time consuming, particularly during the seed moisture contents raising process.

2.6.4. Electrical conductivity test:

This test was first introduced by Fic and Hibbard in 1925 (Copeland and McDonald, 1995) and adopted for testing of cotton seed viability. The test measures the cell membrane integrity and is based on the premise that low vigour (deteriorated) seeds have poor membrane integrity. During soaking the seeds in water and the imbibitions process seeds having poor cell membrane structure leach (cytoplasmic solutes proteins, sugars, amino acids and other electrolytes) into the soaking water. The solutes with electrolytic properties contain electrical charge that can be measured by an electrical conductivity matter. If seed has low vigour the amount of electrolytes will be more and consequently the electrical conductivity of the soaking media will be higher. On the other hand high vigour seed releases less solutes and show low conductivity. Matthews and Bradnock (1968) proposed the use of this test for peas seeds and the procedure has been standardized by the Processors and Growers Research Organization (P.G.R.O., 1981). This test is also accepted in the UK as an officially recognized test for commercial vining peas seed in addition to the germination test (Hadavizadeh and George, 1988; Parera *et al*., 1995). Bedford (1974) found the relationship between electrical conductivity values and vigour in relation to the field emergence potential of vining peas.

The conductivity values (P.G.R.O., 1981) are translated into vigour grades as follows:

24 µs or less	High vigour	Suitable for sowing in early drillings
25-29 µs	Medium vigour	Suitable for early sowing depending the seed bed conditions
30-43 µs	Low vigour	Not suitable for early sowing
Above 43 µs	Very low vigour	Not suitable for sowing at all

The electrical conductivity test is a rapid, cheap and simple test. Several factors affect the test results. Factors which directly affect the results in peas and soybean are pH, soaking temperature, soaking duration, temperature at evaluation, initial seed moisture contents and seed size (Matthews and Bradnock, 1968; Bradnock and Matthews, 1970; Tao, 1978). The electrical conductivity of the seed leachate, and the amount of free amino acids and sugar were found to be higher from larger seeds than smaller seeds of cowpeas (Paul Ramaswamy, 1993). Hampton *et al*., (1992) suggested the use of a bulk conductivity testing method for large seeds of legumes such as mung bean (*Vigna radiate*), soybean (*Glycone max*) and French bean (*Phaseolus vulgaris* L.). Four replicates of seeds (selected at random) should be kept in 250 ml deionized water at 20°C for 24 hours. The initial seed moisture contents of the seeds should be 10-14%. The effect of test variables such as soaking water volume, seed number and initial seed moisture contents of bulk conductivity for small seeded legumes have been determined by Hampton *et al*., (1994) using two herbage legume species (*Lotus corniculantus* L. and *Lotus ulignous* Schr.). They recommended that bulk conductivity testing for Lotus species should also involve four replicates, soaked in 250 ml deionized water for 24 hours and that the seed moisture contents should be 11-17%.

A drawback of the bulk electrical conductivity test is that it expresses results as an average conductivity (bulk leachate conductivity) for 50 seeds. It presumes that all 50 seeds are deteriorated equally and leach the same amount of electrolytes, which is actually not true. Hence if the electrical conductivity of every seed is measured individually it will be better for commercial lots. Copeland and McDonald (1995) have used an instrument to measure individual seed electrical conductivity values. In this method 100 seeds are tested. Each seed is soaked in a cell filled with 4 ml deionized water. A vigour rating is determined for the seed lot on the basis of the percentage of seeds with conductivity above a threshold value. The more seeds that lie above the threshold the lower are the vigour rating for the seed lot. Water and Blanchette (1983) conducted electrolyte leakage tests on individual seeds of sweet corn with the ASA-610 Automatic Seed Analyser and found this to be superior to bulk-seed measurements with a conductivity meter in predicting field emergence potential. The principal advantage of the ASA-610 over the bulk leachate test is that with the readings of individual seeds, it is easy to distinguish seed lots having a large number of mediocre seeds and those having a few extremely poor seeds. Nevertheless, unpublished results show little if any advantage from this technique over bulk leachate conductivity tests for combing between electrical conductivity and field emergence percentage in three cultivars of soybean and concluded that the electrical conductivity test is suitable for evaluation of seed quality. Hosnedl *et al.*, (1993) used two conduct metric tests to measure changes in seed quality in peas and soybean. Their ability to measure electrolyte leakage was compared. The individual test gave variable results due to variation in seed maturation, occurrence of mildews and mechanical damage.

CHAPTER III

MATERIALS AND METHODS

The studies were conducted to evaluate the productive and qualitative potential of two commercial peas cultivars i.e. Meteor and Climax. The study was executed to find out best management practices, packing material and storage environment for better yield and quality seed production of peas. All the field experiments were conducted in Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad and storage experiment was performed in Post Harvest Laboratory, Ayub Agricultural Research Institute, Faisalabad. Details about materials and methods are given as follows:

3.1. Materials

Meteor and climax two promising commercial cultivars were selected and all experiments were conducted from 2004-2009. Seeds of these cultivars were obtained from Ayub Agricultural Research Institute, Faisalabad.

3.1.1. Soil analysis

In field Experiments, before sowing and after harvesting the crop five soil samples from the field were randomly taken at two depths (15cm and 30cm) and their physio-chemical analysis were obtained. Report was obtained from soil and water testing laboratory, Ayub Agricultural Research Institute, Faisalabad. The purpose was to get information about initial and final fertility level of the soil before and after harvesting the crop.

3.1:- Pre-sowing physio-chemical soil analysis

Determinants	Units	Values	Values	Values
		2006-07	2007-08	2008-09
Sand	%	64	65	65
Silt	%	17	16	16
Clay	%	19	19	19s
Soil texture	%	Sandy clay loam	Sandy clay loam	Sandy clay loam
pH	%	8.0	7.9	7.8
Electrical conductivities	dS m^{-1}	0.92	0.95	0.94
Organic matter	%	1.00	1.09	1.17
Total N	%	0.047	0.049	0.050
Available P	mg kg^{-1}	6.80	7.0	7.3
Available K	mg kg^{-1}	1.11	1.38	1.43
Cat ion exchange capacity	c mol kg^{-1}	9.21	9.27	9.20
$CaCo_3$	%	8.6	8.66	8.71

3.1.2. Fertilizer Source

Fertilizers namely Urea, SSP (Single Super Phosphate) and MOP (Murate of Potash) were used as source of nitrogen, phosphorous and potash, respectively. Total amount of Phosphorus and Potash were applied at the time of seed bed preparation whereas half dose of nitrogen was applied at sowing time and remaining was applied after one month of sowing.

3.1.3. Weather:

Main weather variables for the 2005-2006 and 2006-2007 season are presented in Table 1. Although the rainfall has no direct relevance to the experiment, they have an indirect. The season was cooler. November was warm month but December, January and February were cool months and May was also warm at the time of seed ripening. The results of the experiments for both years obtained, summarized and discussed accordingly as here under:

Table 3.2:- **2005-2006 and 2006-2007 mean monthly climate data from the Cop Physiology Department Meteorological Station, University of Agriculture, Faisalabad.**

Mean temperature (°C)			Relative Humidity (%)		Rain Fall (mm)	
	2005-2006	**2006-2007**	**2005-2006**	**2006-2007**	**2005-2006**	**2006-2007**
Nov	20.8	20.9	50.5	47.0	0.0 (Total)	12.8(Total)
Dec	14.6	15.5	52.0	57.4	0.0 (Total)	46.2(Total)
Jan	13.5	12.5	58.1	67.4	8.2 (Total)	0.0(Total)
Feb	20.3	15.5	52.4	67.1	14.6 (Total)	55.9(Total)
Mar	21.4	19.4	40.7	47.0	37.0 (Total)	41.3(Total)
Apr	29.2	28.9	23.4	35.1	0.0 (Total)	0.0(Total)
May	34.8	32.2	23.9	25.0	24.0 (Total)	0.0(Total)

3.1.4. Layout

Field experiments were laid out according to RCBD (Randomized Complete Block Design) with factorial arrangements and CRD (Completely Randomized Design) was used for laboratory experiments. There were six trials for determining irrigation, nutrition, seed maturity, seed storage and packing material for the crop. There were different treatments in all the six experiments. Each experiment was repeated next year. Four experiments had the same number of treatments whereas; the last two experiments had different treatments. Growth & Yield data were collected from each sub-plot and averages were obtained.

3.2 Experiment No.1:

Effect of varying irrigation frequencies on growth, seed yield, vigour and quality of peas crop.

This experiment was designed to observe the effect of irrigation on growth, seed yield, vigor and quality of peas crop. Seeds were sown on 2nd November, 2005 at a distance of 20 cm on beds, made 150 cm apart. Each sub-plot was 1.5 m wide and 5.71 m long, having 8.565 m^2 areas, totally. Standard dose of N 80 kg ha^{-1} alongwith 120 kg ha^{-1} P and 100 kg ha^{-1} K were applied. Phosphorus and potash was applied at the time of seed bed preparation whereas, half dose of nitrogen were applied at the time of seed bed preparation and remaining was applied when flowering started. Immediately, after sowing water was applied. Irrigation (7.5 cm each) was applied on different growth stages of the crop, with 10 days intervals. Crop was looked after properly and finally crop was harvested on 22nd May, 2006. Experiment was also repeated in 2006-2007.

3.2.1. Treatments

Following four treatments were included in this experiment.

I_0 Irrigation as needed by crop (control; 13 irrigations)

I_1 Irrigation up to flowering (8 irrigations)

I_2 Irrigation up to pod filling (10 irrigations)

I_3 Irrigation up to seed filling (12 irrigations)

3.2.2. Parameters studied:

Data were collected for following parameters, separately during both the years.

3.2.3. Growth and seed yield parameters

The following vegetative, reproductive and yield parameters were studied.

3.2.4. Main stem length (cm)

Height of the plant was noted with the help of measuring tape at maturity. For this purpose ten plants from each treatment were selected randomly, their height was taken and averages were computed.

3.2.5. Number of leaves per plant

Ten plants from each treatment were selected randomly, total number of leaves was counted and finally, average was obtained.

3.2.6. Leaf area (cm^2)

For this purpose leaves were picked from ten randomly selected plants from each treatment. Leaf area was measured with leaf area meter (CI-203, Laser Leaf Area Meter) and average was computed.

3.2.7. Number of pods per plant

Pods were harvested when they ripened. Ten plants from each treatment were selected randomly and number of pods was counted and average was calculated.

3.2.8. Length of pod (cm)

Length of pods was measured with the help of measuring tape after harvesting pods and ten pods were selected from each treatment.

3.2.9. Number of seeds per pod

The pods which were selected for measuring the length and width were threshed separately, seeds were counted and numbers of seeds per pod were obtained.

3.2.10. Seed fresh weight per plant (g)

From each replication ten plants were selected randomly. Seeds from plants were threshed individually, seeds were weighed and average was obtained.

3.2.11. Seed dry weight per plant (g)

Samples were kept for 48 hours in oven at 70°C till constant weight was obtained and then average was obtained.

3.2.12. 1000 seed weight (g)

From each replication plants were selected randomly. 1000 seeds were weighed and average was computed.

3.2.13. Seed yield per hectare (tons)

Data for this parameter was obtained by converting seed yield per plant into hectare basis in tons.

All these above parameters were studied for four experiments.

3.3 DIFFERENT EXPERIMENTS FOR THE RECOMMENDATION OF FERTILIZER.

3.3.1 Experiment No.2:-

Influence of different phosphorus levels on peas seed yield and quality.

This experiment was performed to assess the performance of different levels of phosphorus. Different levels of phosphorus were applied alongwith constant doses of N (80 kg ha^{-1}) and K (100 kg ha^{-1}). All Phosphorus levels and potash was applied at the time of seed bed preparation whereas, half dose of nitrogen was applied at the time of seed bed preparation and remaining was applied when flowering started. Immediately, after sowing water was applied. Irrigation was applied according to the requirement of the crop. Crop was looked after properly (all other management practices managed like other crops). Details of the treatments are as below.

3.3.2. Treatments

F_0 0 kg ha^{-1} (control)

F_1 60 kg ha^{-1}

F_2 80 kg ha^{-1}

F_3 100 kg ha^{-1}

F_4 120 kg ha^{-1}

F_5 140 kg ha^{-1}

F_6 160 kg ha^{-1}

3.4. Experiment No.3:-

Influence of different potash levels on peas seed yield and quality.

This experiment was performed to assess the performance of different levels of potash. Different levels of potash were applied alongwith constant doses of N (80 kg ha^{-1}) and P (120 kg ha^{-1}). All Potash levels and Phosphorus was applied at the time of seed bed preparation whereas, half dose of nitrogen was applied at the time of seed bed preparation and remaining was applied when flowering started. Immediately, after sowing water was applied. Irrigation was applied according to crop requirements. Crop was looked after properly.

Details of the treatments are as follows:

3.4.1 Treatments

F_0 0 kg ha^{-1} (control)

F_1 40 kg ha^{-1}

F_2 60 kg ha^{-1}

F_3 80 kg ha^{-1}

F_4 100 kg ha^{-1}

F_5 120 kg ha^{-1}

F_6 140 kg ha^{-1}

F_7 160 kg ha^{-1}

3.5 Experiment No.4:

Qualitative and quantitative response of peas to judicious applications of irrigation with P and K.

This experiment was planned to assess interaction amongst promising levels of phosphorus, potash and irrigation which proved better during earlier experiments. Phosphorus and potash was applied along with constant dose N of @ 80 kg ha^{-1}. Phosphorus and potash was applied at the time of seed bed preparation whereas, half dose of nitrogen was applied at the time of seed bed preparation and remaining was applied when flowering started. Immediately, after sowing water was applied. Irrigation was applied according to the schedule of the crop. Crop was looked after properly.

3.5.1. Treatments

T_0 Irrigation up to seed filling (10 irrigations)

T_1 Irrigation up to seed filling (10 irrigations) + P120 kg ha^{-1}

T_2 Irrigation up to seed filling (10 irrigations) + K100 kg ha^{-1}

T_3 Irrigation up to seed filling (10 irrigations) + P120 kg ha^{-1}+ K100 kg ha^{-1}

3.6. Experiment No.5:-

Effects of different seed moisture contents at harvest on peas seed quality.

This experiment was conducted utilizing seeds from the best treatment of the 4^{th} experiment. Optimum seed moisture contents were determined at which the seed quality is considered better. Seeds were harvested at moisture contents varying from 15 to 45 %. There were seven treatments as under

3.6.1. Treatments

M_1 Seed harvested at 45 % (+ 0.5%) seed moisture contents

M_2 Seed harvested at 40 % (+ 0.5%) seed moisture contents

M_3 Seed harvested at 35 % (+ 0.5%) seed moisture contents

M_4 Seed harvested at 30 % (+ 0.5%) seed moisture contents

M_5 Seed harvested at 25% (+ 0.5%) seed moisture contents

M_6 Seed harvested at 20% (+ 0.5%) seed moisture contents

M_7 Seed harvested at 15% (+ 0.5%) seed moisture contents

3.6.2. Harvesting and post harvest drying

Pods were harvested by hand from each plot when their seeds achieved the desired seed moisture contents as per treatment. Sampling started when most of the pods were light green in colour. At this stage seed moisture contents were around 60%. Seed moisture contents were determined using the double drying method I.S.T.A. (1988). This practice was repeated daily. Pods colour gradually changed from light green to greenish yellow every day. When seed moisture contents were around 45% the color of pods was green-yellow. On the same day each plot was divided into 10 equal sections and from each section 10 plants were uprooted randomly. Then all similar pods by color were picketed from the plants and the seeds threshed out. Seed moisture contents were again determined to confirm that the desired seed moisture had been reached. Seeds were threshed-out from the pods carefully with hands, to avoid any mechanical injury. The seeds were dried at 30°C using a fan to blow air through them to obtain 12% moisture level. Then 1000 seed dry weight of each treatment and replicate was noted. Seeds of each replicate from each harvest were stored separately.

3.6.3. Parameters studied:

3.6.4. Seed fresh weight per plant (g)

Fresh seed weight of randomly selected plants was recorded after harvesting with the help of single pan digital balance.

3.6.5. Seed dry weight per plant (g)

Seeds were placed in oven at 65°C for 3 days until constant weight was achieved and their dry weight was recorded.

3.6.6. Seed moisture contents (%age)

The moisture contents of each sample were determined by using the air forced oven drying method (indirect distillation at 105°C) according to the method described in AACC (2000) Method No. 44- 15A. The moisture contents of the peas seeds were determined by weighting 10 g of sample into weighed moisture dish and drying at oven temperature of 105°C till the constant weight of dry material was obtained. The percentage difference in weight after drying was recorded as the moisture contents of the sample, expressed as a percentage of the original sample.

3.7. Experiment No.6:

Effects of packing material and storage conditions on peas seed quality

This experiment was designed to observe the effect of packing material and storage conditions on peas seed quality. After harvesting the seeds from each treatment were dried to achieve 12 % moisture level. Seeds were stored at room temperature (25-30°C) and in refrigerator at different temperatures (0°C, 5°C, and 15°C) whereas, humidity was kept constant at 50%. Seeds were kept for 6 months in storage under the said conditions and after storage different seed vigour and nutrient tests were performed.

3.7.1. Packing material used:

1. Gunny bags
2. Plastic bags
3. Paper bags

3.7.2. Treatments

T_1 Seeds stored at temperature 0°C (Control)

T_2 Seeds stored at temperature 5°C

T_3 Seeds stored at temperature 15°C

T_4 Seeds stored at room temperature (25-30°C)

3.7.3. Seed quality and vigour tests

The following seed quality and vigour tests were performed in all experiments.

3.7.4. Germination test:

For the germination test, 20 seeds from each treatment were taken and tested for germination in petri dishes on filter paper in the presence of adequate moisture and placed in an incubator at 20°C without light as no light is necessary for germination of peas seeds (I.S.T.A., 1966). The germinated seeds were counted daily for eight days and the final germination percentage was recorded. A seed was defined as germinated when the length of the radical visible outside the seed coat was 3-4 mm (Fernandez and Johnston, 1995).

3.7.5. Electrical conductivity test:

To determine electrical conductivity (Hampton *et al*. 1994) 50 seeds for each replicate were taken and weighed. The electrical conductivity meter used was, portable digital EC meter (Mi 170 Bench Meter, EC/ TDS/Nacl/Temperature). The electrical conductivity meter was calibrated against 0.01N KCI solution and 200 ml distilled water was placed in a conical flask of 250 ml. volume. The electrical conductivity of distilled water was noted and then seeds were soaked in it. The flasks were covered and placed in an incubator at a constant temperature of 20°C. After 24 hours the flasks were taken out and shaken gently. Then sufficient amount of the solution was taken from the flask and placed in a small rinsed beaker and the electrical conductivity was measured by the electrical conductivity meter. The value of electrical conductivity of the distilled water was subtracted from the electrical conductivity of the solution and then this was divided by the weight of 50 seeds of the respective replicate. Hence electrical conductivity value in µs/gm of seeds was obtained as a final observation (Perry, 1977).

3.7.6. Emergence test:

50 seeds of each treatment of all experiments were planted in pots filled with sand and were kept in field. Emergence counts were made daily up to two weeks time. After that harvesting was made for each replicate separately. Each seedling was removed by cutting them from surface level of the pots. Then emergence percentage was recorded.

3.7.7. Accelerated ageing test:

The accelerated ageing test is one of the most frequently used vigour test methods. The seeds of two cultivars (Meteor and Climax) of Peas were obtained in all treatments and tested. Their moisture was adjusted; by putting the seeds on a screen fixed 3 cm above water in a descicator at 20°C. After moisture adjustment seeds were stored hermetically at 3°C for 3 days to equilibrate the moisture among the seeds. The seeds moisture contents were again determined to confirm that the seeds had been adjusted to the required moisture level. The seeds were spread in a single layer on plastic trays and subjected to temperature of 45°C with a relative humidity of 90 % in incubator for 8 days. These aged seeds then were used for further studies like germination and vigour tests.

3.7. 8. Chemical composition of the plant parts (leaves, stems, pods and seeds)

Parts of the plant (leaves, stems, pods) and seeds were air dried, grinded and saved in small bottles for further analysis.

3.7.9. Determination of Nitrogen:

Total nitrogen was determined by Chapman and Parker method (1961). It involved the digestion of plant material with concentrated Sulfuric Acid and digestion mixture, $K_2SO_4.CuSO_4.FeSO_4$ in the ratio of 10:0.5:1.0. On cooling contents were then transferred to a 250 ml. volumetric flask and distilled water was added to make up the volume. Aliquot from prepared material was taken and distilled in micro-Kjeldahl apparatus using 40 percent Sodium Hydroxide, 4 percent Boric Acid and Methyl-red as an indicator. From the quantity of acid used in the titration percentage of element (N) was calculated by using the following formula:

$$\frac{A\text{-}B \times 100 \times 100 \times 0.0014}{\text{Volume of digested sample used}}$$

Where

A	=	Quantity of acid used
B	=	Blank reading
Constant	=	0.0014

Blank reading was taken for estimating the N percentage in the material used other than sample. The procedure of digestion, distillation and titration was the same for blank reading. 0.0014 is a constant, which is equal to grams of nitrogen present in 1 ml of N/10 H_2SO_4.

3.7.10. Extraction for phosphorus and potassium:

One gram oven dried leaf material was transferred to a 50 ml beaker and 20 ml of concentrated Nitric Acid was added to it. It was allowed to stand until the initial reaction subsides. It was covered with a watch glass and low heat was applied until the solid material disappeared, 10 ml of per Choleric Acid ($HOCl_2$) was added after cooling and again heated gently at first and then vigorously until a clear, colourless solution resulted. When the volume was reduced to 3 ml; cooled and transferred through filter paper to a 100 ml. volumetric flask and made upto the volume. This filtrate was stored in plastic tubes for further analysis to estimate phosphorus and potassium.

3.7.11. Phosphorus estimation:

Phosphorus was determined according to the method described by Chapman and Parker (1961). Colour was developed by adding 5 ml each of sulphuric acid and water (1:6), ammonium molybdate 5 percent and Ammonium vanadate 0.25 percent. The standard curve was obtained by using potassium dihydrogen Phosphate instead of samples. Then the samples were fed in spectrophotometer at a wave length of 420 nm and transmittance was noted which was compared with that of standard curve to find out the quantity of the elements in ppm which was then converted into percentage by using the following formula:

$$\frac{\text{ppm on graph x dilution x 100}}{10^6}$$

3.7.12. Potassium estimation:

Potassium was also determined according to the method described by the Chapman and Parker (1961). Potassium concentration was determined by the flame photometer, taking 5 ml of wet digested material. Standard curve was prepared by using potassium chloride and quantity of the element was found in ppm by comparing the emission of flame photometer with that of the standard curve which was then converted to percentage by using following formula:

$$\frac{\text{ppm x dilution x 100}}{10^6}$$

3.7.13. Estimation of protein:

Protein was determined by Chapman and Parker method (1961). One gram of dried sample was digested in Kjeldahl flask with 5 g of catalyst mixture containing K_2SO_4, $CuSO_4$ and $FeSO_4$ (90: 10: 1) and 30 ml of concentrated H_2SO_4. The contents of the flask were heated till a clear solution was obtained. After cooling, the contents of the flask were diluted up to 250 ml in a volumetric flask by adding distilled water. 10 ml of diluted solution was mixed with 10 ml of 40 percent sodium hydroxide solution and the mixture was distilled by using steam in micro Kjeldahl distillation apparatus. The ammonia so produced was collected in 10 ml of two percent Boric Acid solution having two drops of Methyl red as indicator. The distillate was titrated against 0.1 N sulphuric acid to determine the volume of NH_3 (ammonia) evolved. The total protein percentage was calculated by the following formula:

$$\text{Protein (\%)} = \frac{X \times A \times V \times N}{D \times S} \times 100$$

Where,

X = Volume of NH_3

A = NH_3 to N_2 conversion factor (0.0014)

V = Volume of digested sample (250 ml)

N = N_2 to protein factor (6.25)

D = Volume of diluted solution distilled (10 ml)

S = Weight of sample (1g)

3.7.14. Estimation of Ash

Ash contents were determined by following method given in AACC (2000). Sample was taken in crucible and weighted. Placed the crucible on heat at 100°C until water was expelled from the sample and then crucible kept in muffle furnace at 525°C until white ash was obtained.

$$\text{Ash} = \frac{\text{Weight of sample after ashing}}{\text{Weight of sample}} \times 100$$

3.7.15. Statistical Analysis

Data collected on different crop parameters like growth, yield and seed quality were computed by using STATISTICA computer program. The least significant difference at 5% level of probability was used to test the differences among mean values (Steel *et al.*, 1997).

CHAPTER IV

RESULTS AND DISCUSSION

The field experiment was conducted in the Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during year 2004-09. Field experiments were laid out according to RCBD. There were six trials for two promising cultivars of peas i.e. Meteor and Climax were selected and used for these trials. Moreover, physico-chemical analysis for the assessment of fertility status of the soil of experimental site was also done. Data relating to various qualitative and quantitative characters were collected, analyzed through statistical technique and their significance was compared by using Duncan's New Multiple Range Test at 0.05% probability level. The results obtained are presented and discussed as under:

4.1. EXPERIMENT # 1:-

EFFECT OF VARYING IRRIGATION FREQUENCIES ON GROWTH SEED YIELD, VIGOUR AND QUALITY OF PEAS CROP:

This experiment was designed to observe the effect of various frequencies of irrigation on growth, seed yield, vigour and quality of the peas crop. Four irrigation frequencies were applied as per prescribed set of combinations of treatments. Fertilizer, Urea, SSP (Single Super Phosphate) and MOP (Murate of Potash) were used. Total dose of phosphorus and potash were applied at the time of seed bed preparation while half of the urea dose was supplemented at the time of sowing and remaining half after 30 days of sowing.

4.1.1. Main stem length (cm)

Data for the aspect of main stem length was collected and subjected for the analysis through statistical variance which indicated significant results for cultivars and treatments while their interactions were found to be non-significant. Climax was found superior with 57.68 cm main stem length as compared to Meteor with 46 cm. On the other hand, I_3 (Irrigation upto seed filling) was found to be the best with 56.50 cm stem length, followed by I_0 (Irrigation as needed by crop: control) with 54.75 cm and I_2 (Irrigation upto pod filling) with 49.75 cm were observed 2nd and 3rd in descending order while I_1 (Irrigation upto flowering) was found at the bottom with

46.37 cm of stem length. Climax, in particular, benefited from irrigation during the vegetative stage. Meteor appeared relatively insensitive to the timing of a single application. Both years significant results were found but 2006-2007 showed comparatively better because rainfall was also more during that year.

The above scenario clearly indicated the supremacy of Climax over Meteor cultivar of peas under the set of combinations of treatments by giving better stem length whereas, the applications of water till seed filling stage gave maximum main stem length while irrigation applied upto flowering affected significantly by minimizing the stem length. Availability of moisture in plant might be helpful in enhancing the plant growth and development. Resultantly more stem length was achieved. Similar findings have been reported by a number of researchers. Fougereux *et al.*, (1997) reported that physiological quality of peas seed is dependent of various factors including timely supply of water. Hsio *et al.*, (1985) found water stress a limiting factor for reduction in growth. These results partially contradictory with the findings of Salter (1962) who observed positive response of irrigation till flowering.

4.1.2. Number of leaves per plant

Information regarding number of leaves per plant was collected and subjected to statistical analysis of variance. The results obtained are presented in figure 4.1 (b). Which indicated significant results for the two years, cultivars, treatments and interaction of Y x V, V x I, Y x I and Y x V x I. A glance of above depicted result reflected that maximum numbers of leaves per plant 64.00 were counted from Meteor whereas, Climax gave 58.59 number of leaves per plant. Same trend was observed when studied the interaction of year x varieties. As far as the results for the treatments are concerned, I_3 (irrigation upto seed filling) occupied the first position with 64.31 been per plant whereas, I_0 (Irrigation as needed by crop: control) and I_2 (Irrigation upto pod filling) performed with 63.18 and 59.50 leaves per plant respectively in descending order while I_1 (Irrigation upto flowering) was found at the bottom with minimum number of leaves per plant 58.18 as a comparison of V x I interaction V_1I_3 ranked first with mean values of 66.50 number of leaves per plant whereas V_1I_1 also performed well as it produced 65.50 number of leaves which were statistically at par with V_1I_3 while V_2I_2 gave the lowest performance by giving 57.50 number of leaves per plant, on the other hand the interaction of Y x V x I, the combination $Y_2V_1I_3$ was the best with 68.00 number of leaves while $Y_1V_1I_0$ and $Y_2V_2I_0$ stood second with 66.00 number of leaves per plant whereas $Y_1V_2I_1$ secured the last position with 47.75

number of leaves per plant. If we compare above narrated picture of interaction, it would be quite evident that Meteor cultivar gave marvelous performance when it was irrigated upto the seed filling. Climax cultivar did not keep its momentum if irrigating upto pod filling. Likewise during 2006-2007 Meteor performed well when irrigated till seed filling while during both the years of study, both the cultivars performed comparatively well when irrigated as needed by the crop. It was also evident from the above scenario that irrigation upto flowering did not prove its worth for the aspect of study. Vegetative growth was more sensitive to water stress than reproductive growth in peas. Salter (1963) and Maurer *et al*. (1968) found excessive vegetative growth where water stress was avoided. Peas is an indeterminate plant and flowering, pod filling and vegetative growth can occur simultaneously. There is competition for assimilate between these processes and the response of yield components will vary according to the relative strengths of the sources and sinks for assimilates. These results are in line with the findings of Hsio *et al*., (1985) who reported that water stress during growing stage reduced the growth of peas plants.

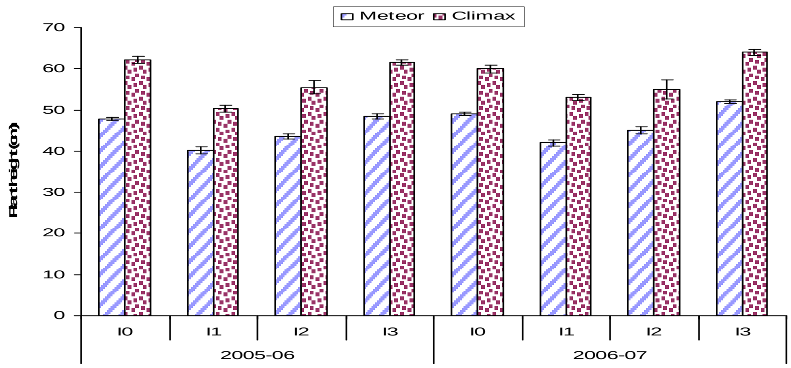
In experiments with two combining peas cultivars, Salter (1962, 1963a) showed that there was a response to irrigation at flowering but not to applications of water in dry conditions during the vegetative growth stage.

4.1.3. Leaf area (cm^2)

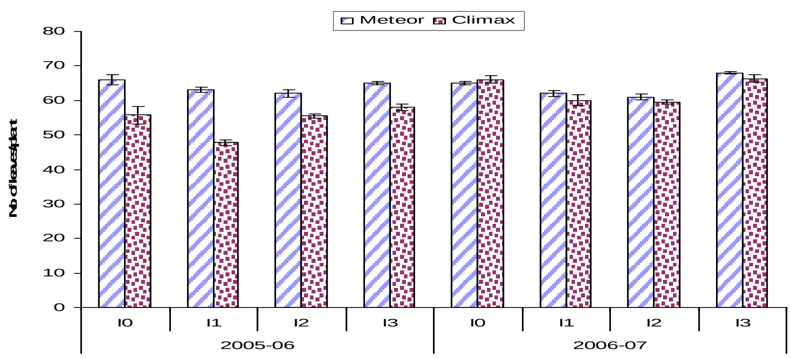
Observations regarding leaf area were subjected to analysis through variance which is presented in figure 4.1 (c). The ANOVA depicted statistically significant results for the two years, cultivars, their interaction, treatments, interactions of treatments with years and cultivars.

Mean leaf area from year 2005-2006 produced 213.46 cm^2 leaf areas as compared to 206-2007 with 215.93 cm^2. Meteor gave comparatively better leaf area with 215.18 cm^2 as compared to Climax which gave mean leaf area of 214.21 cm^2. The interaction of cultivars with years indicated that during the year I, Meteor gave better leaf area of 214.18 cm^2 as compared to Climax with 212.75 cm^2 of leaf area while during years 2006-2007 same trend was observed. The treatment mean comparison reflected upon that I_3 (irrigation upto seed filling) produced 243.00 cm^2 leaf area followed by I_1 and I_3 while I_1 (irrigation upto flowering) gave poor performance with 187.93 cm^2. As far as interaction of Y x I concerned, Y_2I_3 superseded other combinations with 246.00 cm^2 leaf areas, followed by Y_1I_3 with 241.00 cm^2 and Y_1I_1 while Y_2I_1 performed poorly with 186.12 and 189.75 cm^2 leaf area, respectively. The interactions of Y x V x I clearly depicted that $Y_1V_1I_3$ was formed the best combination with 255.50 cm^2 and $Y_1V_1I_1$ gave poor performance with 170.00 cm^2 leaf area. In these treatments, plants were not stressed during peas growth, so could compensate more for reduced pod numbers. In this experiment, water stress may have stronger effect on reducing the number of pods/unit area than on leaf area development. The resulting source-sink relationships during the filling phase would then have been quite different for early and late drought plots experienced. Consequently, there might have been a surplus of photosynthates to fill the peas in treatments with low peas numbers/unit area despite less favorable conditions for growth. Above picture indicated that Meteor cultivar was found superior and the irrigation provided upto the seed filling stage gave best performance. These results were supported by findings of the following scientists. Hsio *et al*, (1985) reported that water stress reduces growth via an effect on cell expansion. In experiments with two combining peas cultivars, Salter (1962, 1963a) showed that there was a response to irrigation at flowering but not to applications of water in dry conditions during the vegetative growth stage.

(a)



(b)



(c)

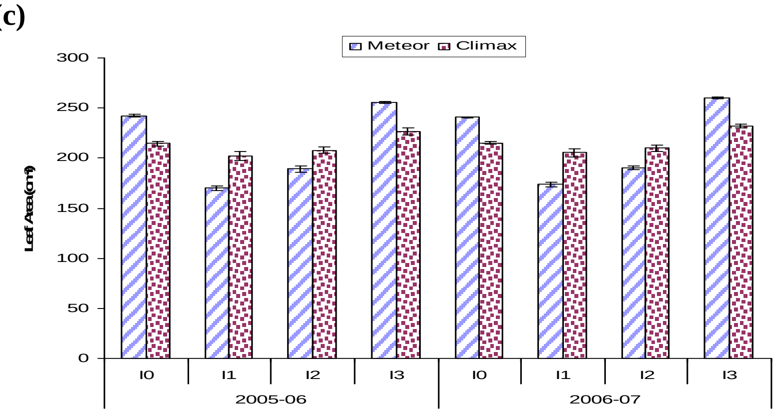


Fig. 4.1:- **Effect of varying irrigation frequencies on (a) Main stem length (cm) (b) Number of leaves per plant and (c) Leaf Area (cm^2)**

4.1.4. Number of pods per plant

Data of this aspect of study were procured and subjected to analysis of variance which is presented in figure 4.2 (a). The ANOVA depicted that the results were statistically significant for years, cultivars, interaction of year x cultivars and treatments but interaction of V x I and Y x V x I were found to be non-significant.

Mean values for the year gave 22.75 numbers of pods per plant during 2006-2007 while during 2005-2006 produced 20.97 pods per plant. Data for cultivars revealed that Meteor gave 22.84 number of pods per plant as compared to Climax with 21.28 number of pods per plant. As far as the mean values for treatments combination are concerned I_3 (irrigation upto seed filling) gave superior results with 23.69 number of pods per plant, followed by I_0 (irrigation as needed by crop) and I_2 (irrigation upto pod filling) gave 22.44 and 21.75 number of pods per plant, respectively in descending order while I_1 (irrigation upto flowering) produced lowest number with 19.56 pods per plant. Irrigation at any growth stage increased the yield of Climax. The highest yields for this cultivar were achieved where irrigation was applied throughout the season (treatment 3) but these did not different significantly from other irrigation treatments where less water was applied. There was also a large response from irrigating Meteor throughout other individual applications produced widely differing response. As in the previous year, Climax was more responsive to irrigation at the vegetative stage than Meteor and overall. In these treatments, plants were not stressed during peas growth, so could compensate more for reduced pod numbers. In this experiment, water stress might have a stronger effect on reducing the number of pods/unit area than on leaf area development. The low yields were associated with low number of pods, nodes/stem and pods/node and a slower increase in pod weight (Milbourn & Hardwick 1968). Whether these changes would affect the balance between sources and sinks is uncertain. The resulting source-sink relationships during the filling phase would then have been quite different for early and late drought plots experienced. Consequently, there may have surplus photosynthates to fill the peas in treatments with low peas numbers/unit area despite less favorable conditions for growth. Moisture stress during seed development can substantially decrease the amount of viable peas seed production (Raymond and Jeffrey, 1987).

Martin and Jamieson (1996) reported that water stress during the last half of the growing season (pollination, pod and seed formation periods) was a major factor in reducing seed yield in temperate dry areas. Water stress during seed filling decreased seed yield and seed quality.

While, stress during seed filling reduced seed size (De Souza *et al*., 1997) seed per unit area and yield can be reduced by short periods of stress during flowering and pod set (Vieira *et al*., 1992).

The sensitivity of peas to drought stress during flowering (GS 203) and pod filling stage (GS 206) (Knott 1987) and the effect of irrigation have been reported by Salter (1962, 1963a, b) at Wellesbourne, Warwickshire and in the USA by Pumphrey & Schwanke (1974). The interaction with plant density was also studied by Anderson & White (1974) and Salter & Williams (1967).

4.1.5. Number of seeds per pod

Data for number of seeds per pod were collected and subsequently subjected to the analysis of variance. The results obtained are presented in figure 4.2 (b). The results revealed statistically significant differences between years, cultivars and treatments. The interactions of years x hectares and varieties x treatment were also found significant while interactions of Y x V x I was found to be non-significant.

The mean values for the years depicted the superiority of 2006-2007 with 5.63 number of seeds per pod while in year 2005-2006 produced 5.23 seeds pod^{-1}. Whereas, Climax cultivar gave maximum number of seed per pod with 6.31 while Meteor produced 4.54 seeds pod^{-1}. A glance of interaction for year x cultivar indicated about the best combination Y_2V_2, with mean value of 6.54 number of seeds per pod followed by Y_1V_2 with 6.09 while Y_1V_1 gave minimum number of seed per pod with 4.36. As far as the mean value for the treatments are concerned, I_3 (irrigation upto seed filling) was found the best with 5.67 number of seeds pod^{-1}, followed by I_0 (irrigation as needed by crop) with 5.63 seed per pod and I_2 (irrigation upto pod filling) gave 5.55 number of seeds per pod while I_1 (irrigation upto flowering) produced lowest number of seed per pod with 4.87. Regarding the interaction between year and treatments it was observed that Y_2I_3 combination ousted all other combinations with 6.17 number of seeds per pod while Y_1I_2 performed poorly with 4.81 number of seeds pod^{-1}. On the other hand the interaction of V x I gave maximum number of seeds per pod in combination of V_2I_2 with 6.54 followed by 6.481 in V_2I_2, 6.19 in V_2I_0 and 6.05 in V_2I_1, respectively in descending order while the combination of Y_1I_2 gave the minimum number of seeds per pod 3.69.

Water stress during the flowering period did not reduce seed quality but reduce seed yield only. Peas seed yield was closely related to pod number per unit area, which was also related to water stress. The number of peas pods^{-1} were unaffected by water stress (Martin and Jamieson 1996).

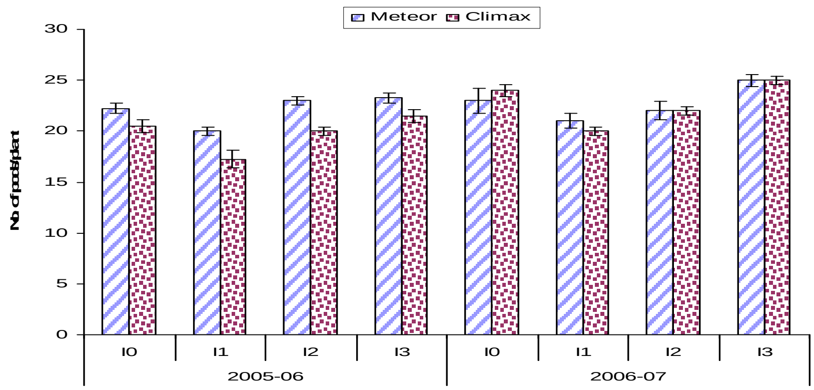
Water stress initiated during vegetative or early reproductive growth of soybean usually reduced yield by reducing number of seeds per unit area (Brevedan and Egli, 2003). While stress during seed filling reduced seed size (De Souza *et al*., 1997) seeds per unit area and yield can be reduced by short periods of stress during flowering and pod set (Vieira *et al*., 1992). The major portion of this yield reduction was related to fewer seeds being produced (Dornbos *et al*., 1989 and Heatherly, 1993.

4.1.6. 1000-seed weight (g)

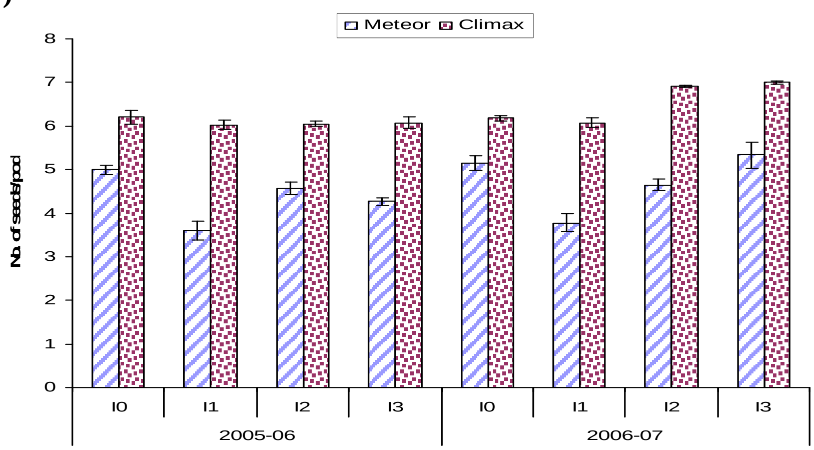
Information for this aspect of study was noted and subjected to analysis of variance technique and presented in figure 4.2 (c) which depicted significant differences among cultivars and treatments while their interaction was found to be non-significant. A perusal of mean values regarding this aspect of study for cultivars, showed supremacy of Climax with 241.44 g 1000 seed weight while Meteor gave 235.34 g of 1000-seed weight. The average values of treatments, reflected upon that I_0 (irrigation as needed by crop) gave maximum fresh weight of 250.87 g followed by I_3 (irrigation upto seed filling) with 242.25 g and I_2 (irrigation upto pod filling) produced 234.00 g respectively in descending order while I_1 (irrigation upto flowering) gave minimum 226.43 g 1000-seed weight. Peas seed weight increased with increasing drought stress, the increase being greater in early drought treatments. Water use efficiency by the whole crop was increased by the severity of water stress but not by its timing. Increased water use efficiency with increasing water stress has also been reported for lentils (McKenzie & Hill 1990) and reflects the lower soil evaporation component of water use without irrigation. Water use efficiencies in this trial are similar to those reported for peas by Zain *et al*. (1983).

Vieira *et al*., (1991) reported yield of 35-41 % when drought stress was imposed during seed filling in green house experiment but found no effect on germination. Drought stress resulted in significantly inferior quality seeds as compared to well watered control plants. Irrigation during the full reproductive period was required to both maximum seed yield and maximum germination of harvested seed (Heatherly, 1993).

(a)



(b)



(c)

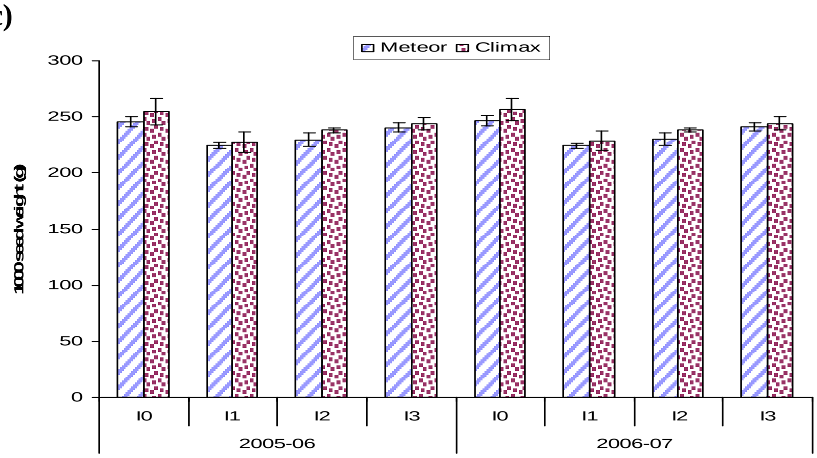


Fig. 4.2:- **Effect of varying irrigation frequencies on (a) Number of pods per plant(b) Number of seeds per pod and (c) 1000 seed weight (g)**

4.1.7. Seed fresh weight per plant (g)

Data regarding seed fresh weight per plant were collected and subjected to analysis of variance [figure 4.3 (a)] which revealed significant results for cultivars, treatments and their interactions.

It is evident from the figure that Climax cultivar produced the best results for this aspect of study with 87.65 g while Meteor gave 75.36 g fresh weight per plant. A perusal of mean values for treatments, it was observed that I_0 (irrigation as need by crop) produced 88.69 g fresh weight per plant, followed by I_1 (irrigation upto flowering) with 82.86 g and I_3 (irrigation upto seed filling), 80.48 g while I_2 (irrigation upto pod filling) gave the lowest weight of 74.01 g per plant. As the interaction of V x I concerned, the combination V_2I_0 gave maximum fresh weight of 96.36 g followed by V_2I_1 (87.18 g), V_2I_3 85.12 g and V_2I_2 with 81.94 g in descending order as per their performance while V_1I_2 produced the lowest fresh weight per plant with 66.07g.

Vieira *et al*., (1991) reported yield of 35-41% when drought stress was imposed during seed filling in green house experiment but found no effect on germination. Drought stress resulted in significantly inferior quality seeds as compared to well watered control plants. Irrigation during the full reproductive period was required to observe both maximum seed yield and maximum germination of harvested seed (Heatherly, 1993).

4.1.8. Seed dry weight per plant (g)

Data on seed dry weight per plant were subjected to statistical analysis and the results obtained are presented in figure 4.3 (b) as the analysis of variance which reflected upon significant results for years, cultivars and treatments yet their interaction were found to be non-significant.

A thorough examination of the mean values for years of study indicated significant superiority for 2006-2007 with 64.00 g while 2005-2006 gave 62.97 g seed dry weight per plant. Whereas, in case of cultivars it was viewed that Climax cultivar produced 64.77 g seed dry weight per plant while Meteor gave 62.02 g seed dry weight per plant. As far as the mean values for treatments are concerned, I_0 (irrigation as needed by crop) gave maximum weight of 65.65 g followed by I_3 (irrigation upto seed filling) with 64.03 g and I_1 (irrigation upto flowering) with 62.25 g of seed dry weight in descending order as per their performance while I_2 (irrigation upto pod filling) produced the lowest dry seed weight 62.00 g. These results are in line with

Vieira *et al*., (1991) who reported that yield of 35-41% decreased when drought stress was imposed during seed filling. When drought stress was imposed significantly inferior quality seeds were produced as compared to well watered control plants. Irrigation during the full reproductive period was required to observe for both maximum seed yield and maximum germination of harvested seed (Heatherly, 1993).

4.1.9. Seed yield per hac (tons)

Data for this parameter were collected and subjected to analysis of variance [figure 4.3 (c)] which showed significant differences among years, cultivars and treatments while their interaction were found to be non-significant.

A perusal of mean values for years, it was observed that 2006-2007 produced maximum yield of 2.21 tons while 2005-2006 was runner up with 2.03 tons of seed yield. The comparison of varieties mean showed that Climax gave better yield with 2.27 tons while Meteor produced 1.97 tons of yield ha^{-1}. A glance of the mean value for treatments, Data showed the supremacy of I_3 (irrigation upto seed filling) with 2.41 tons of yield ha^{-1}, followed by I_0 (irrigation as needed by crop) with 2.34tons and I_2 (irrigation upto pod filling) with 2.08 tons of seed yield in descending order, while I_1 (irrigation upto flowering) produced the lowest yield of 1.65 tons ha^{-1}.

The response to irrigation can be expressed as irrigation efficiency. Yield increase compared with unirrigated peas as seed yield ha^{-1} per irrigation and figure showed the higher efficiency of early applications to Climax compared with Meteor in both the year. Irrigation at flowering and again at pod filling represented the traditional irrigation recommendation for dry peas grown on heavier soils (Stoker 1979). This treatment was very similar to early drought treatments in terms of irrigation timing and amount. In most seasons, spring sown crops would not experience an early drought, but when one occurs, using such an irrigation regime would reduce yields. In practice, irrigation scheduling must take account of both rainfall and crop water use throughout the growth of the crop.

This trial was sown relatively late and yields were lower than the crop sown at normal time in early spring (Martin & Tabley 1981). The low yields were associated with low number of pods, nodes/stem and pods/node and a slower increase in pod weight. Whether these changes would affect the balance between sources and sinks is uncertain (Milbourn & Hardwick 1968).

In this experiment, irrigation at any growth stage increased yield but the highest yield for both cultivars were achieved where water stress was completely eliminated by irrigating throughout the season. The yield was significantly higher than those achieved by other irrigation treatments.

Raymond *et al***.,** (1988) found reduced peas seed quality when water was with held during seed filling. They concluded that applying the final irrigation at 500 degree days after blooming (after 2 weeks) was necessary to produce viable seed yields similar to those obtained with continuous irrigation through early senescence. Water stress resulted in significantly inferior quality seeds as compared to well watered control plants. Irrigation during the full reproductive period was required for both maximum seed yield and maximum germination of harvested seed (Heatherley, 1993).

Moisture stress during seed development can substantially decrease the amount of viable peas seed production (Raymond and Jeffrey, 1987). Baigorri *et al.* (1999) stated that peas seed yield was strongly dependent on water availability, especially at flowering and pod filling. Irrigation usually required producing profitable yield of high quality peas seed (Raymond and Jeffrey, 1987).

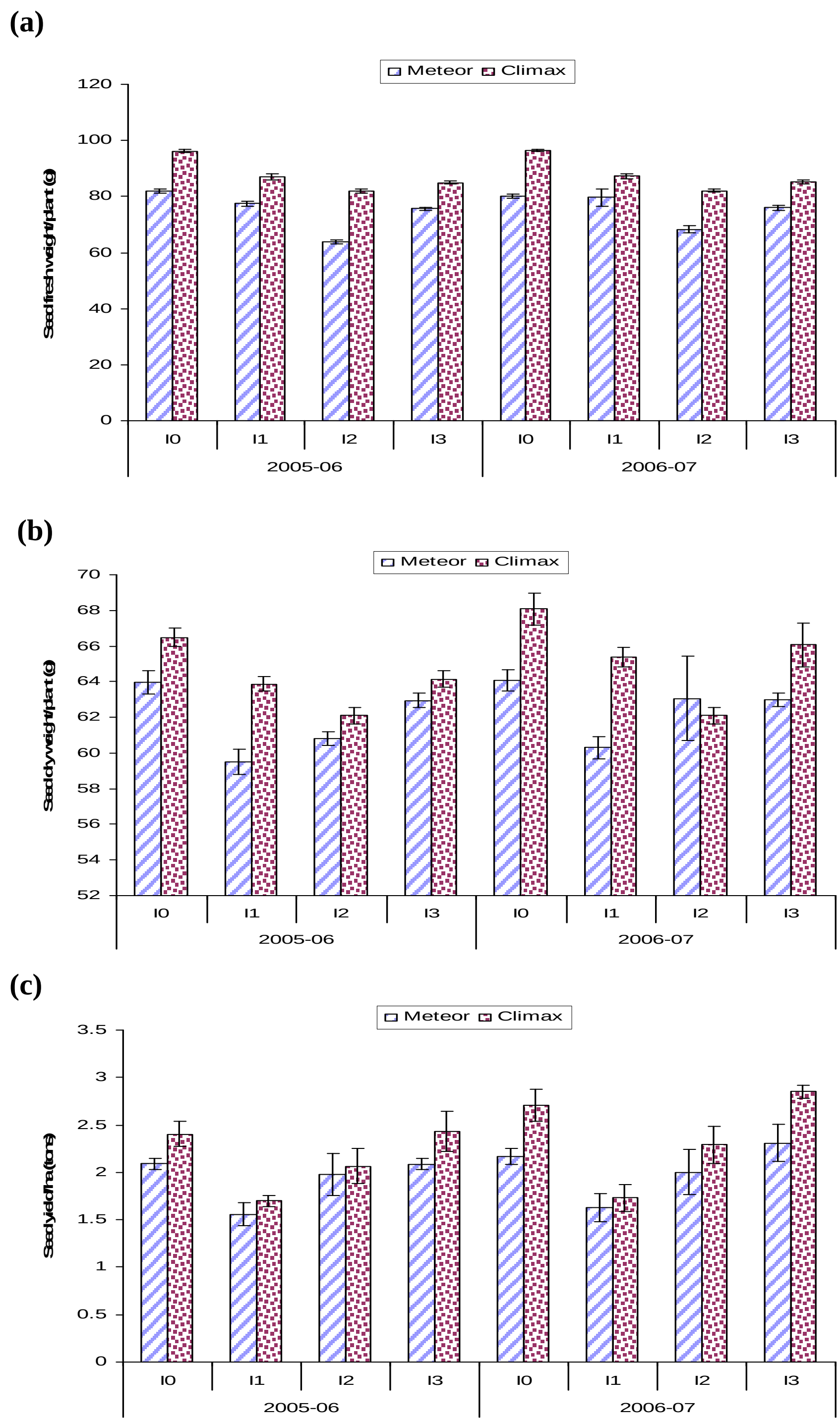


Fig 4.3:- Effect of varying irrigation frequencies on (a) seed fresh weight per plant (g) (b) seed dry weight per plant (g) and (c) seed yield per hac (Tons)

4.1.10. SEED QUALITY PARAMETERS:

4.1.10.1. Electrical Conductivity:

Data for seed quality parameter like electrical conductivity were gathered through prescribed technique and subjected to analysis of variance method to identify significance differences among treatments which is presented in figure 4.4 (a). A perusal of the results indicated significant results for years, cultivars and treatments while except of VXI all interactions were found to be non-significant.

The mean values for the year indicated that 2006-2007 with 22.12 electrical conductivity was found superior while the data of 2005-2006 gave 21.76 electrical conductivity. The mean value for the cultivars, it was observed that Climax was better as compared to Meteor with electrical conductivity 24.09 and 19.79, respectively. Amongst treatment mean, I_3 (irrigation upto seed filling) with 23.25 ousted all other combinations of treatment, followed by I_2 (irrigation upto pod filling) and I_1 (irrigation upto flowering) with 22.46 and 21.62, respectively in descending order while I_0 (irrigation as needed by crop) with EC 20.43 was found at the bottom.

Nichols *et al*, (1978) working with potted peas plants observed no effect of drought stress on seed conductivity or germination. This test was first introduced by Fic and Hibbard in 1925 (Copeland and McDonald, 1995) and adopted for testing of cotton seed viability. The test measures the cell membrane integrity and was based on the premise that low vigour (deteriorated) seeds have poor membrane integrity. During soaking the seeds in water and the imbibitions process seeds having poor cell membrane structure leach (cytoplasmic solutes proteins, sugars, amino acids and other electrolytes) into the soaking water. The solutes with electrolytic properties contain electrical charge that can be measured by an electrical conductivity matter. If seed has low vigour the amount of electrolytes will be more and consequently the electrical conductivity of the soaking media will be higher. On the other hand high vigour seed releases less solutes and show low conductivity.

Matthews and Bradnock (1968) proposed the use of this test for peas seed and the procedure has been standardized by the Processors and Growers Research Organization (P.G.R.O., 1981). This test is also accepted in the UK as an officially recognized test for commercial vining peas seed in addition to the germination test (Hadavizadeh and George, 1988; Parera *et al*., 1995). Bedford (1974) found the relationship between electrical conductivity values and vigour in relation to the field emergence potential of vining peas.

4.1.10.2. Germination %

Data for seed quality parameter of Germination were gathered through the prescribed techniques and were subjected to analysis of variance method to identify significant differences among the variable studied which has been presented in figure 4.4 (b). A perusal of the table indicated significant results for years, cultivars and treatments, while all other interactions except VXI were found to be non-significant.

The mean values for the year2005-2006 indicated that 93.68 Germination was found to be superior, while 2006-2007 gave 91.40 Germination. The mean values for the cultivars, it was observed that Meteor cultivar was better as compared to Climax with 93.31 and 91.78 Germination, respectively. Amongst treatment means, I_0 (Irrigation as needed by crop: control) with 95.31% ousted all other combinations followed by I_2 (irrigation upto seed filling) and I_3 (Irrigation upto seed filling) with 92.25% and 91.56% respectively in descending order while I_1 (Irrigation upto flowering) with 91.06% germination was found at the bottom. Soybean seeds that experienced hot, dry weather during maturation exhibited reduced laboratory germination and field emergence. Severe drought that occurred throughout seed filling reduced yield and seed number at a faster rate than seed mass, germination or vigour and maintained the development of at least some viable and vigorous seed.

Smiciklas *et al*., (1989) mentioned that drought stress can lower seed quality and germination of seeds of soybean if applied during various stages of flowering and seed development. Environmental stress during seed production can affect subsequently seed quality. Stress occurring after physiological maturity, but before harvest can cause reduction in soybean seed germination and vigour (Tekrony *et al*., 1980; Vieira *et al*., 1991 & 1992; Dornbos *et al*., 1989).

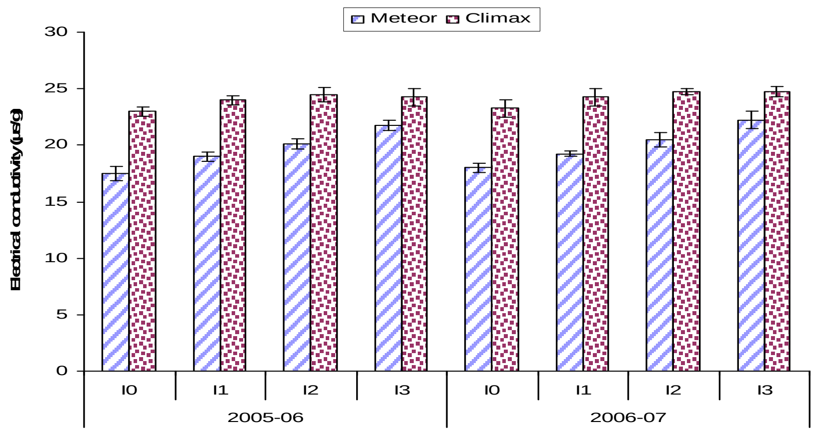
Data suggested that drought stress have no effect on seed germination or vigour, unless the stress was sever enough to produce shriveled, flat, undeveloped seeds (Vieira *et al*., 1992). Environmental stress such as drought during plant growth development can affect subsequently seed quality. Water limitation has shown reduced maize and sorghum yield but it had no effect on seed germination or vigour seeds, accelerated ageing, and conductivity tests (Golezani *et al*, 1997). Nichols *et al*, (1978) working with potted peas plants observed no effect of drought stress on seed conductivity or germination. Heatherly, (1993) observed that drought stress resulted in reduced germination of harvested soybean. The results of germination were seedlings which may be normal or abnormal.

4.1.10.3. Emergence %

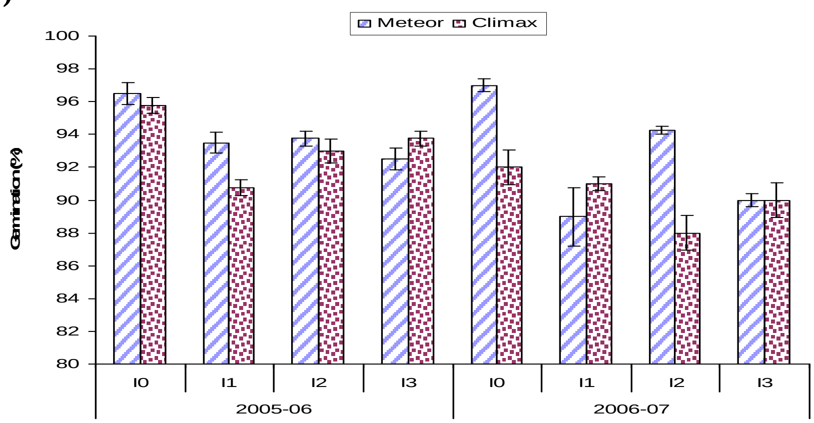
Data for emergence were gathered through prescribed technique and subjected to the analysis of variance method presented in figure 4.4 (c). A perusal of the above figure indicated significant results for years, cultivars, treatments and all interactions. The mean values for the years indicated that year 2006-2007 with 86.87% emergence was found superior while Year 2005-2006 gave 86.84% emergence. The mean value for the varieties revealed that Climax cultivar was better as compared to Meteor with 88.96% and 84.75% emergence, respectively. Amongst treatment mean, I_3 (irrigation upto seed filling) with 95.25% ousted all other combinations followed by I_3 (irrigation upto seed filling) and I_1 (irrigation upto flowering) with 83.62 and 82.12% respectively in descending order while T_0 (irrigation as needed by crop) with 86.43 emergence was found at the bottom.

A field emergence percentage test gives information about seed vigour and gives more accurate data to predict the storability of the seed lot tested. If the field conditions are optimal, the results of emergence test usually correlate well with field emergence (Abdella and Roberts, 1969; Perry, 1977; Egli and Tekrony, 1979), but under suboptimal field conditions, the laboratory germination results often overestimate the actual field emergence of seed lots (Tekrony and Egli, 1977; Johnson and Wax, 1978; Yaklich and Kulik, 1979; Naylor, 1981). There can be considerable differences between the laboratory germination of a seed lot and its emergence in the field. Matthews (1977) found that soil infection, seed born diseases, soil conditions such as low temperatures and both high and low soil moisture adversely affected seed emergence.

(a)



(b)



(c)

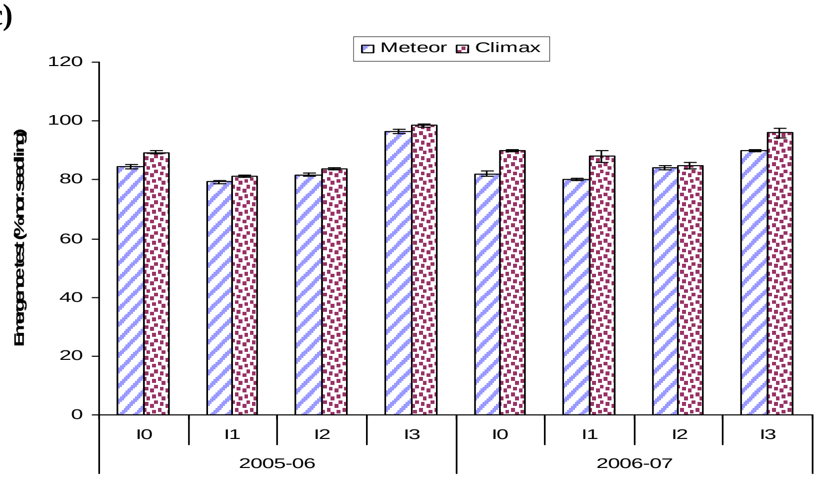


Fig. 4.4:- **Effect of varying irrigation frequencies on (a) Electrical Conductivity (µs / g) (b) Germination % and (c) Emergence %**

Conclusion:

Different irrigation frequencies were studied in two peas cultivars, Climax and Meteor during 2005-06 and 2006-07. The best results were obtained from I_3 (irrigation upto seed filling: 12 irrigation applied) followed by control I_0 (Irrigation as needed by crop). It is concluded that Climax with I_3 (Irrigation upto seed filling) performed remarkably well as compared to other irrigation frequencies in both years but comparatively performance was better in 2006-2007 due to more rainfall. The other treatments followed a sequence of, control (Irrigation as needed by crop), I_2 (Irrigation upto pod filling), I_1 (Irrigation upto flowering), whereas, some of the qualitative tests of seeds showed best results for I_3 (Irrigation upto seed filling).

4.2. EXPERIMENT NO.2:-

INFLUENCE OF DIFFERENT PHOSPHORUS LEVELS ON PEAS SEED YIELD AND QUALITY OF PEAS CROP.

This experiment was performed to assess the performance of different levels of phosphorus which were applied along with constant doses of N (80 Kg ha^{-1}) and K (100 Kg ha^{-1}). Results regarding various parameters are being presented and discussed below.

4.2.1. Main stem length (cm)

Data regarding main stem length was collected, organized, subjected to analysis of variance and results are presented in figure 4.5 (a) which indicated significant results for cultivars, phosphorus levels and their interactions.

In case of cultivars, Climax ousted Meteor showing 57.11 cm long stem compared with 46.14 cm long main stem. As far as treatments are concerned T_5 (P 120Kg ha^{-1}) remained at the top with 58.88 cm stem length, followed by T_6 (54.88 cm) while T_1 (control) remained at the bottom with 45.5 cm stem length. Treatment means followed a sequence of T_5, T_6, T_7, T_4, T_3, T_2 and T_1. The efficiency of inoculation for better results is influenced by the proper availability of phosphorus and potassium. As these elements are directly involved in nutrition of legumes and help to improve the root as well as shoot growth of the crop.

In case of interaction of cultivars and treatments, Climax with treatment T_5 (P120 Kg ha^{-1}) remained at the top, followed by Meteor in T_7 (P160 Kg ha^{-1}), Whereas Meteor in T_1, and T_2 seemed lost two positions. It was concluded that T_5 (P120Kg ha^{-1}) remained better for both cultivars. Similar results have been mentioned by the Tripathi *et al.*, (1991) Vimala and Natarajan (1999), who reported that plant height increased with increasing rates of nitrogen and phosphorus. In any case, Climax behaved comparatively better than Meteor. All other combinations remained in between and showed overlapping results. These results revealed that 120 Kg P ha^{-1} remained better for both cultivars as compared to other levels of P. Although vegetative growth requires N but for legumes comparatively more P is needed for growth and N fixation which might had contributed in this regard to get more stem length. Excessive dose of P (140, 160 Kg ha^{-1}) did not increase stem length. These results are supported by Berg and Lynd, 1985, Pacovskoi *et al.*, 1986, Kasturikrishna and Ahlawat, 1999) who reported that, Phosphorus is needed in relatively large amounts by legumes for growth and nitrogen fixation. Patel *et al.*, (1998) stated that peas cv. Arbel showed significantly increased plant height, when applied 20 Kg N/ha +80 Kg P_2O_5/ ha + 40 Kg K_2O/ha. Parsad *et al.*, (1989) conducted an experiment during rabi season to study the effect of application of P_2O_5. They studied P_2O_5 @ 0, 40, 80 and 120 Kg $ha^{-1}$with and without rhizobium inoculation of seeds. P_2O_5 resulted in significant increase in growth compared with control. The highest green pod yield was obtained with combination of 120 kg P_2O_5 $ha^{-1}$and rhizobium inoculation. Shukla *et al.*, (1993) presented a table of correlation coefficient for 5 garden peas cultivars, grown in 2 climates, in Himachal Pradesh in response to 3 rates of P application (45, 60 and 75 kg P_2O_5 ha^{-1}). The results showed that plant height was greater with 75 kg $P_2O_5ha^{-1}$ compared with control and other doses of P_2O_5.

4.2.2. Number of leaves per plant

Data related to number of leaves was collected, organized, subjected to analysis of variance and results are presented in figure 4.5 (b). It showed significant results for cultivars, phosphorus levels and their interactions.

In case of cultivars, Climax ousted Meteor cultivar producing 72.29 number of leaves compared with 64.35 whereas in case of P levels T_5 (P 120Kg ha^{-1}) remained at the top with 78.41 number of leaves, followed by T_7 (71.87) while T_1 (control) remained at the bottom with 58.69 numbers of leaves. Treatment means followed a sequence of T_5, T_7, T_6 T_4, T_3, T_2 and T_1.

Interaction of cultivars and treatments depicted that Climax with T5 (P120 Kg ha^{-1}) remained at top, than Meteor in T_5 (P120 $Kgha^{-1}$) Whereas Meteor in T_1 and T_2 secured last two positions. It was observed that T_5 ($P120Kgha^{-1}$) remained better for both cultivars. In any case, Climax behaved comparatively better than Meteor. All other combinations remained in between and showed overlapping results.

These results showed 120 Kg P ha^{-1} better for both cultivars Climax and Meteor for seed production, as compared to other levels of phosphorus. High dose of P (140, 160 Kg ha^{-1}) did not increase number of leaves. These results are in agreement with the findings of the following scientist. Phosphorus is an important nutrient for high quality seed production of peas. Its effects on plants are complex. Phosphorus is needed in relatively large amounts by legumes for growth and nitrogen fixation. It plays very important physiological role in plant growth. (Raghothama, 1999, Pacovskoi *et al.*, 1986, Berg and Lynd, 1985, Kasturikrishna and Ahlawat, 1999).

Patel *et al.*, (1998) stated that peas cv. Arbel showed number of leaves per plant significantly increased, when applied 80 Kg P_2O_5 ha^{-1}.

4.2.3. Leaf area (cm^2)

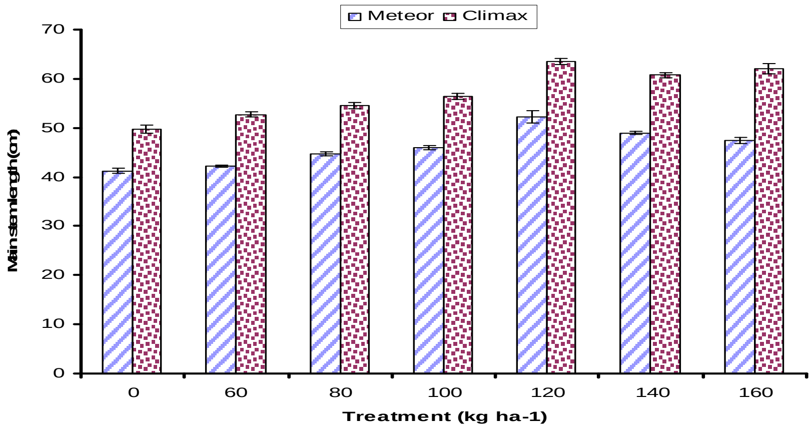
Data pertaining to leaf area were subjected to analysis of variance and results are presented in figure 4.5 (c). Significant results were found for cultivars, phosphorus levels and their interactions.

Among cultivars, Climax had more leaf area 220.9 cm^2 than Meteor 220.86 cm^2. As far as phosphorus levels are concerned T_5 (P 120Kg ha^{-1}) remained at the top with 255.13 cm^2 followed by T_4 (241.38 cm^2) while T_2 remained at the bottom with 186.38 cm^2 leaf area. Treatment means followed a sequence of T_5, T_4, T_1, T_6, T_7, T_3 and T_2.

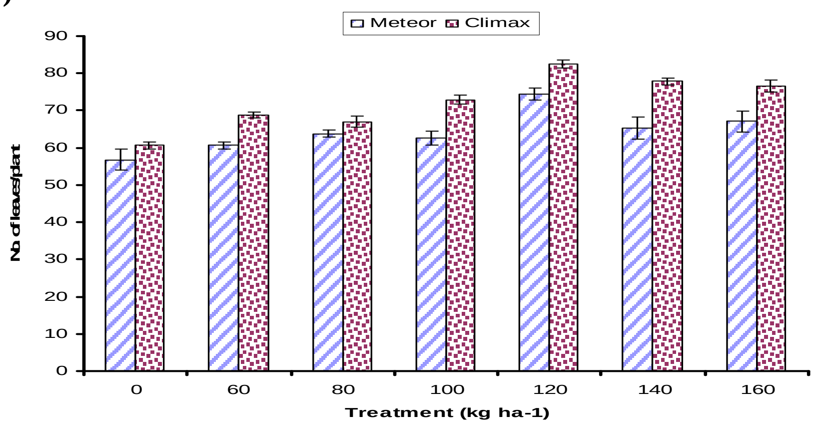
With regard to interactions of cultivars and treatments it was noted that Climax with T_5 (P 120Kgha^{-1}) was at the top, followed by Meteor in T_5 (P 120Kg ha^{-1}), whereas Climax in T_2, and T_3 having last two positions. Climax behaved comparatively better than Meteor. Overall T_5 (P 120Kgha^{-1}) remained better for both cultivars. All other combinations remained in between and showed overlapping results. These results showed that P 120Kgha^{-1} remained better for both cultivars as compared to other levels of phosphorus.

These results are in accordance with the finding of Raghothama (1999) who reported that Phosphorus plays very important physiological role in plant growth. Phosphorus is needed in relatively large amounts by legumes for growth and nitrogen fixation and has been reported to promote leaf area (Svoboda, 1976, Berg and Lynd, 1985, Pacovskoi *et al.*, 1986, Patel *et al*., 1998, Kasturikrishna and Ahlawat, 1999).

(a)



(b)



(c)

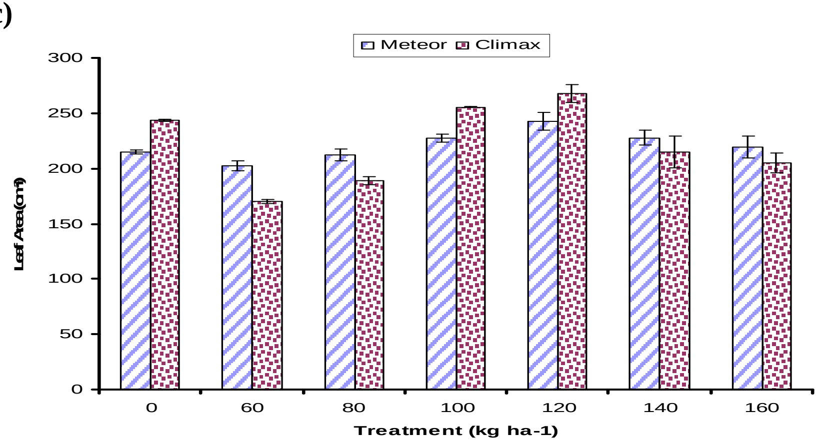


Fig.4.5:- Influence of different phosphorus levels on (a) Main stem length (cm) (b) Number of leaves per plant and (c) Leaf area (cm^2)

4.2.4. Number of pods per plant

Observations regarding number of pods per plant were organized, subjected to analysis of variance and results are presented in figure 4.6 (a). It depicted the significant results for phosphorus levels and their interactions but non-significant among cultivars.

Both cultivars, Climax and Meteor showed 21.87 and 21.73 number of pods per plant respectively. Whereas, treatment means for phosphorus levels showed significant difference among them. In this case T_5 (P 120Kg ha^{-1}) remained at the top with 25.85 number of pods, followed by T_7 (23.31) number of pods per plant, while 1 (control) remained at the bottom with 18.17 number of pods per plant. Figure illustrate that treatment means followed a sequence of T_5, T_7, T_6, T_4, T_3, T_2 and T_1.

With regard to interaction of these factors, it may be found that, Climax with T_5 (P120 Kg ha^{-1}) remained at the top, followed by Meteor in T_7 (P160 Kg ha^{-1}), whereas Meteor in T_1 secured 2^{nd} last and Climax last position in T_1. With regard to phosphorus levels, T_5 (P120 Kg ha^{-1}) remained better for Climax and T_7 better for Meteor cultivar. In any case, Climax behaved comparatively better than Meteor. All other combinations remained in between and showed overlapping results. These results proved that P 120 Kg ha^{-1} remained better for both cultivars as compared to other levels of P. The results obtained are in accordance with Fageria, 1979, Berg and Lynd, 1985, Pacovskoi *et al.*, 1986, Kasturikrishna and Ahlawat, 1999). Prasad *et al.*, 1989, Tripathi *et al.,* (1991) who stated that number of pods per plant were greatest in combination of nitrogen and phosphorus. High dose of P (140, 160 Kg ha^{-1}) increased number of pods per plant. Phosphorus is needed in relatively large amounts by legumes for growth and nitrogen fixation and has been reported to promote leaf area, biomass, yield, nodule number, nodule mass, etc., in a number of legumes (Kohli *et al*., (1992) studied the response of peas to phosphorus given different doses i.e. 0, 30 and 60 kg $P_2O_{5\ ha}{}^{-1}$. Phosphorus significantly increased number of peas/pod and total green pod yield, at the highest phosphorus rate.

Naeem (2003) reported that nitrogen applied @ 80 Kg $ha^{-1\ -1}$ and phosphorus @ 120 Kg ha^{-1} produced maximum length of pod and maximum number of pods per plant in peas. Gupta *et al*., (2000) studied the effect of P applied @ 0, 25, 50 and 75 Kg $ha^{-1\ -1}$ and lime @ 0, 50, 100 and 150% on peas cv. Bonneville, for growth and yield characteristics. They observed that increasing P levels increased seed yield and yield parameters such as pod length, number of grains per pod and pod weight.

Shukla *et al*., (1993) presented a table of correlation coefficient for 5 garden peas cultivars, grown in 2 climates, in Himachal Pradesh in response to 3 rates of P application (45, 60 and 75 kg P_2O_5 ha^{-1}). The results showed that plant height, shelling percentage, number of pods/plant and seeds/pod was maximum with 75 kg P_2O_5 ha^{-1} compared with control and other doses of P_2O_5.

4.2.5. Length of pod (cm)

Observations recorded in relation to this parameter were subjected to analysis of variance and results are presented in figure 4.6 (b) which depicted the significant results for phosphorus levels and their interactions but non-significant among cultivars.

In case of cultivars, Climax showed 2.87 cm and Meteor 5.67 cm length of pods respectively. Whereas, treatment means for phosphorus levels showed significant difference among them. In this case T_5 (P 120Kgha^{-1}) remained at the top with 6.62 cm length of pod, followed by T_5 (5.92 cm) while T_1 (control) remained at the bottom with 5.12 cm length of pod. Treatment means followed a sequence of T_5, T_7, T_6, T_4, T_3, T_2 and T_1.

Regarding the interaction of these factors, it may be observed that, Climax with T_5 (P120 Kg ha^{-1}) remained at the top, followed by Meteor in T_5 (P120 Kgha^{-1}), Whereas Meteor and Climax both occupied last two positions. Over all T_5 (P120Kgha^{-1}) remained better for both cultivars. In any case, Climax depicted comparatively better than Meteor. All other combinations remained in between and showed overlapping results. These results revealed that P120Kg ha^{-1} remained better for both cultivars as compared to other levels of P. Similar findings have been reported by previous workers, Naeem (2003) reported that nitrogen and phosphorus produced maximum length of pod and maximum number of pods per plant in peas.

Gupta *et al*., (2000) studied the effect of P applied @ 0, 25, 50 and 75 Kg ha^{-1} and lime @ 0, 50, 100 and 150% on peas cv. Bonneville, for growth and yield characteristics. They observed that increasing P levels increased seed yield and yield parameters such as pod length, number of grains per pod and pod weight.

4.2.6. Number of seeds per pod

Data regarding number of seeds per pod were subjected to analysis of variance and results are presented in figure 4.6 (c).The figure described significant results for cultivars, phosphorus levels and their interactions.

In case of cultivars comparison, Climax showed more number of seeds per pod 6.15 as compared to Meteor with 5.60 numbers of seeds per pod. Treatment means for phosphorus levels showed significant difference among themselves. Figure illustrate that T_5 (P 120Kg ha^{-1}) remained at the top with 6.43 number of seeds per pod, followed by T_6 (6.28, while T_1 (control) was at the bottom with 5.28 number of seeds per pod. All treatment means followed a sequence of T_5, T_6, T_7, T_3, T_2, T_4 and T_1.

Interaction of cultivars and treatments are revealed that, Climax with T_5 (P120 Kg ha^{-1}) remained at the top, followed by Meteor in T_2 (P 60 Kgha^{-1}) whereas both Meteor and Climax in T_1 remained at last two positions. As the observation concluded that T_5 (P120Kgha^{-1}) remained better for both cultivars. In any case, Climax behaved comparatively better than Meteor. All other combinations remained in between and showed overlapping results. These results showed that P 120 Kg ha^{-1} remained better for both cultivars as compared to other levels of P. Excessive dose of P (140, 160 Kgha^{-1}) did not increase seed numbers. These results are supporting with the work of following scientist (Fageria, 1979, Berg and Lynd, 1985, Pacovskoi *et al.*, 1986, Kasturikrishna and Ahlawat, 1999, Kohli *et al.*, 1992). Phosphorus is needed in relatively large amounts by legumes for growth Phosphorus significantly increased number of peas/pod and total green pod yield, at the highest phosphorus rate Gupta *et al.*, (2000) studied the effect of P applied @ 0, 25, 50 and 75 Kg ha^{-1} and lime @ 0, 50, 100 and 150% on peas cv. Bonneville, for growth and yield characteristics. They observed that increasing P levels increased seed yield and yield parameters such as pod length, number of grains per pod and pod weight.

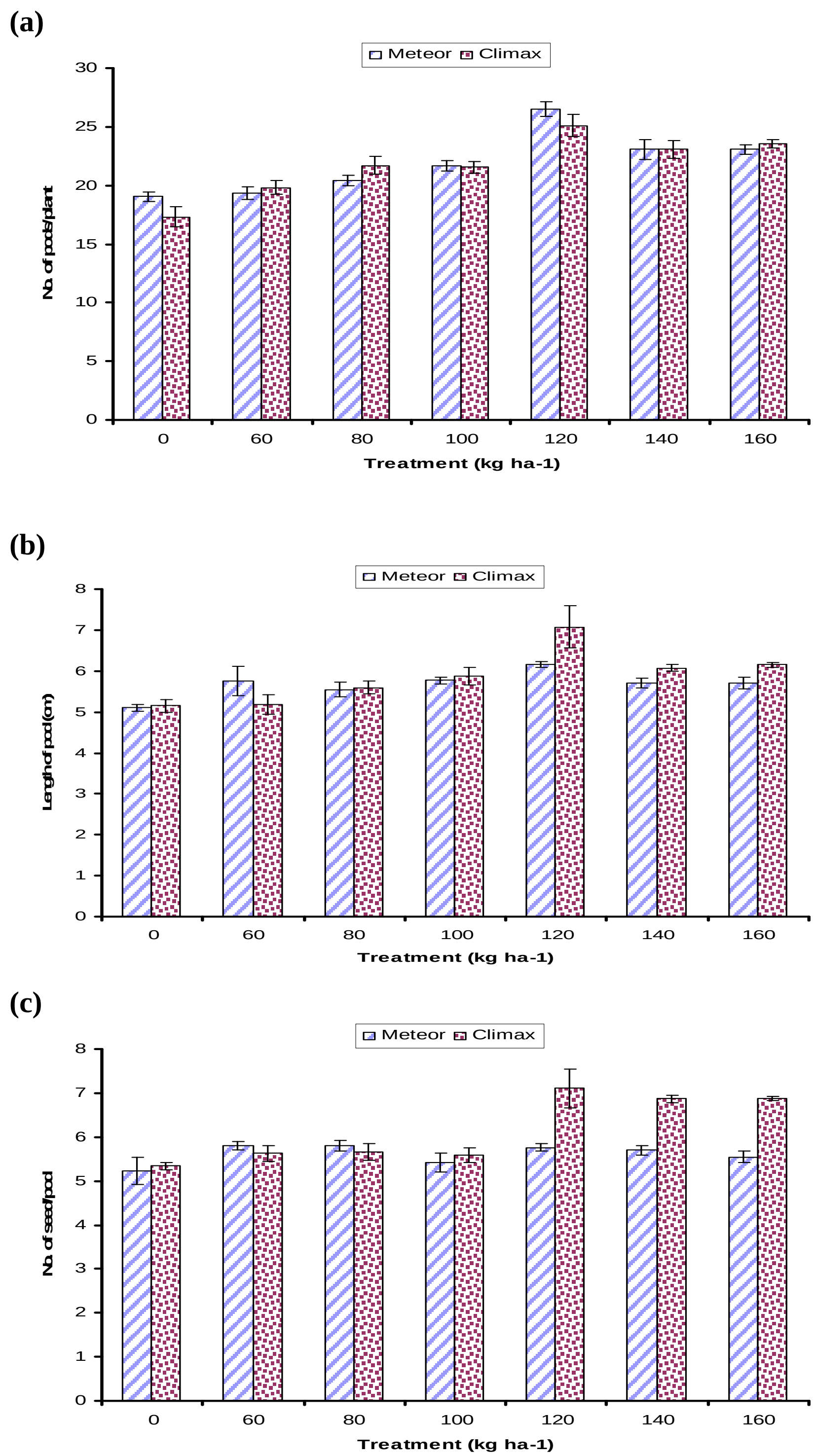


Fig.4.6:- **Influence of different phosphorus levels on (a) Number of pods per plant (b) Length of pod (cm) and (c) Number of seeds per pod**

4.2.7. 1000 seed weight (g)

Data regarding 1000 seed weight was collected, organized, subjected to analysis of variance and results are presented in figure 4.7 (a). It showed significant results for cultivars, phosphorus levels and their interactions.

Figure regarding cultivars revealed that Climax ousted Meteor showing 144.11 g compared with 138.43 g 1000 weight. Whereas, treatment means for phosphorus levels showed significant difference among them. In this case (P 120Kgha^{-1}) remained at the top with 149.75, followed by T_6 (146.38 g) while T_2 remained at the bottom with 130.88 g 1000 weight. Treatment means followed a sequence of T_5, T_6, T_4, T_7, T_3, T_1 and T_2. As far as interaction are concerned, Climax with T_5 (P120Kgha^{-1}) remained at the top, whereas T_2 seemed last position. Observation showed that T_5 (P120Kgha^{-1}) remained better for both cultivars. In any case, Climax showed better results than Meteor. All other combinations remained in between and showed overlapping results. These results revealed that 120 Kg P ha^{-1} remained better for both cultivars as compared to other levels of P. Although vegetative growth requires N but for legumes comparatively more P is needed for growth and N fixation which might had contributed in this regard to get 1000 seed weight. These results are supported by the work of following scientist.

Amjad *et al*., (2004) conducted an experiment on peas crop providing phosphorus and potassium. They observed that seed yield increased significantly with increasing level of P_2O_5.

4.2.8. Seed yield per hac (Tons)

Seed yield in peas is also influenced by varying plant nutrition requirements during its growth period. Application of fertilizer at suitable stage is necessary to achieve maximum yield of the crop. In addition, for seed crop the effect of fertilizer on seed nutrient contents are also important.

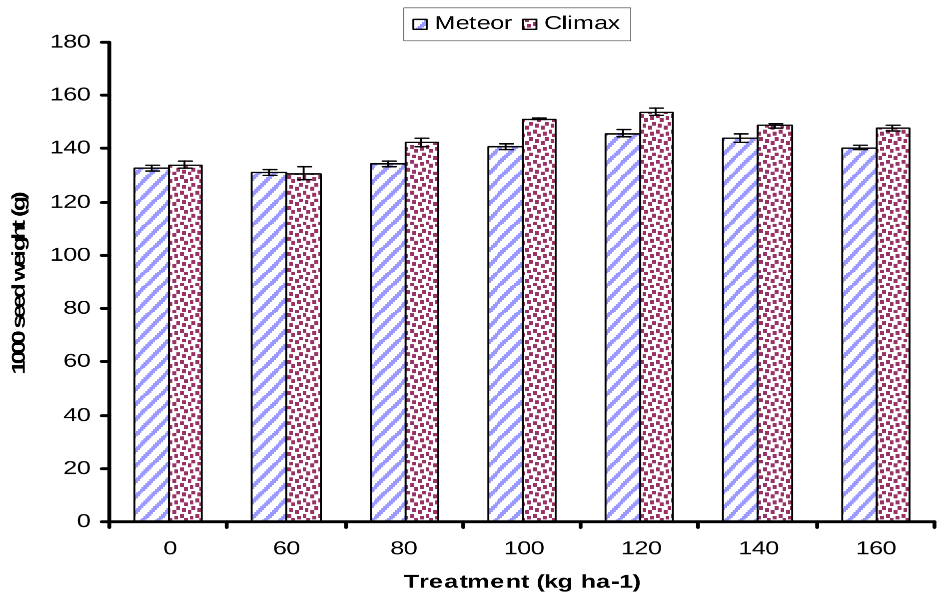
Data relation to seed yield ha^{-1} was subjected to analysis of variance and results are presented in figure 4.7 (b). It indicated significant results for cultivars, phosphorus levels and their interactions.

In case of cultivars, Climax showed better 2.10 tons seed yield, while 2.14 tons seed yield was found in Meteor. Treatment means for phosphorus levels showed significant difference. In this case T_5 (P 120Kg ha^{-1}) remained at the top with 3.04 tons seed yield, followed by T_5 (2.42 tons while T_2 showed at the bottom with 1.72 tons. Treatment means followed a sequence of T_5, T_6, T_4, T_7, T_1, T_3 and T_2.

Fageria, 1979 and Sinha *et al.* (2000), they reported that seed yield increased with increasing levels of phosphorus. With revealed to interaction of cultivars and treatments it is clear that, Climax with T_5 (P120 Kg ha^{-1}) remained at the top, followed by Meteor in T_5 (P120 Kg ha^{-1}), Whereas Meteor in T_2 and T_1 at last position. It was concluded that T_5 (P120 Kg ha^{-1}) remained better for both cultivars. Similar results were reported by Pochauri *et al.* (1991) who said that increased levels of nitrogen and phosphorus increase seed yield. In any case, Climax behaved comparatively better than Meteor. All other combinations remained in between and showed overlapping results. These results revealed that 120 Kg ha^{-1} P remained better for both cultivars as compared to other levels of P. Amjad *et al*., 2004, Kanaujia *et al*., (1997) concluded that growth and nodulation increased significantly with increasing levels of P and K. Best dose of phosphorus and potash reported was 60 Kg ha^{-1}, which increased seed yield and quality significantly. Seed yield increased significantly with increasing level of P_2O_5. Boyd *et al*., (1971) have reported a relationship between seed size and vigour which may be increased by nitrogen application. There is general agreement that nitrogen fertilizer has the most important effect in increasing number of flowers, seed yield and quality of wide cultivars of plant species. Negi (1992) stated that when peas cv. Lincolin were fertilized with 20 kg N/ha. It increased seed yield (1.66 tons ha^{-1} in 1989 and 3.32 tons ha^{-1} in 1990) compared with control yields of 1.18 and 2.42 tons ha^{-1}, respectively. Application of 60 kg P_2O_5 also significantly increased seed yield (1.73 tons ha^{-1} in 1989 and 3.28 tons ha^{-1} in 1990) compared with control of 1.04 and 2.08 tons ha^{-1}, respectively.

Gupta *et al*., (2000) studied the effect of P applied @ 0, 25, 50 and 75Kgha^{-1} and lime @ 0, 50, 100 and 150% on peas cv. Bonneville, for growth and yield characteristics. They observed that increasing P levels increased seed yield and yield parameters such as pod length, number of grains per pod and pod weight. Tawaha and Turk (2004) observed the effect of phosphorus fertilizer with placement method (banded or broadcasted) and seeding rate (30, 60 and 90 seeds m^2) in field peas. Phosphorus fertilization and seeding rate had significant effect on most of the traits measured. Increase in seeding rate from 30 to 90 seeds/m^2 and increase in P fertilization from 17.5 to 52.5 Kg ha^{-1} increased 50% seed yield. Posypanov *et al*., (1994) found in a pot experiment with peas plants that the critical phosphorus content for nitrogen fixation with boron and molybdenum was 25 mg P_2O_5/kg soil which increased atmospheric nitrogen fixation and seed yield.

(a)



(b)

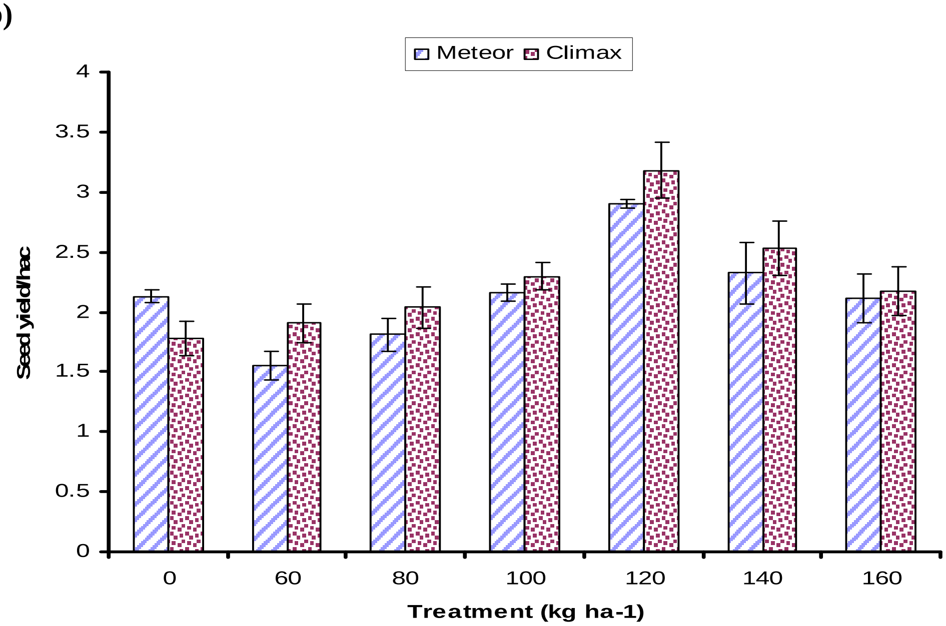


Fig.4.7:- **Influence of different phosphorus levels on (a) 1000 seed weight (g) (b) Seed yield per hac (Tons)**

4.2.9. Chemical composition of the plant parts (leaves, stems and pods)

4.2.9.1. Chemical composition of the peas leaves

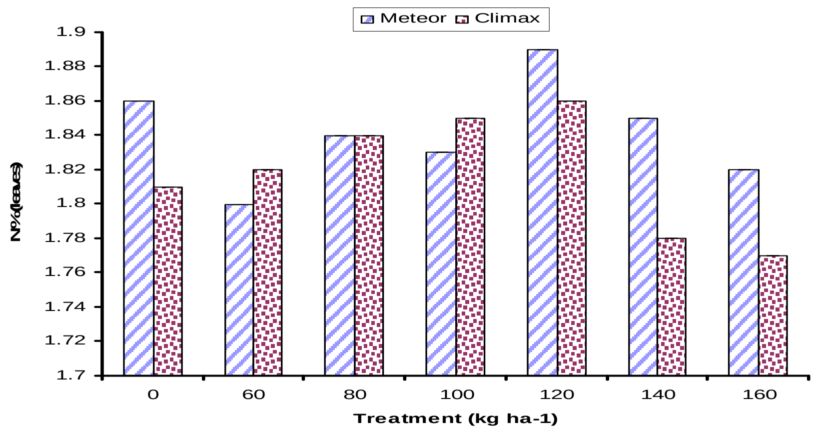
Phosphorus is an important nutrient for high quality seed production of peas. Its effects on plants are complex. Seed yield in peas is also influenced by varying plant nutrition requirements during its growth period. Application of fertilizer at suitable stage is necessary to achieve maximum yield of the crop. In addition, for seed crop the effect of fertilizer on seed nutrient contents are also important.

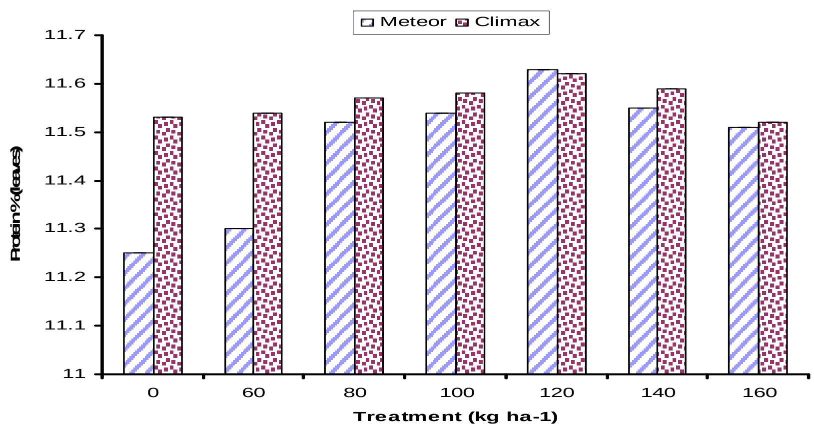
Data related to chemical composition of the peas leaves were subjected to analysis of variance and results are presented in figure 4.8 which revealed significant results for cultivars, phosphorus levels and their interactions.

Ash was better in Climax 13.98% as compared to Meteor 13.93%, Nitrogen% was better in Meteor 1.84% than Climax 1.82% but Protein better in Climax 11.56% as compared to Meteor 11.47%. In case of phosphorus levels, high in T_5 (14.34%) but at bottom T_7 (13.83%) is present while other treatments showed results in between T_5 and T_7. In case of protein, Climax showed protein 11.56% as compared to Meteor 11.47%. The treatments means showed that T_5 (11.63%) remained at top while, T_1 was present at bottom in which 11.39% protein was present, while other treatments showed narrow difference and fall in between T_5 and T_1.

Interaction of cultivars and treatments for ash% showed that, Climax with T_5 (P12Kgha^{-1}) remained at the top, followed by Meteor in T_5 (P120Kgha^{-1}), Whereas, Climax in T_7, T_1 and T_2 got last three positions. Overall T_5 (P120Kgha^{-1}) remained better for both cultivars. All other combinations remained in between and showed overlapping results. Interaction of cultivars and treatments for Nitrogen% showed that, Meteor with T_5 (P120ha^{-1}) was at the top, Climax in T_5 (P120Kgha^{-1}), Whereas Climax in T_7 and T_6 at last two positions. Observation showed that T_5 (P120Kgha^{-1}) remained better for both cultivars. All other combinations remained in between and showed overlapping results. The results obtained are in accordance with the finding of Rana *et al.* (1998) who reported that increased of nitrogen, increase uptake of nitrogen with in their plant stature. Interaction of cultivars and treatments for Protein showed, Meteor with T_5 (P120Kgha^{-1}) at the top, Climax in T_5 (P120Kgha^{-1}), Whereas Meteor in T_1 and T_2 at last two positions. Over all T_5 (P120Kgha^{-1}) remained better for both cultivars. All other combinations remained in between and showed overlapping results. These results revealed that P 120Kgha^{-1} remained better for both cultivars as compared to other levels of P. These results are supporting with the work of following scientist. Kanaujia *et al*., (1997) evaluated the effect of P, K and rhizobium on growth, yield and quality of peas cv. Lincolin and stated that the growth and nodulation increased significantly with increasing levels of P and K (0, 30, 60, 90 Kg ha^{-1}) alone. Best dose of P and K reported was 60 Kg ha^{-1}, which increased seed yield and quality significantly.

Seeds from plants supplied with additional nitrogen might be more vigorous than control seeds. In wheat and other grasses there were strong correlations between an increase in grain protein content associated with nitrogen fertilizer and the production of more vigorous seedlings (Ries and Everson, 1973; Ene and Bean, 1975. Application of nitrogen fertilizer increased the quality of proteins to a greater degree than all other amino acids (Trachuk, 1966).





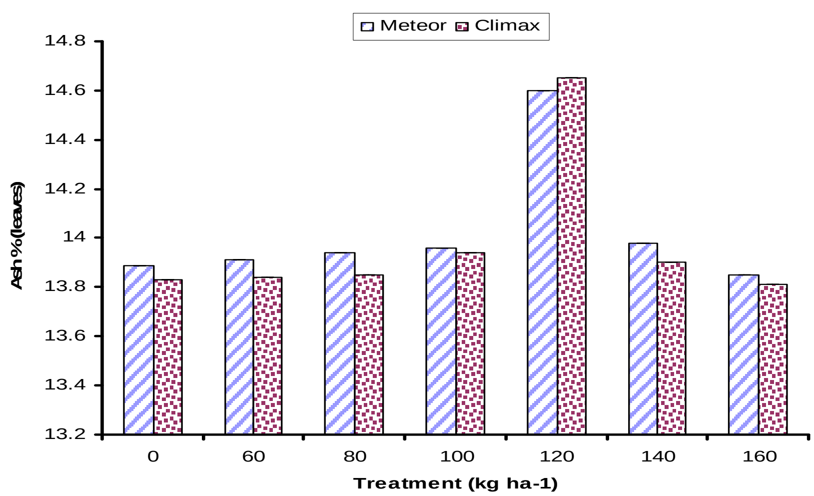


Fig.4.8:- **Influence of different phosphorus levels on chemical composition (Nitrogen, Protein and Ash) of the peas leaves**

4.2.9.2. Chemical composition of peas stems

Data regarding chemical composition of the peas stems were subjected to analysis of variance and results are presented in figure 4.9. Data indicated significant results for cultivars, phosphorus levels and their interactions.

Ash was better in Climax 11.94% as compared to Meteor 11.69 , phosphorus levels high in T_5 (12.23%) but at bottom T_1 (11.58%) is present while other treatments showed results in between T_5 and $T_{1.}$ Interaction of cultivars and treatments for ash% showed, Meteor with T_5 (P120Kgha^{-1}) remained at the top, followed by Climax also in T_5 (P120 Kg ha^{-1}), whereas Meteor in T_1, T_2, T_3, T_4 and T_6 got last three positions. Overall T_5 (P120Kgha^{-1}) remained better for both cultivars. All other combinations remained in between and showed overlapping results.

Nitrogen was better in Meteor 1.34% as compared to Climax 1.33%, the phosphorus level high in T_2 (1.35%) but at bottom T_6 (1.32%) is present while other treatments showed results in between T_2 and T_6. Interaction of cultivars and treatments for Nitrogen% showed that Meteor with T_2 (P 60Kgha^{-1}) was at the top, Climax in T_3 (P 80 Kg ha^{-1}), whereas Climax in T_4 occupied last position T_5 (P 60Kgha^{-1}) remained better for both cultivars. All other combinations remained in between and showed overlapping results.

Protein was better in Climax 8.36% as compared to Meteor 8.36%, the phosphorus level high in T_5 (8.46%) but at bottom T_1 (8.24%) was present while other treatments showed results in between T_5 and T_1. Interaction of cultivars and treatments for Protein% showed, Meteor with T_5 (P 120Kgha^{-1}) was at the top, Climax in T_5 (P 120Kgha^{-1}), whereas Meteor in T_1 got last position. T_5 (P 120Kgha^{-1}) remained better for both cultivars. All other combinations remained in between and showed overlapping results. The following workers in line with, Trachuk, 1966; Ries and Everson, 1973; Ene and Bean, 1975. The reported that seeds protein content associated with nitrogen fertilizer and the more vigorous seedlings are produced when the application of nitrogen increased.

Kanaujia *et al*., 1997; who said that peas growth and seed yield increased significantly with increasing phosphorus and potash levels.

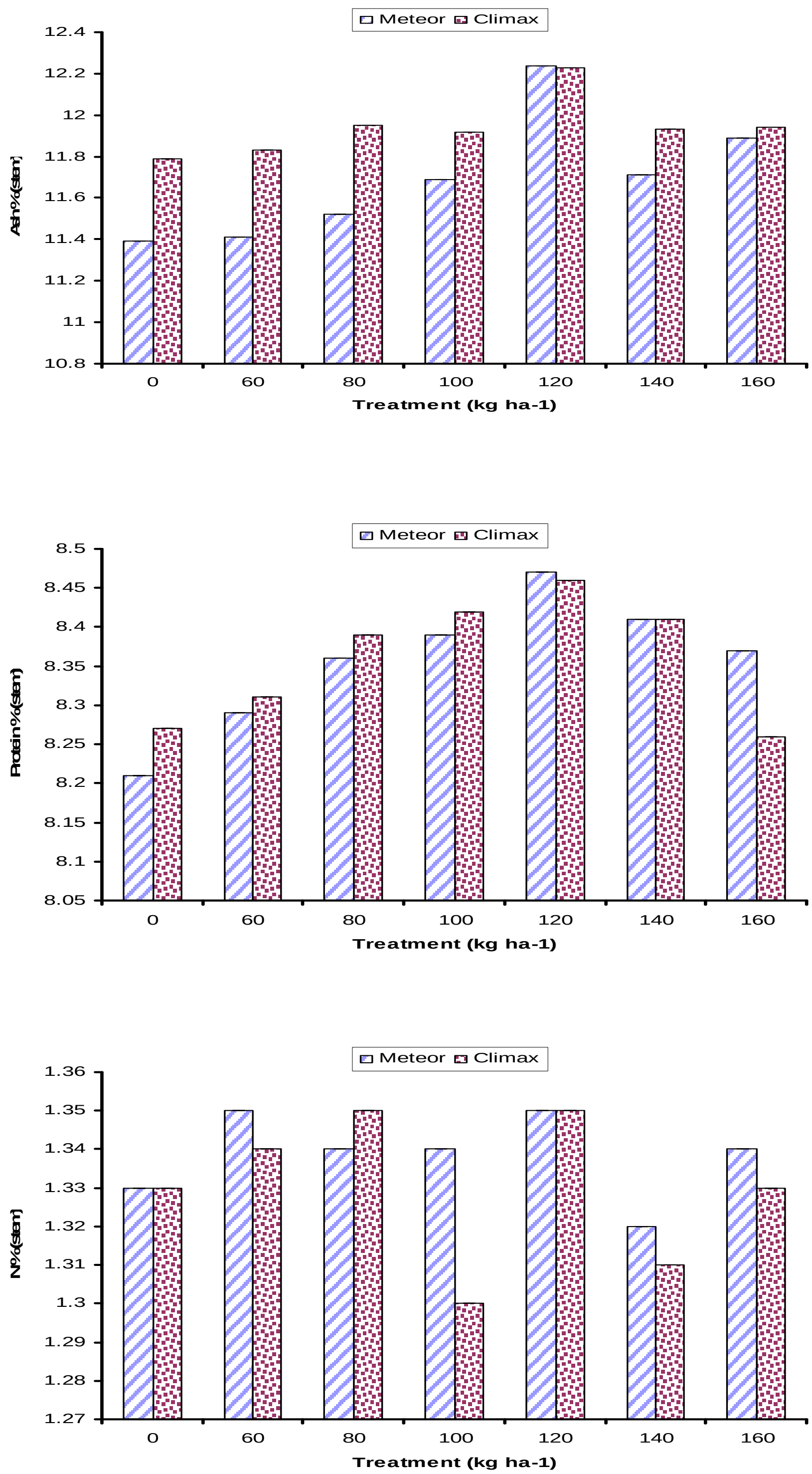


Fig.4.9:- **Influence of different phosphorus levels on chemical composition (Ash, Protein and Nitrogen) of peas stems**

4.2.9.3. Chemical composition of pod+ Seeds

Phosphorus application at suitable stage is necessary to achieve maximum yield of the crop. In addition, for seed crop the effect of fertilizer on seed nutrient contents are also important.

Data pertaining to chemical composition of peas pod + seeds were subjected to analysis of variance and results are presented in figure 4.10. Data showed significant results for cultivars, phosphorus levels and their interactions.

Ash was better found in Meteor 4.53% as compared to Climax 4.53%. The phosphorus level high in T_5 (4.71%) but at bottom T_1 (4.44%) is present while other treatments showed results in between T_5 and T_1. Interaction of cultivars and treatments for ash% showed that Meteor with T_5 (P120Kgha^{-1}) was at the top, followed by Climax also in T_5 (P120Kgha^{-1}), whereas, Meteor in T_7 and T_1 with Climax at last two positions. Over all T_5 (P120Kgha^{-1}) remained better for both cultivars. All other combinations remained in between and showed overlapping results.

Nitrogen was better in Climax 3.43% as compared to Meteor 3.39%, the phosphorus level high in T_5 (3.46%) but at bottom T_1 (3.3788%) is present while other treatments showed results in between T_5 and T_1. Interaction of cultivars and treatments for Nitrogen% showed that Meteor with T_5 (P 120 Kgha^{-1}) got the top, Climax also in T_5 (P120 Kgha^{-1}), whereas Meteor in T_1, T_2, $T_{3,}$ T_7 and T_4 at last positions. T_5 (P 120 Kg ha^{-1}) remained better for both cultivars. All other combinations remained in between and showed overlapping results.

Protein was better in Climax 21.435% as compared to Meteor 21.16%, the phosphorus level high in T_5 (21.64%) but at bottom T_1 (20.93%) is present while other treatments showed results in between T_5 and T_1. Interaction of cultivars and treatments for Protein% showed that Meteor with T_5 (P 120 Kg ha^{-1}) at the top, followed Climax in T_5 (P 120 Kg ha^{-1}), whereas Meteor in T_5 and T_2 got last two positions. Results showed that T_5 (P 120Kgha^{-1}) remained better for both cultivars. All other combinations remained in between and showed overlapping results.

These results are supporting the work of the following scientist, Ries and Everson, 1973; Ene and Bean, 1975; Kanaujia *et al*., (1997 and Trachuk, 1966, they stated that peas seed quality and vigour significantly increased by increasing nitrogen, phosphorus and potash levels. Peas seed nutrient composition also increased when the dose of fertilizer increased and more vigorous seedlings were produced.

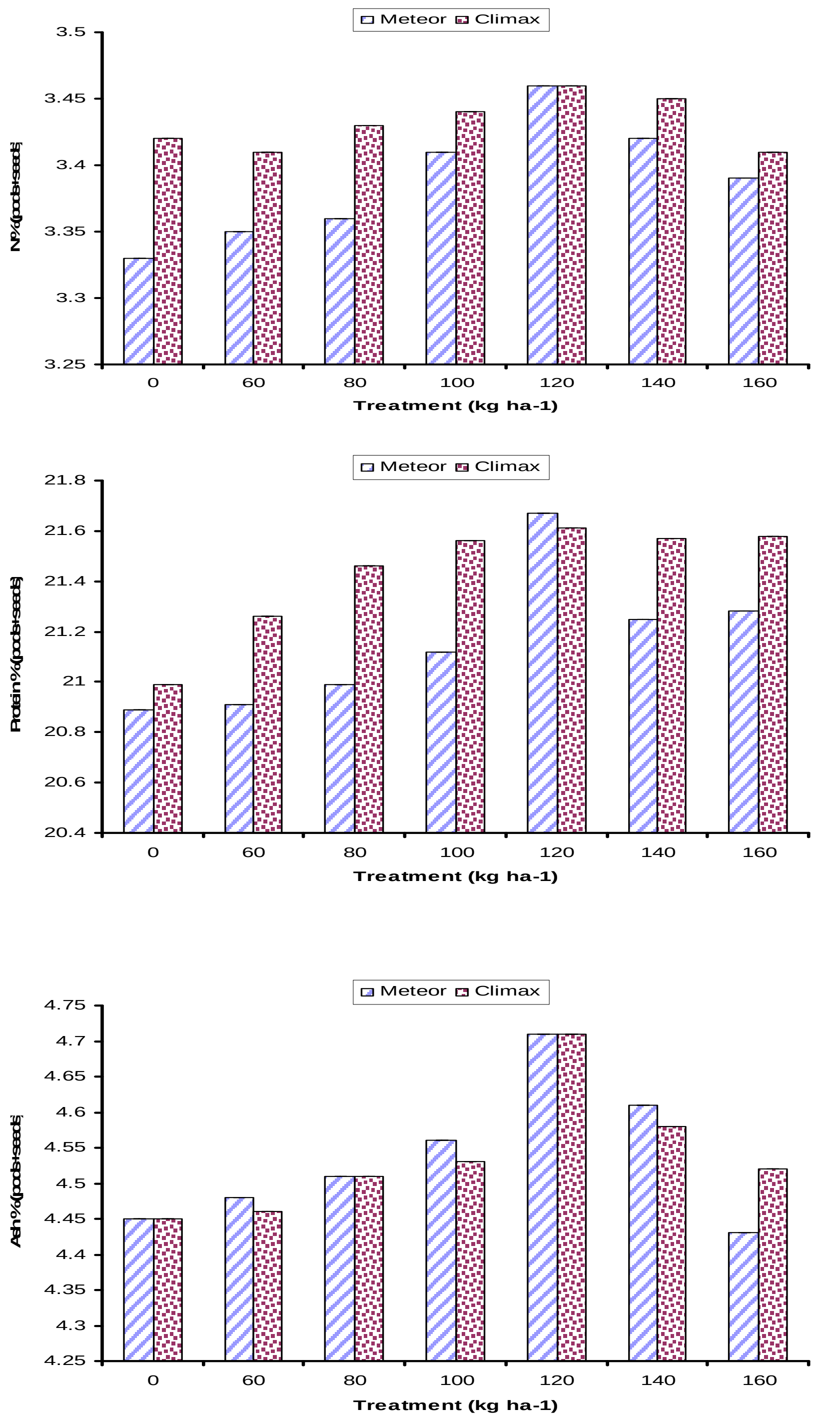


Fig.4.10:- **Influence of different phosphorus levels on chemical composition (Nitrogen, Protein and Ash) of the pod+ Seeds**

4.2.10. Seed nutrient concentration (N, P, K and protein contents)

Seed nutrient concentration in peas is also influenced by varying plant nutrition requirements during its growth period. Application of fertilizer at root shoot development stage is necessary to achieve maximum yield of the crop. In addition, for seed crop the effect of fertilizer on seed nutrients are also important.

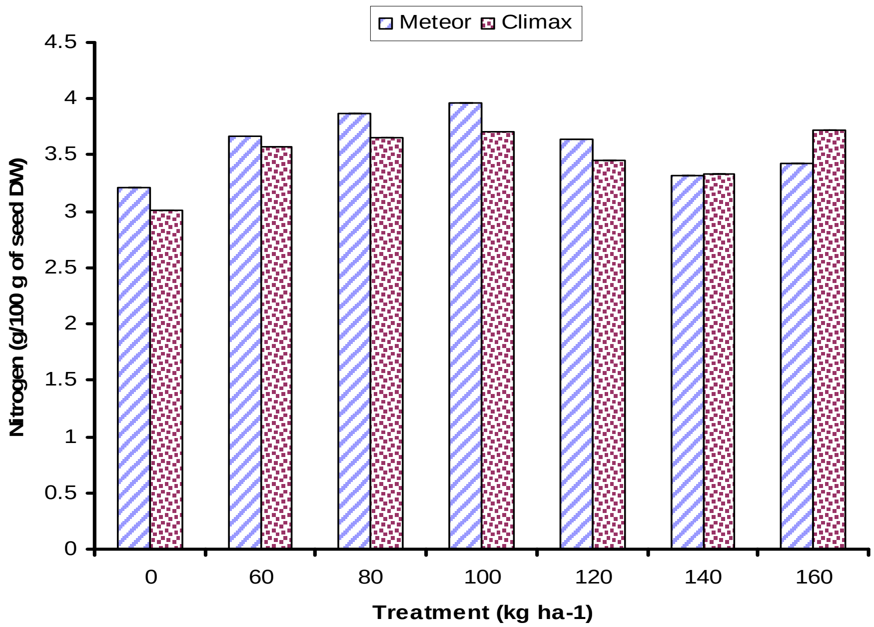
Data related to chemical composition of the peas seed nutrient concentration were subjected to analysis of variance and results are presented in figure 4.11. It indicated significant results for cultivars, phosphorus levels and their interactions.

Nitrogen was better in Meteor 3.56% as compared to Climax 3.39%, the phosphorus level high in T_4 (3.82%) but at bottom T_1 (3.15%) is present while other treatments showed results in between T_4 and T_1. Interaction of cultivars and treatments for Nitrogen% showed, Meteor with T_4 (P 100Kg ha^{-1}) was at the top, Climax in T_7 (P160 Kg ha^{-1}), whereas Climax in T_1 and Meteor also in T_1 are present at last two positions. T_4 (P 100 Kg ha^{-1}) showed better results for Meteor and T_7 (P16 Kg ha^{-1}) better for Climax. All other combinations remained in between and showed overlapping results.

Phosphorus was better in Climax 0.32% as compared to Meteor 0.31%, the phosphorus level high in T_7 (0.38%) but at bottom T_1 (0.25%) is present while other treatments showed results in between T_7 and T_1. Interaction of cultivars and treatments for Phosphorus showed that Meteor with T_7 (P 160 Kg ha^{-1}) was at the top, Climax also in T_7 (P160 Kg ha^{-1}), whereas Meteor in T_1 and Climax also in T_1 are present at last two positions. Overall T_7 (P 160Kgha^{-1}) better for both cultivars. All other combinations remained in between and showed overlapping results.

Potash was better in Climax 0.78% as compared to Meteor 0.6%, the phosphorus level high in T_7 (0.95%) but at bottom T_1 (0.57%) is present while other treatments showed results in between T_7 and T_1. Interaction of cultivars and treatments for potash% showed that Climax with T_7 (P160 Kg ha^{-1}) was at the top, Meteor also in T_7 (P160 Kg ha^{-1}), whereas Meteor in T_1 and also Climax in T_1 present at last two positions. Overall T_7 (P160 Kg ha^{-1}) showed better results for both cultivars. All other combinations remained in between and showed overlapping results.

Protein was better in Climax with 23.66% as compared to Meteor with 23.61%, the protein level high in T_7 (27.13%) but at bottom T_1 (20.74%) is present while other treatments showed results in between T_7 and T_1. Interaction of cultivars and treatments for Protein showed that Climax with T_7 (P 160 Kg ha^{-1}) was at the top, Meteor also in T_7 (P 160 Kg ha^{-1}), whereas Meteor in T_1 are present at last position. Results showed T_7 (P 160 Kg ha^{-1}) showed better results for both cultivars. All other combinations remained in between and showed overlapping results. Phosphorus is needed for growth and N fixation which might have contributed in this regard. These results are in line with the work of following scientist, Ene and Bean, 1975; Trachuk, 1966; Kanaujia *et al.*, 1997; Ries and Everson, 1973. They reported that peas seed chemical composition (quality and vigour) significantly increased when fertilizer quantity increased.



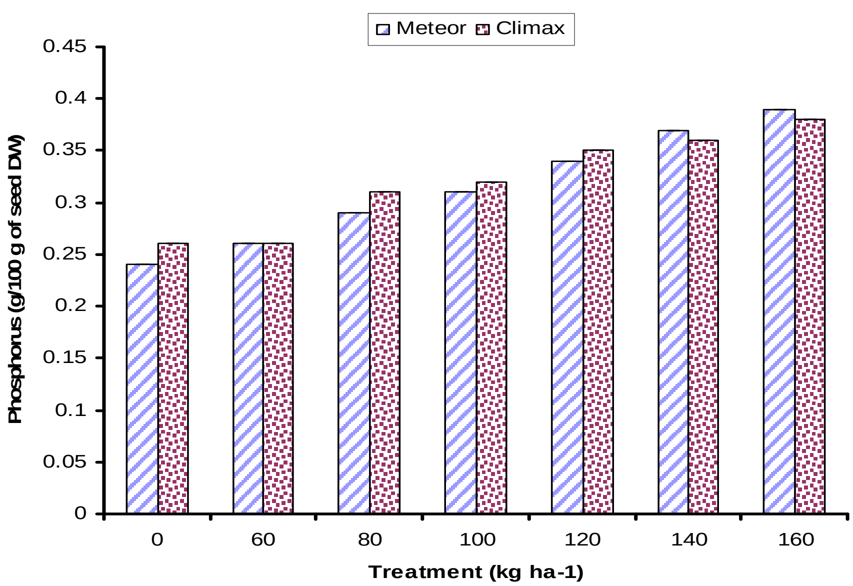
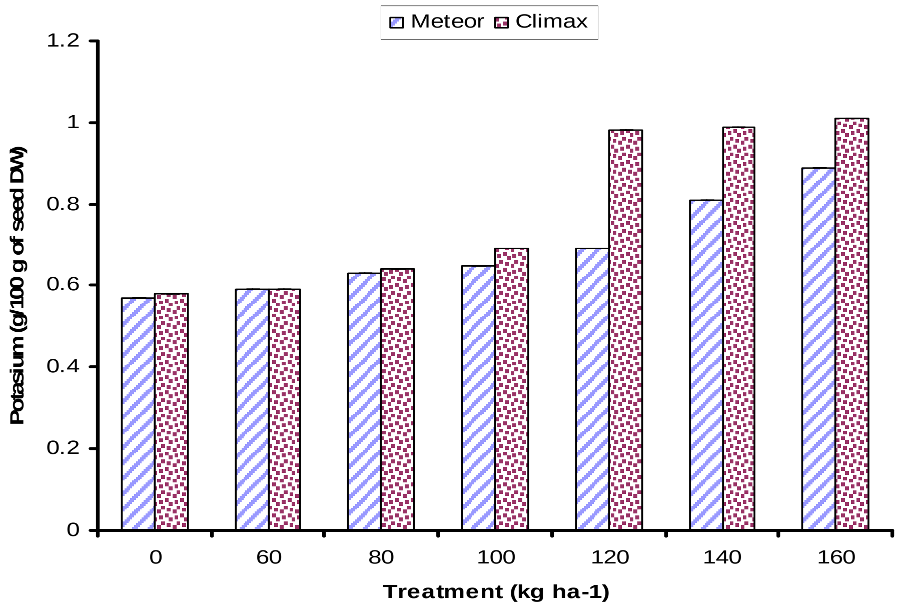


Fig.4.11 (a):- Influence of different phosphorus levels on Seed nutrient concentration (Nitrogen and Phosphorus)



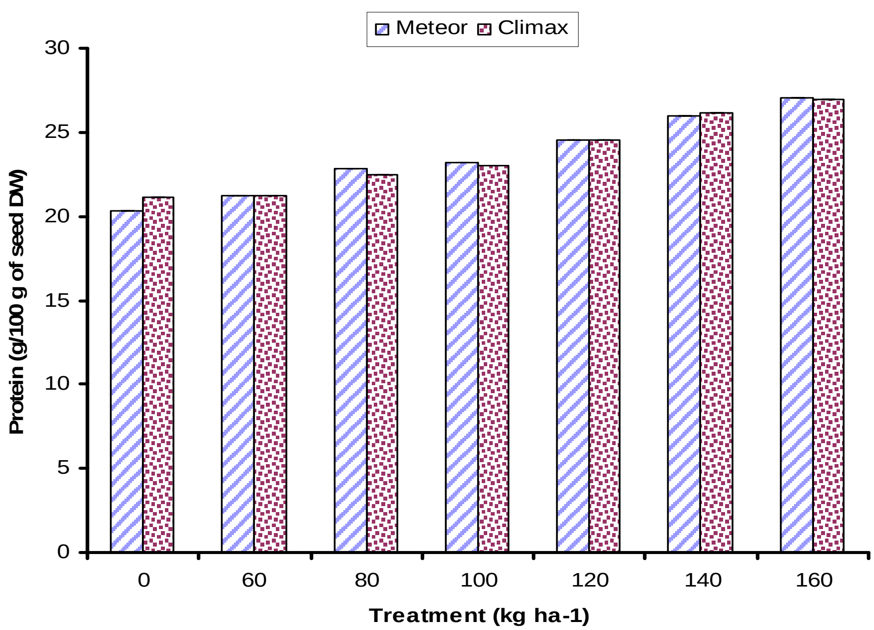


Fig.4.11 (b):- Influence of different phosphorus levels on Seed nutrient concentration (Potash and Protein)

4.2.11. Electrical conductivity test

Data for this parameter was collected, Subjected to statistical analysis of variance and results are presented in figure 4.12 (a). Data revealed significant results for cultivars, phosphorus levels and their interactions.

Climax behaved comparatively better than Meteor, for this parameter showing 23.0 and 20.45 EC, respectively.

As far as treatments are concerned, T_5 secured 1st position, followed by T_4, Whereas, T_7 and T_6 occupied the last two positions showing less electrical conductivity than control. In any case treatment means followed a sequence of T_5 (24), T_4 (23.63), T_3 (22.31), T_2 (21.38), T_1 (20.75), T_7 (20.13) and T_6 (19.88).

In case of interactions of cultivars and treatments, Climax with T5 remained at top, followed by Meteor in T_4. Meteor with T_5 remained in between almost whereas; Meteor in T_1 and T_2 got the last two positions, respectively.

Electrical conductivity is a test to measure seed vigour, less electrical conductivity more seed vigour and vice versa. So in this study T_7 and T_6 showed overlapping results with control remaining at the bottom (last three positions). Situation clears the pictures that less dose of phosphorus applied exhibited less electrical conductivity, which demonstrate about increased seed vigour and germination. These results are in line with the findings of Hadavizadeh, 1989; Padrit *et al*., 1996; Perry, 1972, they found that phosphorus application to the seed crop of peas had improved seed vigour.

Application of fertilizer to the mother plant increased the nutrient contents of peas (McNeal *et al*., 1971 and Lysenko, 1979) correlated with improved germination and greater seedling vigour (Schlesinger, 1970; Ries and Everson 1973; Lowe and Ries, 1973).

Koostra and Harrington (1969) found that seed solute leaching was due to impairment in the effectiveness of membranes within the cytoplasm. Perhaps some of the membrane lipid changed in cucumber and peas seed also occur during moist storage. They found that there was a marked fall in the phosphorus content of the membrane lipids after only one week of moist storage.

Hadavizadeh and George, 1988; Parera *et al*., 1995). Bedford (1974) the found the relationship between electrical conductivity values and vigour in relation to the field emergence potential of vining peas. (Matthews and Brandnock, 1968; Brandnock and Matthews, 1970; Tao, 1978). Hampton *et al*., (1992) suggested the use of a bulk conductivity testing method for large seeds of legumes such as peas etc.

4.2.12. Emergence test (%)

Seed quality in peas is also influenced by varying plant and could be tested by emergence test. Data for this parameter were collected, Subjected to statistical analysis of variance and results are presented in figure 4.12 (b).

Climax showed better results for emergence 89.14% than Meteor 88.28% respectively. As far as treatments concerned, T_5 secured 1st position, followed by T_4, Whereas, T_2 and T_3 occupied the last two positions and showed less emergence. In any case treatment means followed a sequence of T_5 (97.87), T_4 (93.62), T_6 (90.50), T_7 (89.00), T_1 (86.87), T_3 (82.87) and T_2 (80.25). In case of interactions of cultivars and treatments, Climax with T_5 remained at top, followed by Meteor. Meteor with T_4 remained in between almost whereas, Meteor in treatments T_1 got the last position, respectively. Emergence is a test to measure seed vigour, less emergence% less seed vigour and vice versa. So in this study T_6, T_1 and T_7 showed overlapping results with control remaining at the bottom (last three positions). Situation clears the pictures that less dose of Phosphorus applied exhibited less emergence%, which demonstrate about less seed vigour. These results are in line with the findings of Hadavizadeh, 1989; Padrit *et al.*, 1996, they found that increasing phosphorus application led to increase of seed vigour. Proteins, carbohydrates and other seed reserves were depleted during germination by the process of hydrolysis and translocated to the embryonic axis to provide a substrate for seedling growth.

Matthews (1977) found that soil infection, seed inborn diseases, soil conditions such as low temperatures, and both high and low soil moisture adversely affected seed emergence.

4.2.13. Germination test (%)

Data were pertaining to analysis of variance and results are presented in figure 4.12 (c). Data revealed non-significant results for cultivars but significant results for phosphorus levels and their interactions. Meteor behaved comparatively better than Climax, for this parameter showing 93.82 and 92.92 Germination respectively.

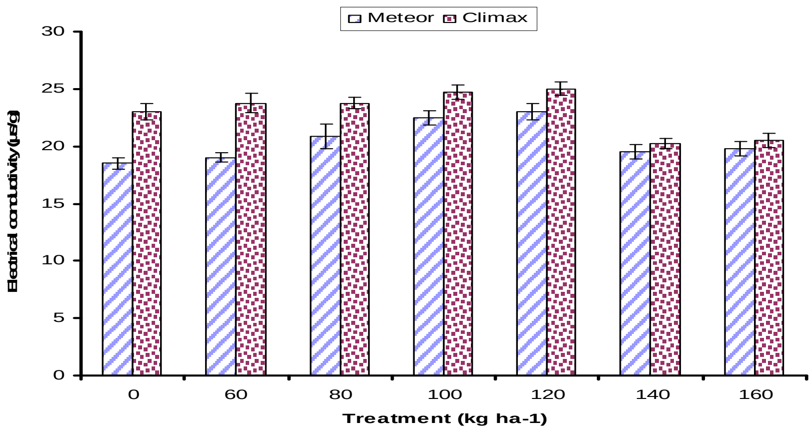
As far as phosphorus levels are concerned, T_1 secured 1st position, followed by T_5, where as, T_6 and T_7 occupied the last two positions showing less Germination. In any case treatment means followed a sequence of T_1 (96.37), T_5 (96.37), T_3 (94.00), T_2 (92.37), T_4 (92.00), T_7 (91.87) and T_6 (90.62).

In case of interactions of cultivars and treatments, Meteor with T_5 remained at top, followed by Meteor in T_1. Meteor with T_5 remained in between almost whereas, Climax in treatments T_5 and T_2 got the last 2 positions, respectively.

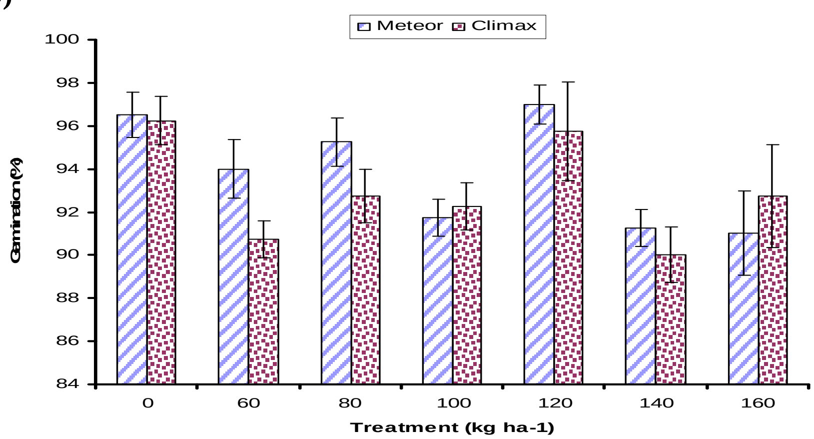
Germination is a test to measure seed vigour, so in this study T_2 and T_6 showed overlapping results. Situation clears the pictures that less dose of phosphorus applied exhibited less Germination, which demonstrate about low seed vigour. These results are in agreed with the results of Hadavizadeh, 1989; Padrit *et al*., 1996, they found that application of fertilizer to the mother plant increased the nutrient contents of cereal grain (McNeal *et al*., 1971) and peas (Lysenko, 1979) and might be correlated with improved germination and greater seedling vigour (Schlesinger, 1970; Ries and Everson 1973; Lowe and Ries, 1973).

Phosphorus supply may also affect seed quality. Rao *et al*., (1983) observed that plants deficient in phosphorus produce seed having slower germination than normal seed. Mother plants given additional phosphorus produced seed which tended to germinate more quickly than those of control plants. Hence phosphorus is important in the production of quality seed.

(a)



(b)



(c)

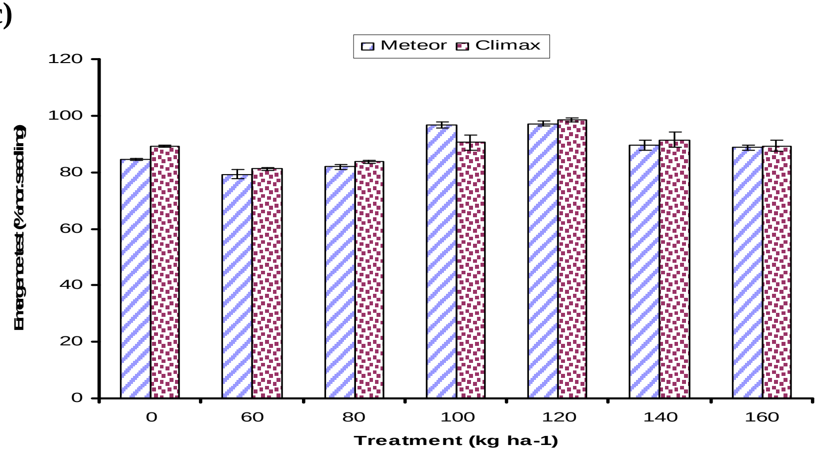


Fig.4.12:- **Influence of different phosphorus levels on (a) Electrical Conductivity(b) Germination % and (c) Emergence %**

Conclusion:

The results showed that Climax gave high seed yield 2.10 tons ha^{-1} whereas; 2.14 tons ha^{-1} seed yield was obtained in Meteor. T_5 (P 120Kg ha^{-1}) was at the top with 3.04 tons ha^{-1} seed yield, followed by T_6 (2.42 tons ha^{-1}) while, T_2 was found at the bottom with 1.72 tons ha^{-1}. Treatment means followed a sequence of T_5, T_6, T_4, T_7, T_1, T_3 and T_2. Climax showed better results than Meteor with respect to chemical composition and vigour tests. It is concluded that Climax with Phosphorus level 120 Kg ha^{-1} gave better results as compared to other levels of Phosphorus.

4.3. EXPERIMENT NO.3:-

INFLUENCE OF DIFFERENT POTASH LEVELS ON PEAS SEED YIELD AND QUALITY OF PEAS CROP.

Experiment was performed to assess the performance of different levels of potash. Different levels of potash were applied along with constant doses of N (80 Kg ha^{-1}) and P (120 Kg ha^{-1}).

4.3.1. Main stem length (cm)

Influence of different potash levels on main stem length was observed which showed significant differences among cultivars and different potash levels.

Data regarding cultivars reflected Climax ousted Meteor with 56.28 cm long stem as compared to 45.87 cm long main stem. Whereas, treatment means for potash levels showed significant difference among them. In this case T_4 (K100 Kg ha^{-1}) remained at the top with 57.75cm stem length, followed by T_6 (54.62 cm) while, the control remained at the bottom with 45.62 cm stem length. The values of treatment means followed a sequence of T_4, T_5, T_6, T_7, T_3, T_2, T_1 and T_0.

As far as interactive effect of cultivars and treatments are concerned, Climax with T_4 (K100 Kg ha^{-1}) remained at the top, Whereas, Meteor in T_4. Meteor presented last seven positions except T_4. Overall T_4 (K100 Kg ha^{-1}) remained better for both the cultivars. Climax behaved comparatively better than Meteor in both the cultivars studied. All other combinations remained in between by showing almost similar results. These results indicated that level K with 100 Kg (ha^{-1}) remained better for both cultivars as compared to other variables. Potassium is directly involved to activate enzymes which are responsible for the synthesis of protein, carbohydrates or other main substances but it activates metabolism for the essential biochemical action involved in the synthesis of these substances. It is retained mainly in cell sap and regulates the osmotic pressure and maintains the turgidity of the plant. The efficiency of inoculation for better results is influenced by the proper availability of phosphorus and potassium. As these elements are directly involved in nutrition of legumes and help to improve the root as well as shoot growth of the crop. These results are in agreement with the findings of Habbasha who reported that foliar application of potash increased no. of leaves branches and stem length in peas. El-Habbasha *et al*., (1992)

Costa and Paulino (1992) observed that with the application of potassium, biomass production was found increased. Hanolo *et al*., (1994) reported that with the application of potash at the rates of 0, 50, 100, 150 and 200 kg KCl/ha, plant growth and seed yield of peas was found increased with the increased of potash rate.

4.3.2. Number of leaves per plant

Analysis of variance revealed significant effect of different potash levels on number of leaves per plant. Plant vegetative growth was found increased with the numbers of leaves due to high potash concentration in the plant. The results are presented in figure 4.13 (b) which showed statistical significance for cultivars, levels of potash and their interactions.

The effect of potash on cultivars showed that Climax ousted Meteor by giving 73.74 numbers of leaves as compared to 64.73 whereas, treatment means for potash levels showed significant difference among them. T_4 (K100Kg ha^{-1}) was found at the top with 78.52 numbers of leaves, followed by T_4 72.876 while, T_0 (control) remained at the bottom with 60.113 numbers of leaves. Treatment means followed the sequence T_4, T_5, T_6, T_7, T_3, T_2, T_1 and T_0 in descending order as per their performances.

Interaction among cultivars and treatment gave Climax with T_4 (K100 Kg ha^{-1}) remained at the top, while comparable with Meteor T_4 (K100 Kg ha^{-1}) was at 2nd position, whereas Meteor in T_0, and T_1 performed badly and were found at the bottom. Finally, it was concluded that T_4 (K100Kg ha^{-1}) was better in both the cultivars. All other combinations remained in between and showed intermediately results.

These results showed that the level of K with 100 Kg ha^{-1} was observed better for both the cultivars as compared to other levels of K. Potassium plays a vital role in essential metabolic processes i.e. photosynthesis, respiration and transpiration of assimilates from one plant part to another. These results are in agreement with the findings of El-Habbasha *et al.*, (1992) who reported that with the foliar spray application of potassium (0, 2 an d 3 times with 15 days intervals) to peas crop, it was observed that the decrease in plant height, increased the number of leaves, branches, and shoot dry weight while two sprays of potassium effected seed yield increased by 42.2 and 24.1% as compared to the control. He also concluded that seed yield, length of pods, seed size, numbers of seed were found increased. Costa and Paulino (1992) reported that with the application of potassium, the biomass, nodulation, phosphorus and nitrogen uptake were found increased. Hanolo *et al.*, (1994) found that potassium was effective for the increase of plant growth and seed yield with the increase of potassium rate.

4.3.3. Leaf Area (cm^2)

Leaf area of peas showed significant results which are presented in figure 4.13 (c). Analysis of variance table gave significant results for cultivars and potash levels. Data regarding the cultivars showed that Meteor produced leaf area of 217.91 cm^2 which Climax gave leaf area of 211.31 cm^2. Whereas, treatment means for potash levels revealed a small difference among them. In case of potash levels T_4 (K100Kg ha^{-1}) was found at top with 255.00 cm^2 followed by T_3 with 241.75cm^2, while T_8 was at the bottom with 168.00 cm^2. The means values followed a sequence of T_4, T_3, T_0, T_5, T_6, T_2, T_1 and T_7.

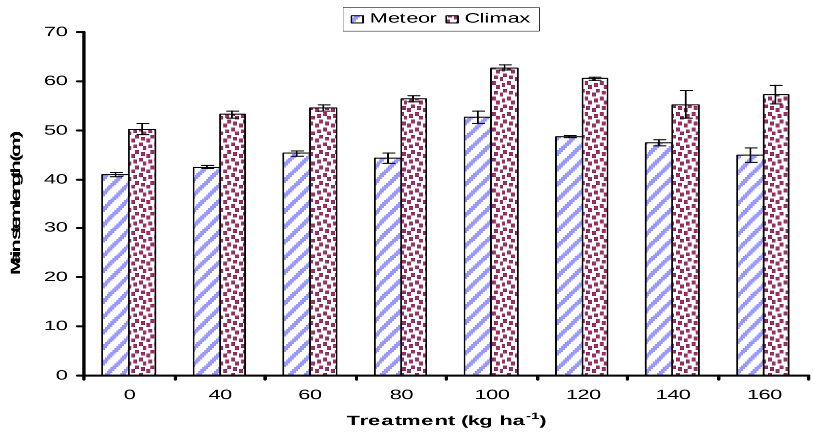
The interactions among the cultivar showed that Meteor with treatment T_4 (P120 Kg ha^{-1}) was at the top, but Climax in treatment T_4 (K100 Kg ha^{-1}) at 4^{th} position whereas Climax with T_7 at last position. Meteor, behaved comparatively better than Climax. Treatment T_4 (K100 Kg ha^{-1}) showed better results for both the cultivars. All other combinations showed overlapping results. These results showed that K 100 Kg ha^{-1} better for both Cultivars as compared to other levels of potash.

These results are in accordance with the work of following scientist, El-Habbasha *et al*., (1992) tested three treatments of potassium as foliar spray (0, 2 and 3 times with 15 days intervals) given to a peas seed crop in the field. Spraying potassium 2-3 times decreased plant height, increased number of leaves, branches, and shoot dry weight. Two sprays of potassium increased the seed yield by 42.2 and 24.1% as compared to the control in the first and second seasons, respectively. Three spray of potassium doubled the seeds yield, length of peas pods, seed size, number of seeds/pod; total carbohydrate and nitrogen of peas pods were increased,

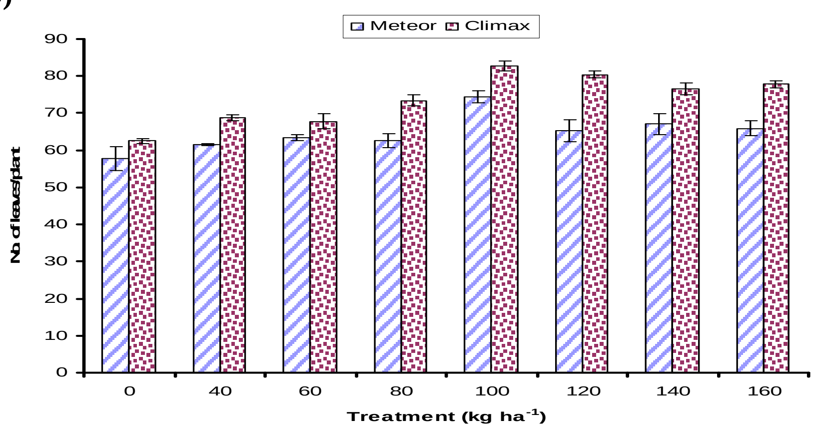
Phosphorus fertilizer application alone did increase root weight but had a negligible effect on number of nodules. However, with potassium the nodule numbers and size both were improved significantly (Shaukat, 1994).

Costa and Paulino (1992) reported that in a green house pot experiment using ultysol with Pigeon peas (*Cajanus cajan* L.), fertilized with potassium, increased biomass production, nodulation and phosphorus, nitrogen uptake over the control values. Hanolo *et al*., (1994) conducted field trial by giving potassium at the rates of 0, 50, 100, 150 and 200 kg KCl/ha to peas seed crop and concluded that plant growth and seed yield were increased with the increasing rates of potassium.

(a)



(b)



(c)

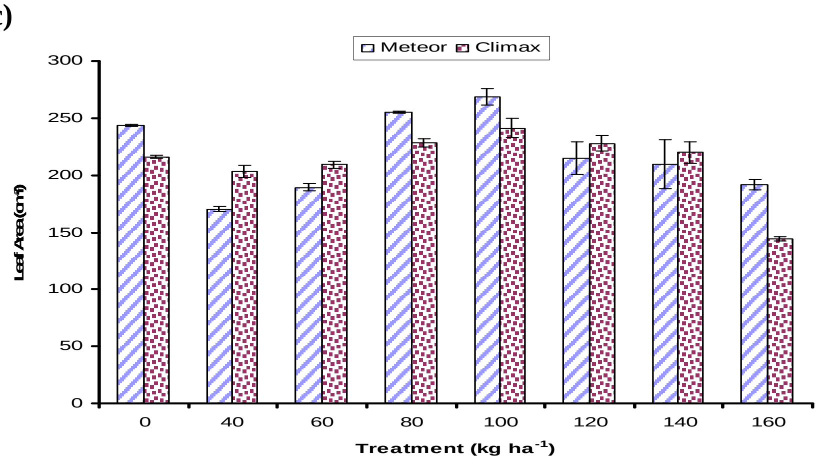


Fig.4.13:- **Influence of different potash levels on peas (a) Main stem length (cm) (b) Number of leaves per plant and (c) Leaf Area (cm^2)**

4.3.4. Number of pods per plant

The results pertaining to number of pods per plant are presented in figure 4.14 (a), which clearly indicated the effect of different potash levels. Statistically significant variations were observed between these cultivars. These results indicated significant differences in mean values of cultivars, potash levels and their interactions.

Climax and Meteor produced 22.42 and 21.48 number of pods per plant respectively. Whereas, treatment means for potash levels showed significant difference among them. Treatments means values revealed that T_4 (K 100 Kg ha^{-1}) was remained at the top with 25.12, followed T_5 (23.15) number of pods per plant, while T0 (control) remained at the bottom with 19.44 number of pods per plant. The results indicated that treatment means followed a sequence of T_4, T_5, T_3, T_6, T_7, T_2, T_1 and T_0. The Interaction of Cultivars and Treatments gave T_4 (K120Kg ha^{-1}) with better results for both Climax and Meteor, whereas Meteor was found at the last two positions.

With regard to potash levels, T_4 (K100 Kg ha^{-1}) remained better for both the cultivars. Moreover, Climax performed comparatively better than Meteor. All other combinations of treatments mean were in between by showing overlapping results. These results proved that the level of K (100 Kg ha^{-1}) was better for both cultivars as compared to other levels of K. These results are in concurrence with findings of following scientists, El-Habbasha *et al*., (1992) reported that the decrease in plant height while, the number of leaves, branches, and shoot dry weight were increased with the application of spray of 0, 2, 3, time at 15 days interval with the more seed yield upto 42.2 and 24.1% respectively as compared to the control.

Ahmad, 1973 and Mushtaq *et al.* 1986 reported that the number of pods per plant, number of grains per pod, straw yield, total dry matter production and grain yield of legume crops were increased with the application of potassium.

4.3.5. Length of pod (cm)

Observations recorded in relation to length of pod (cm) were subjected to analysis of variance and results obtained are presented in figure 4.14 (b) which revealed significant results for cultivars, treatments and their interactions.

As far as the cultivars are concerned, Climax showed 5.87 cm while Meteor gave 5.63 cm length of pod respectively. Whereas, treatment means for potash levels showed significant difference among them. T_4 (K100 Kg ha^{-1}) was at the top with 6.63 cm length of pod, followed by T_6 (5.92 cm) while, T_0 (control) was at the bottom with 5.19 cm length of pod. Treatment means followed a sequence of T_4, T_6, T_5, T_7, T_3, T_2, T_1 and T_0.

The interaction of cultivars and treatments revealed that, Climax with T_4 (K100 Kg ha^{-1}) was at the top, and Meteor also gave better results with T_4 (K100 Kg ha^{-1}) but found at 4th position. In general T_4 (K100 Kg ha^{-1}) was better for both the cultivars. Moreover, Climax showed comparatively better results as compared to Meteor. All other combinations were found in between by showing almost similar results. These results indicated that K 100 Kg ha^{-1} was better combination for both cultivars as compared to other levels of K.

Similar findings were reported by, El-Habbasha *et al*., (1992) who conducted that 42.2% to 24.1% of yield increase was observed with the application of foliar spray of 0, 2, 3, time with15 days interval. It also decreased plant height, while no. of leaves, branches and shoot dry weight were showed an increasing.

Hanolo *et al*. 1994 and Naik, 1989) reported that plant growth and seed yield increased in peas with the increasing of potassium rate.

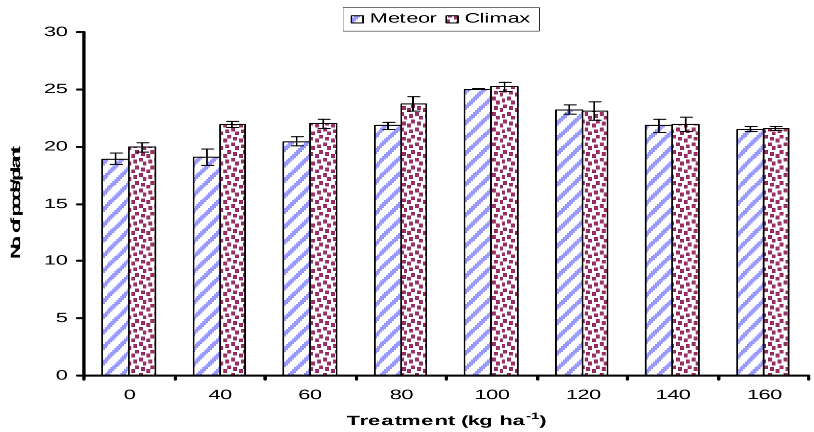
4.3.6. Number of seeds per pod

The results for the number of pods per plant are presented in figure 4.14 (c), which clearly indicated the effect of different potash levels. Significant variations were observed between these cultivars which showed significant results among cultivars, potash levels and their interactions.

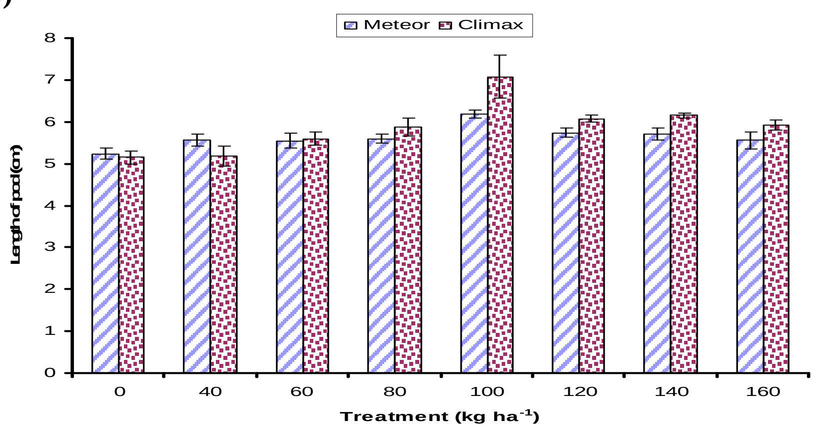
As far as the comparison of cultivars is concerned Climax produced more number of seeds with 6.03 as compared to Meteor with 5.61 numbers of seeds per pod. Treatment means for potash levels showed significant difference. Results revealed that T_4 (K100 Kg ha^{-1}) was at the top with 6.57 number of seeds per pod, followed by T_6 (6.00) while T_0 (control) was found at the bottom with 5.31 number of seeds per pod. The treatment means followed a sequence of T_4, T_5, T_6, T_7, T_2, T_1, T_3 and T_0. Interaction of cultivars and treatments indicated that Climax in T_4 (K100 Kg ha^{-1}) remained at the top, followed by T_6, T_5 and T_7 Meteor with T_4 (K 100 Kg ha^{-1}), whereas both Meteor and Climax in T_0 occupied the last two positions. In general, T_4 (K100 Kg ha^{-1}) gave better results for both the cultivars. All other combinations of treatments were in between by showing almost similar results. These results showed that K 100 Kg ha^{-1} level was better for both cultivars as compared to other Variables. These results are in line with the findings of Naik, 1989 and Mushtaq *et al.* 1986 who reported that application of potassium increased the number of pods per plant, number of grains per pod, straw yield, total dry matter production and grain yield of legume crops.

El-Habbasha *et al*., (1992); Costa and Paulino (1992) observed that with the application of potassium as foliar spray (0, 2 and 3 times with 15 day's intervals) to peas seed crop increased the seed yield upto 42.2 and 24.1% as compared to the control.

(a)



(b)



(c)

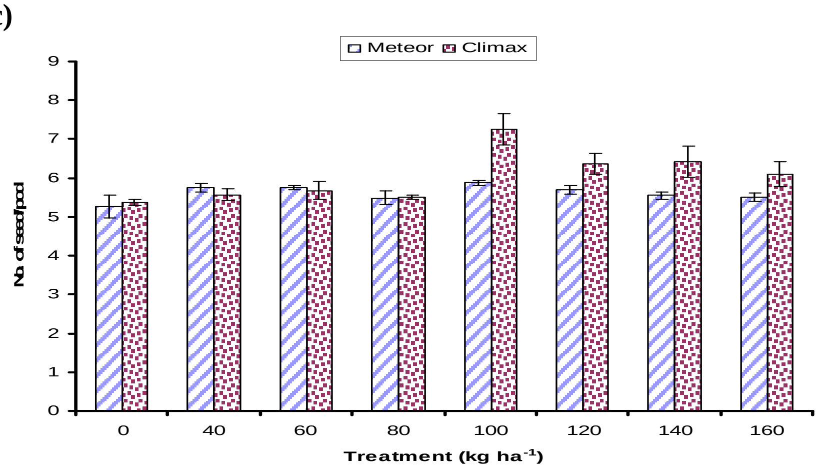


Fig.4.14:- **Influence of different potash levels on peas (a) Number of pods per plant (b) Length of pod (cm) and (c) Number of seeds per pod**

4.3.7. 1000 seed weight (g)

Data regarding 1000 seed weight (g) was collected, organized, subjected to analysis of variance and results obtained are presented in figure 4.15 (a) which indicated significant results for cultivars, potash levels and their interactions.

The results regarding cultivars (Climax & Meteor) showed similar results by showing 139.00 g as compared to 139.00 g 1000 weight. Whereas, treatment means for potash levels showed significant difference among them. T_4 (K 100 Kg ha^{-1}) was at the top with 150.50 g followed by T_5 (147.75 g) while T_1 was at the bottom with 132.13 g 1000 weight. Treatment means followed a sequence of T_4, T_5, T_3, T_6, T_7, T_2, T_0 and T_1.

Figure portrayed the interaction of these factors, Climax with T_4 (K 100 Kg ha^{-1}) remained at the top, whereas T_1 seemed at the last position. Overall T_4 (K 100 Kg ha^{-1}) remained better for both cultivars. In any case, both cultivars (Climax & Meteor) gave same results.

4.3.8. Seed yield per hac (tons)

Seed yield in peas was influenced by varying plant nutrition requirements during its growth period. Application of fertilizer at suitable stage is necessary to achieve maximum yield of the crop. In addition, for seed crop the effect of fertilizer on seed nutrient contents are also important.

Data in relation to seed yield per hectare (tons) was subjected to analysis of variance and results are presented in figure 4.15 (b) which indicated significant results for cultivars, potash levels and their interactions.

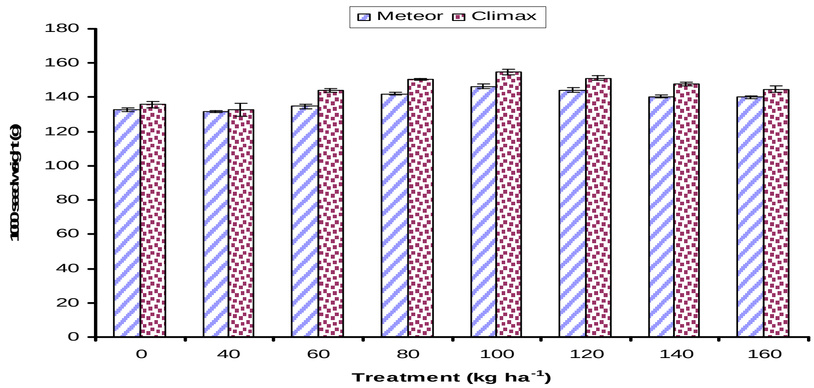
In case of cultivars, Meteor showed yield with 2.15 tons seed, while 2.15 tons seed yield was achieved from Climax. There were no differences between both Meteor and Climax. Treatment means for phosphorus levels showed significant difference among themselves. T_4 (K100 Kg ha^{-1}) remained at the top with 2.95 tons seed yield, followed by T_4 (2.24 tons) while T_1 remained at the bottom with 1.75 (tons). Treatment means followed a sequence of T_4, T_3, T_5, T_6, T_7, T_2, T_0 and T_1.

The interaction of cultivars and treatments are concerned, Climax with T_4 (K 100 Kg ha^{-1}) remained at the top, followed by Meteor in T_4 (100 Kg ha^{-1}), Whereas Climax in T_1 and Meteor in T_0 at the last two positions. Overall T_4 (K100 Kg ha^{-1}) remained better for both cultivars. All other combinations remained in between by showing overlapping results. These results revealed that K 100 Kg ha^{-1} remained better for both cultivars as compared to other levels of K. Similar results were found by following workers.

Haeder (1990) found in an open-air pot trial, with semi-leafless fodder peas given 4.5, 16 and 28 mg potassium/100 g soil, seed yield was increased with the increase of potassium rate given to the plants respectively with increase of starch percentage as well.

El-Habbasha *et al*., (1992) tested three treatments of potassium as foliar spray (0, 2 and 3 times with 15 days intervals) given to a peas seed crop in the field. Spraying potassium 2-3 times decreased plant height, increased number of leaves, branches, and shoot dry weight. Two sprays of potassium increased the seed yield by 42.2 and 24.1% as compared to the control in the first and second seasons, respectively. Three spray of potassium doubled the seeds yield. Length of peas pods, seed size, number of seeds/pod, total carbohydrate and nitrogen of peas pods were increased by potassium spray. Costa and Paulino (1992) found that in a green house pot experiment using ultysol with Pigeon peas (*Cajanus cajan* L.), fertilized with potassium increased biomass production, nodulation and phosphorus, nitrogen uptake over control values. Hanolo *et al*., (1994) conducted a field trial with potassium given at rates of 0, 50, 100, 150 and 200 kg KCL ha^{-1} to a peas seed crop. Plant growth and seed yield increased as the potassium rate increased.

(a)



(b)

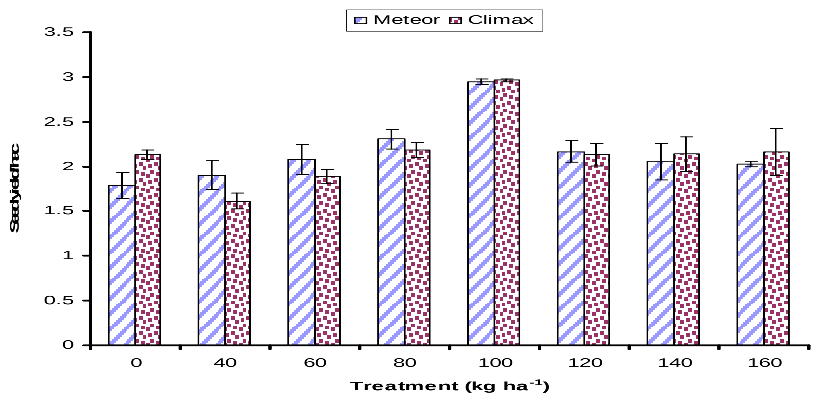


Fig.4.15:- **Influence of different potash levels on peas (a) 1000 seed weight (g) and (b) Seed yield per hectare (Tons)**

4.3.9. Chemical composition of the plant parts (Leaves, Stems and Pods)

Balanced nutrition to the seed crop may improve seed quality (George *et al.*, 1980). This increases the reserve food of the seed and enhances resistance against the deterioration under adverse storage conditions and withstands against environmental field conditions at seed emergence time.

4.3.9.1.1. Chemical composition of peas Leaves

Data regarding chemical composition of the peas leaves were subjected to analysis of variance and results obtained are presented in figure 4.16. In peas leaves, nitrogen, ash and protein are indicating significant results for cultivars, potash levels and their interactions.

The presence of ash in Meteor was 14.00% as compared to Climax with 13.97%, Nitrogen was found better in Meteor with 1.84% while Climax produce 1.82% Nitrogen whereas, Protein was better in Climax with 11.56% as compared to Meteor with 11.48%. A glance on the results of ash indicated that T_4 showed at top with 14.63% as compared to other treatments while, T_6 with 1.83% was found at the bottom. As far as Nitrogen concerned, T_4 showed superiority with 1.87% as compared to other variables whereas, T_0 was found at the bottom with 1.80%. Mean values for protein indicated the supremacy of T_4 with 11.63% while, T_7 was found at bottom with 11.39%. All other treatments values were indicated fall in between T_4 and T_7.

Interaction of cultivars and treatments for the aspect of nitrogen showed that Meteor was at top with T_4 (100kg K_2O ha^{-1}) whereas, Climax was found at bottom with T_0. As far as the interaction of the treatments and cultivars are concerned T_4 with (100 kg K_2O ha^{-1}) were showed superiority in Climax cultivar while Meteor in T_7 and T_0 perform badly and occupied at the lowest positions.

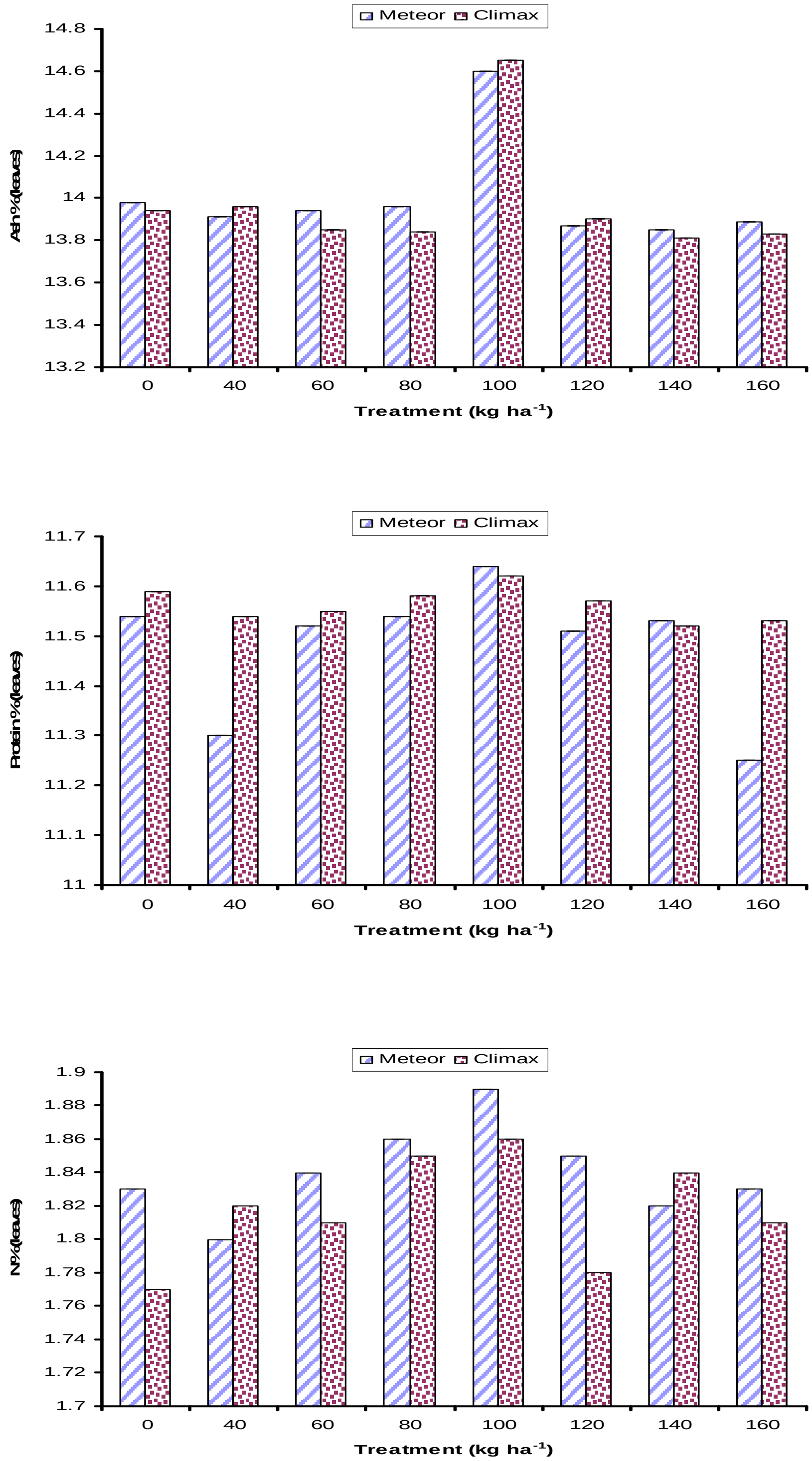


Fig.4.16:- Influence of different potash levels on peas chemical composition (Ash, Nitrogen and Protein) of Peas Leaves

4.3.9.2. Chemical Composition of Peas Stems

Potassium is an important element for high quality seed production of peas. It effects on a number of planting functions. Thus acts as catalytic agent to activate metabolic process like photosynthesis, spreading up the flow of assimilation to all parts of the plants as well as enzymes for synthesis of proteins and quality which are vital for better growth and developments as well as seed yield. Seed yield in peas is affected much with the variable nutrients availability during its growth stages which can be overcome through the supplementary of fertilizers at time they are required. Moreover, effect of fertilizer applications on the nutrient reservoir of seed is also crucial.

Interaction of cultivars and treatments for Nitrogen showed that Climax with T_2 (K 60 kg ha^{-1}) was at the top, while, Meteor in T_1 was found at second position, whereas Climax in T_5 was found at last position. T_1 was better for both cultivars.

Protein in Climax was 11.56% as compared to Meteor with 11.48%, whereas, T_7 with 11.39% was found at the lower position. Interaction of cultivars and treatments for Protein showed Meteor with T_4 (K 100 Kg ha^{-1}) was at the top position whereas, Meteor in T_7 occupied at the last position.

Ash was observed better in Climax with 11.92% as compared to Meteor with 11.69%. T_4 with 12.24% was found superior while, T_7 with 11.594% was at the bottom while, other combinations of treatments were found in between. The interaction of cultivars and treatments showed that T_4 was superior with Meteor followed by Climax under the same variable T_4 (100 kg K_2O) whereas Meteor was observed at the bottom. In general, T_4 (100 kg K_2O ha^{-1}) was found superior as compared to other variables in both the cultivars. Meteor has same value with 1.33% as compared to Climax with 1.33%. T_4 (100 kg K_2O ha^{-1}) was better with 1.35% of N as compared to control. T_5 with 1.31% was found at the bottom.

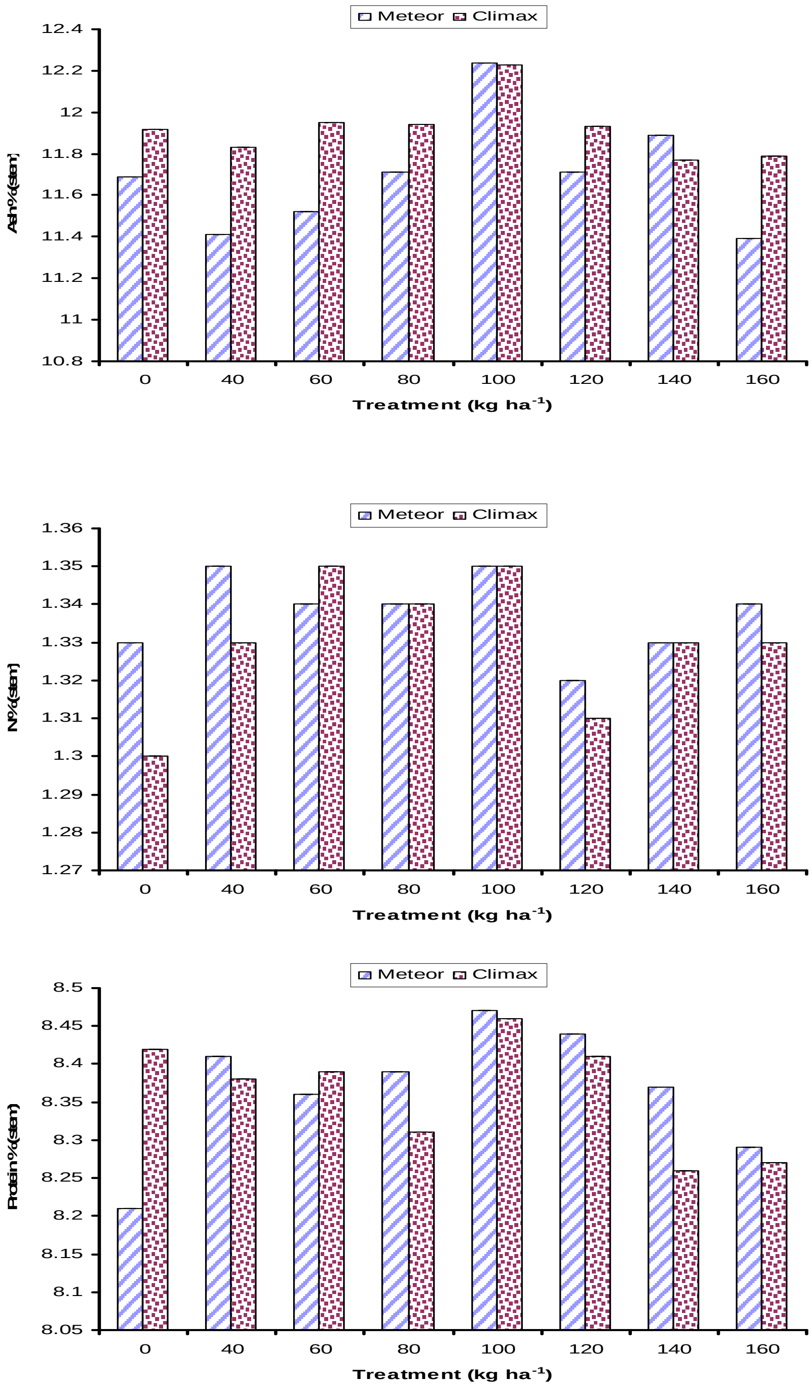


Fig.4.17:- **Influence of different potash levels on chemical composition (Ash, Nitrogen and Protein) of Peas Stems**

4.3.9.3. Chemical composition of peas Pod + Seeds

Phosphorus application at suitable stage is necessary to achieve maximum yield of the crop. Moreover, the effect of fertilizer on seed nutrient contents for seed crop is important.

Data regarding chemical composition of peas pod + seeds were subjected to analysis of variance and the results obtained are presented in figure 4.18. The chemical composition (nitrogen, ash and protein) showed significant results for cultivars, phosphorus levels and their interactions.

Ash in Climax was 4.55% as compared to Meteor with 4.54% while treatments mean showed that T_4 (4.72%) at the top and T_1 was found at the bottom with 4.48% while the results for other treatments were in between T_4 and T_1. Interaction of cultivars and treatments for the aspect of ash showed that Meteor with T_4 (K100 Kg ha^{-1}) at the top followed Climax in T_4 (K100 Kg ha^{-1}), whereas Meteor in T_4 and Climax in T_0 were occupied at last two positions.

Nitrogen was better in Climax with 3.43% as compared to Meteor with 3.37%. The Nitrogen was high in T_4 (3.46%) while, T7 with (3.37%) was located at bottom, other treatments showed results in between T_4 and T_7. Interaction of cultivars and treatments for Nitrogen showed Meteor with T_4 (K 100 Kg ha^{-1}) was at the top, Climax in T_4 (K100 Kg ha^{-1}), whereas Meteor in T_0, T_1, $T_{2,}$ T_6 and T_3 occupied at last positions.

Protein was better in Climax with 21.45% as compared to Meteor with 21.13%. Protein was greater in T_4 (21.644%) while T_7 with (20.99%) occupied at bottom. Interaction of cultivars and treatments for Protein showed Meteor with T_4 (K 100 Kg ha^{-1}) was at the top, followed Climax in T_4 (K 100 Kg ha^{-1}), whereas Meteor in T_0 and T_1 occupied at last two positions. Overall T_4 (K100 Kg ha^{-1}) remained better for both cultivars.

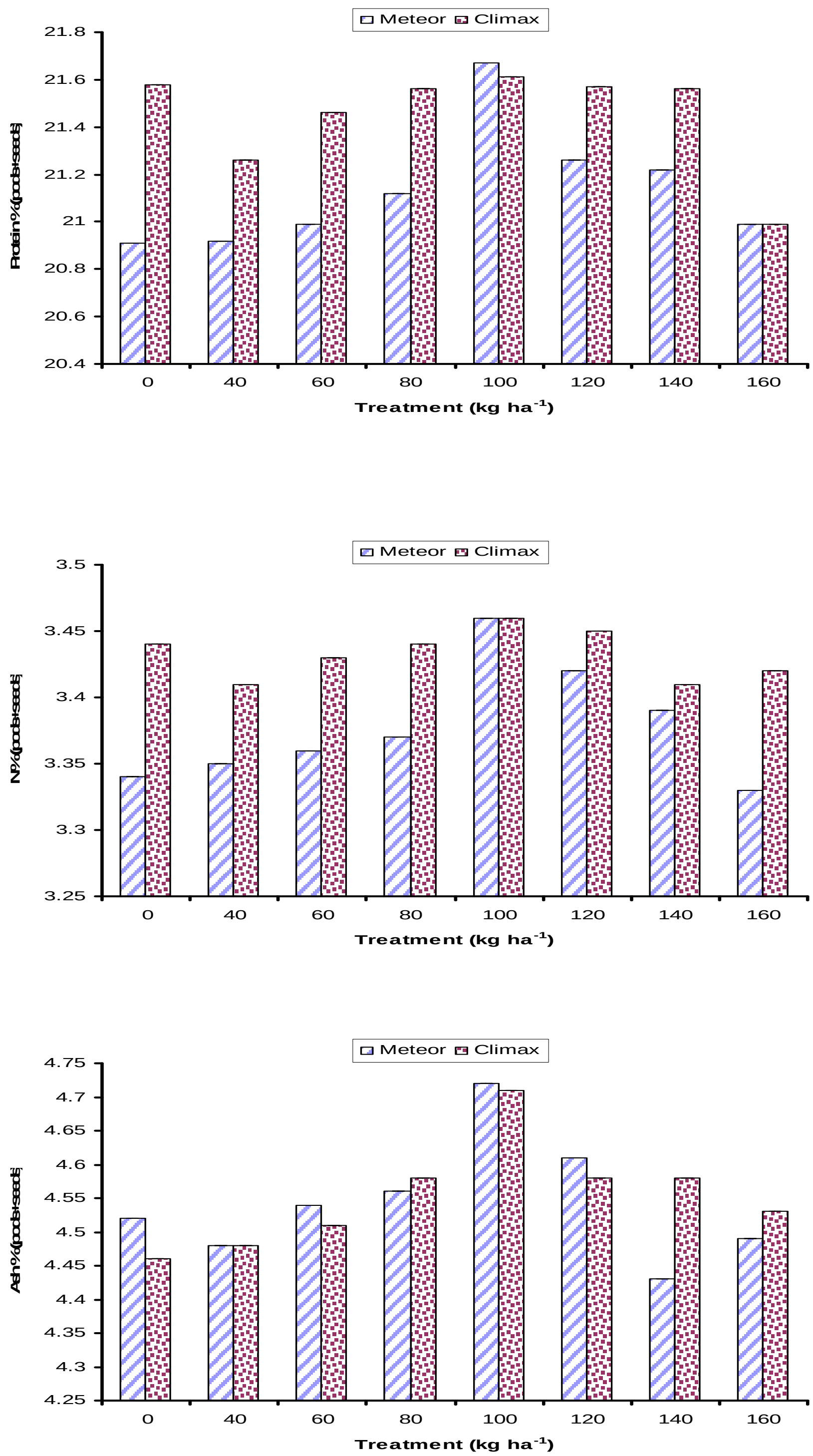


Fig.4.18:- **Influence of different potash levels on chemical composition (Protein, Nitrogen and Ash) of Peas Pod + Seeds**

4.3.10. Seed nutrient concentration (N, P, K and protein contents)

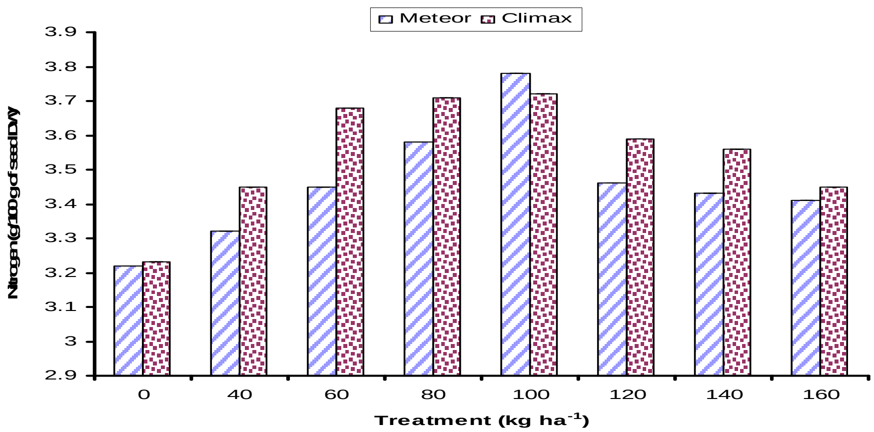
Seed nutrient concentration in peas is also influenced by varying plant nutrition requirements during its growth period. Application of fertilizer at root shoot development stage is necessary to achieve maximum yield of the crop. In addition, for seed crop the effect of fertilizer on seed nutrients are also important. Data related to chemical composition of the peas seed nutrient concentration were subjected to analysis of variance and results are presented in figure 4.19(a, b) which indicated that the results for nitrogen, ash and protein were significant results for cultivars, potash levels and their interactions.

Potash in Climax was 0.70% as compared to Meteor with 0.70%, Treatments mean showed that T_4 with 0.94% and T_0 with 0.58% were found at bottom. The results of other treatments were in between T_4 and T_0. Interaction of cultivars and treatments for potash showed that Climax with T_4 (K100 Kg ha^{-1}) was at the top while Meteor with T_4 (K100 Kg ha^{-1}) was occupied at second position whereas, Climax in T_7 and Meteor in T_0 were found occupied at last two positions.

Nitrogen was better in Climax with 3.54% as compared to Meteor with 3.45%. Nitrogen was high in T_4 (3.74%) while T_0 with 3.23% were observed at the bottom. Other treatments were in between T_3 and T_0. Interaction of cultivars and treatments for Nitrogen showed that both cultivars, Meteor and Climax with T_4 (K 100 Kg ha^{-1}) were at the top whereas found at the bottom with T_0.

Phosphorus was better in Climax with 0.3331% as compared to Meteor with 0.31%. Treatments mean showed that T_4 with (0.38%) was at top while T_0 with (0.26%) found at bottom while other treatments showed results were in between T_4 and T_0. Interaction of cultivars and treatments for Phosphorus showed that both Climax and Meteor were better with T_4 (K100 Kg ha^{-1}) whereas they were found at bottom in T_4.

Protein was better in Climax with 23.93% as compared to Meteor with 23.89%, t Protein was high in T_4 with 27.14% but T_0 was at bottom with 21.35%. Interaction of cultivars and treatments for Protein depicted that Climax in T_4 (K 100 Kg ha^{-1}) was at the top while Meteor in T_4 with (K100 Kg ha^{-1}) whereas both Meteor and Climax were at bottom with T_0. Results showed that K100 Kg ha^{-1} gave better results for both cultivars.



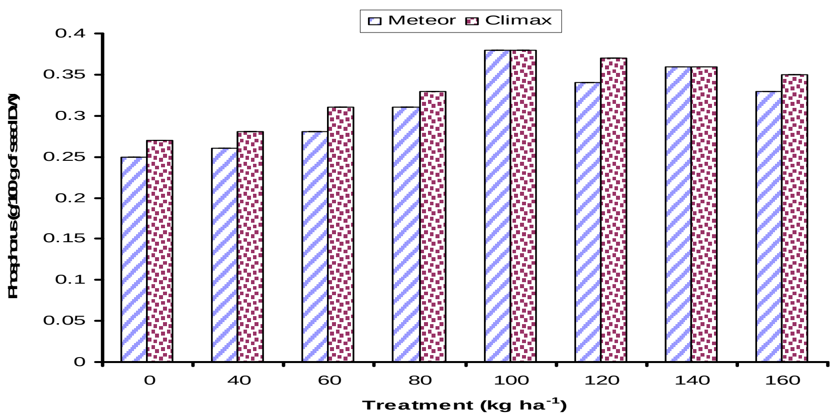
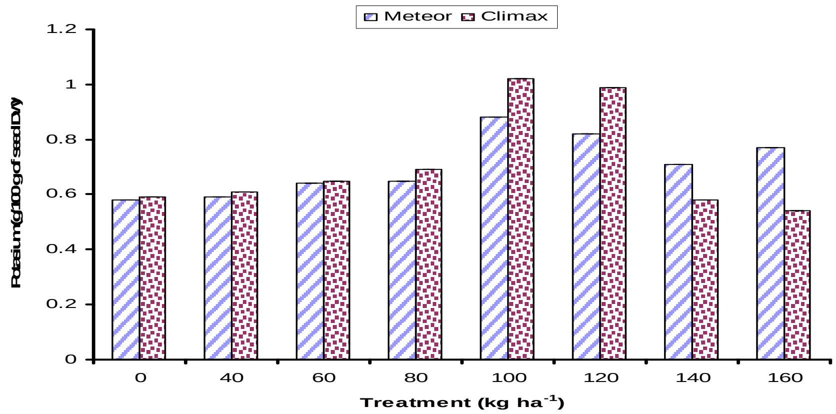


Fig.4.19 (a):- Influence of different potash levels on peas Seed nutrient concentration (Nitrogen and Phosphorus)



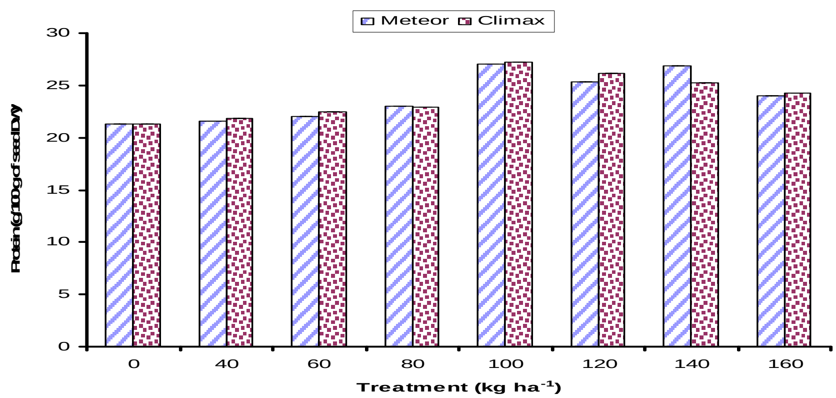


Fig.4.19 (b):- Influence of different potash levels on peas seed nutrient concentration (Potash and Protein)

4.3.11. Electrical conductivity test

Data regarding electrical conductivity was conducted and subjected for the statistical analysis of variance and the results obtained are presented in figure 4.20 (a). They revealed significant results for cultivars, treatments and their interactions. Climax performed comparatively better than Meteor, for the aspect of showing 22.56 and 20.57 electrical conductivity respectively.

As far as the treatments are concerned, T_4 took the 1st position, followed by T_3, Whereas, T_0 and T_7 occupied last two positions by showing less electrical conductivity than control. Treatments mean followed a sequence of T_4 (24.25), T_3 (23.87), T_2 (22.06), T_1 (21.62), T_5 (21.62), T_6 (20.12), T_7 (19.62) and T_0 (19.37). In case of interactions of cultivars and treatments, Climax and Meteor both were superior in T_4 whereas; Meteor in treatments T_0 and T_1 were occupied last two positions.

These results are in agreement with the findings of Matthews and Bradnock (1968) who concluded that by using the test for peas seeds a procedure was standardized by the Processors and Growers Research Organization (P.G.R.O., 1981). This test has been accepted in UK as an official vining peas seed test for germination (Hadavizadeh and George, 1988; Parera *et al*., 1995). Bedford (1974) found the relationship between electrical conductivity seed and vigour values with aspect to the field emergence potential of vining peas.

The electrical conductivity test is a rapid, cheap and simple test. Several factors affect the test. The factors which directly affect the results in peas and soybean are pH, soaking temperature, soaking duration, temperature at evaluation, initial seed moisture contentss and seed size (Matthews and Bradnock, 1968; Bradnock and Matthews, 1970; Tao, 1978). The electrical conductivity of the seed leachate, and the amount of free amino acids and sugar were found to be higher from larger seeds than smaller seeds of cowpeas (Paul Ramaswamy, 1979). Hampton *et al*., (1992) suggested the use of a bulk conductivity testing method for large seeds of legumes such as mung bean (*Vigna radiate*), soybean (*Glycone max*) and French bean (*Phaseolus vulgaris* L.).

4.3.12. Emergence (%)

Data for this parameter were collected and subjected to statistical analysis of variance. The results are presented in figure 4.20 (b). The results indicated that both cultivars were better with 89.12 % and 88.15% respectively.

A glance of treatments means revealed that T_4 at 1st position, followed by T_3, Whereas, T_1 and T_2 were observed at the last two positions by showing less emergence. Treatment means followed a sequence of T_4 (97.87), T_3 (93.62), T_5 (90.50), T_0 (89.00), T_6 (87.62), T_7 (87.00), T_2 (83.00) and T_1 (80.50).

Interaction of cultivars and treatments showed that Climax with T_4 was at the top, followed by Meteor. Whereas, Meteor with T_1 occupied at the last position.

In this study T_5, T_7 and T_0 showed almost similar results. This situation clears the pictures that potash application directly proportional to emergence which exhibits less seed vigour. Seed yield and quality in peas is also affected by varying plant nutrition availability during its growth stages. The application of fertilizer at the critical stage is necessary to achieve maximum yield from the crop. Moreover, for seed crop the effect of fertilizer on seed nutrient contents are also important.

These results are in accordance with the findings of Abdella and Roberts, 1969; Perry, 1977; Egli and Tekrony, 1979, who reported that a field emergence percentage test gives information about seed vigour and gives more accurate data to predict the storability of the seed lot tested.

4.3.13. Germination (%)

Data for Germination were collected and Subjected to statistical analysis of variance. The results are presented in figure 4.20 (c). The data revealed significant results for cultivars, treatments and their interactions.

Meteor performed comparatively better than Climax by showing 94.28% and 92.81%..

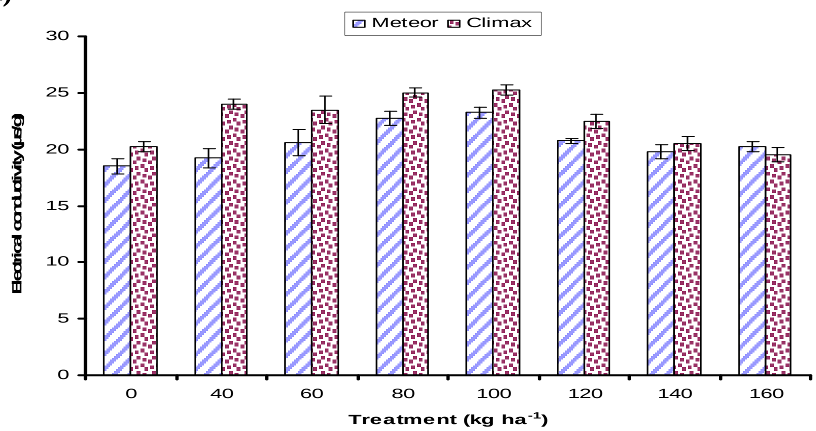
As far as the K levels are concerned, T_0 was at the 1st position, followed by T_4, where as T_5 and T_6 occupied at last two positions. Treatments mean followed a sequence of T_0 (96.37%), T_4 (96.37%), T_2 (94.12%), T_1 (93.87%), T_3 (92.37%), T_7 (92.37%), T_6 (91.87%) and T_5 (91.00%).

Interactions of cultivars and treatments showed Meteor with T_4 remained at the top followed by Meteor in T_0. Climax in T_5 and T_1 occupied at the last two positions.

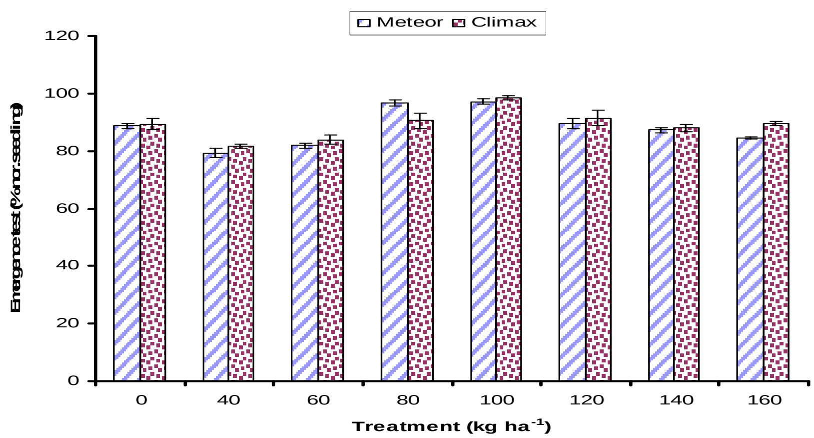
Seed yield and quality in peas is also affected much by varying plant nutrition requirements during its critical growth stage. The application of fertilizer at the most critical stage is compulsory to achieve maximum yield from the crop. Moreover, the effects of fertilizer on seed nutrient contents are also important.

Germination is a test for seed crop to measure seed vigour, in this study T_1 and T_5 showed similar results. This situation clear that lesser the dose of Phosphorus applied the lesser Germination, which indicated the lower seed vigour. Germination percentage test gives estimation about field survival of progeny plants from the seed and results can be used to differentiate between different seed lots.

(a)



(b)



(c)

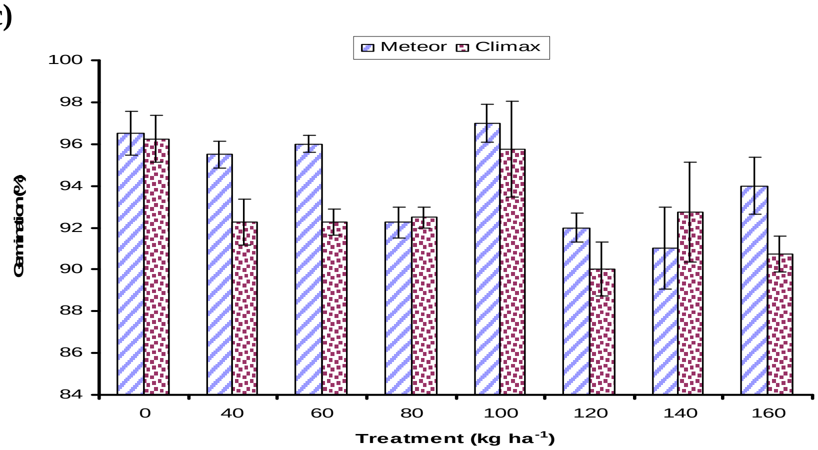


Fig.4.20:- **Influence of different potash levels on peas (a) Electrical conductivity (b) Emergence %and (c) Germination %**

Conclusion:

Different potash levels were studied in two Peas cultivars, Meteor and Climax. Meteor obtained 2.15 tons seed yield as compared to Climax with 2.15 tons seed yield. Climax with T_4 (K100 Kg ha^{-1}) was at the top, followed by T_6, T_5 and T_7. The results showed that K 100 Kg ha^{-1} was better for both cultivars as compared to other variables of K. With respect to seed vigour tests, results showed that potash with 100 Kg ha^{-1} was better for both cultivars as compared to other levels of potash. Different chemical composition tests of leaves, stems and pods were observed to see the concentration of nitrogen, phosphorus, potassium and protein. It was observed that Climax cultivar was better as compared to Meteor. It is concluded that Climax cultivar with potash level 100 Kg ha^{-1} performed better as compared to other levels of potash.

4.4. EXPERIMENT NO.4:-

QUALITATIVE AND QUANTITATIVE RESPONSE OF PEAS (*Pisumsativum* L.) TO JUDICIOUS APPLICATIONS OF IRRIGATION WITH P AND K.

This experiment was planned to assess the effects of different combinations of phosphorus, potash and irrigation and their interactions with which individually assess their efficacy during earlier experiments. Phosphorus and potash were applied at the constant dose to all treatments N while was applied @ 80 Kg ha^{-1}.

4.4.1. Main stem length (cm)

Data regarding main stem length were collected, organized and subjected to analysis of variance. The results obtained are presented in figure 4.21 (a). It indicated significant results for cultivars, treatments and their interactions.

As far as the cultivars are concerned, Climax and Meteor both were showing similar results with 57.87 cm long main stem. Whereas, treatment means indicated significant difference among them. T_3 (Irrigation upto seed filling+ P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top with 60 cm stem length, followed by T_2 (52.62 cm) while T_0 (control) remained at the bottom with 48.25cm stem length. Treatment means followed a sequence of T_3, T_2, T_1 and T_0.

As far as interaction of cultivars and treatments are concerned, Climax in T_3 (Irrigation upto seed filling+ P120 Kg ha^{-1}+ K100 Kg ha^{-1}) remained at the top, Meteor in T_3 obtained best last two positions, whereas Meteor in T_0. T_3 (Irrigation upto seed filling+ P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was better for both the cultivars. Climax performed comparatively better than Meteor. All other combinations were remained in between. The similar results were repeated by Patel *et al*., (1998) who stated that peas cv. “Arbel” significantly increased in plant height, number of branches, leaves per plant, number of pods per plant, grains per pod and pod yield when applied @ 20 kg N/ha + 80 kg P_2O_5/ha + 40 kg K_2O/ha.

Shaukat (1994) reported that with the application of P increased root weight while negligible effects on number of nodules were observed. Vimala and Natarajan (1999) observed that plant height with increasing the rate of N and P was increased as well as the number of branches per plant were found enhanced.

4.4.2. Number of leaves per plant

Data for number of leaves were collected and subjected to analysis of variance. The results are presented in figure 4.21 (b) which showed significant results for cultivars, treatments and their interactions.

The results indicated that cultivars Meteor ousted Climax with 66.87 numbers of leaves as compared with Climax 66.12 whereas; treatment means revealed significant difference among them. T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was found at the top with 69.12 numbers of leaves, followed by T_2 with 67.00 cm, T_1 with 66.00 while T_0 (control) was at the bottom with 63.87 numbers of leaves. Treatment mean values followed a sequence of T_3, T_2, T_1 and T_0.

Interaction of cultivars and treatments indicated Climax T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) remained at the top, followed by Meteor in T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}). Whereas Meteor in T_0, and T_1 were occupied last two positions. Overall T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was better for both the cultivars. In any case, Climax performed comparatively better than Meteor. All other combinations of treatment were in between by showing almost similar results.

These results revealed for different treatments applied indicated that T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 kg/ ha-1) was better for both the cultivars. Although vegetative growth requires N yet for legumes comparatively more P is needed for growth and N fixation which might had contributed on the aspect to get more number of leaves. These results are supporting with the findings of Patel *et al*., (1998) who reported that peas cv. Arbel showed significantly increased in leaves per plant when applied 20 kg N/ha + 80 kg P_2O_5/ha + 40 kg K_2O/ha.

4.4.3. Leaf Area (cm^2)

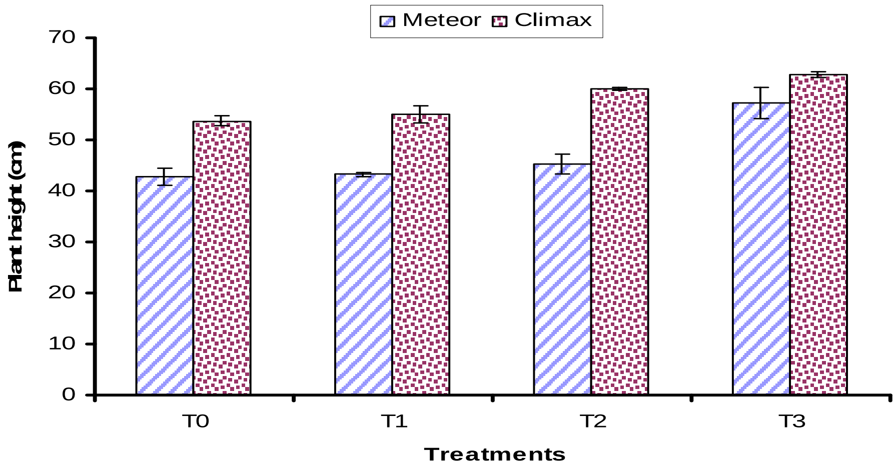
The data pertaining to the parameter were subjected to analysis of variance and results are presented in figure 4.21 (c) which revealed significant results for cultivars, treatments and their interactions.

Among cultivars, Meteor has Leaf area 253.50 cm^2 and Climax has 252.38 cm^2. Whereas, treatment mean values revealed a little difference among them. As far as treatments are concerned T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top with 254.50 cm^2 followed by T_2 253.50 cm^2, while T_1 252.62 cm^2 and T_0 remained at the bottom with 186.38 cm^2 leaf area. Treatment mean values followed a sequence of T_3, T_2, T_1 and T_0.

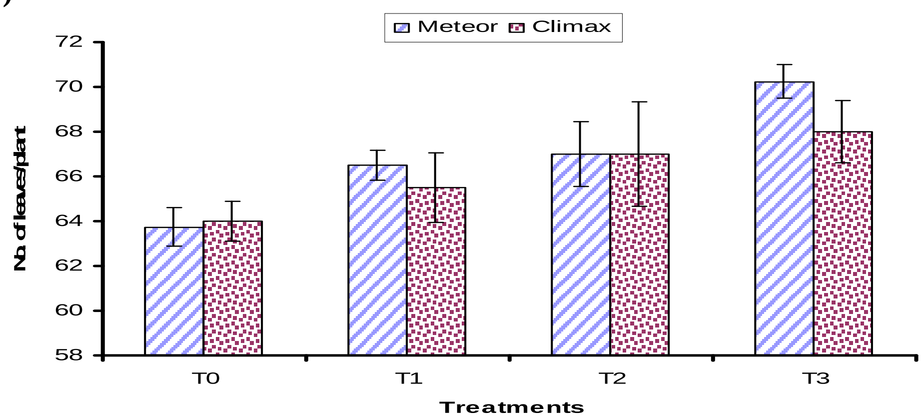
Regarding interaction between Cultivars and treatments, T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) gave better results for both the cultivars, Whereas, Climax with T_0 was at the last position. Climax performed comparatively better than Meteor. Overall T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) remained better for both the cultivars. All other combinations of treatments remained in between and showed almost similar results.

These results are in line with the findings of Patel *et al*., (1998) who reported that peas cv. Arbel significantly increased in leave area when applied 20 kg N/ha + 80 kg P_2O_5/ha + 40 kg K_2O/ha. Vimala and Natarajan (1999) who reported that the increasing P rate the numbers of branch peas plant were found increased. The number of days taken for 50% flowering increased with increasing rate of nitrogen.

(a)



(b)



(c)

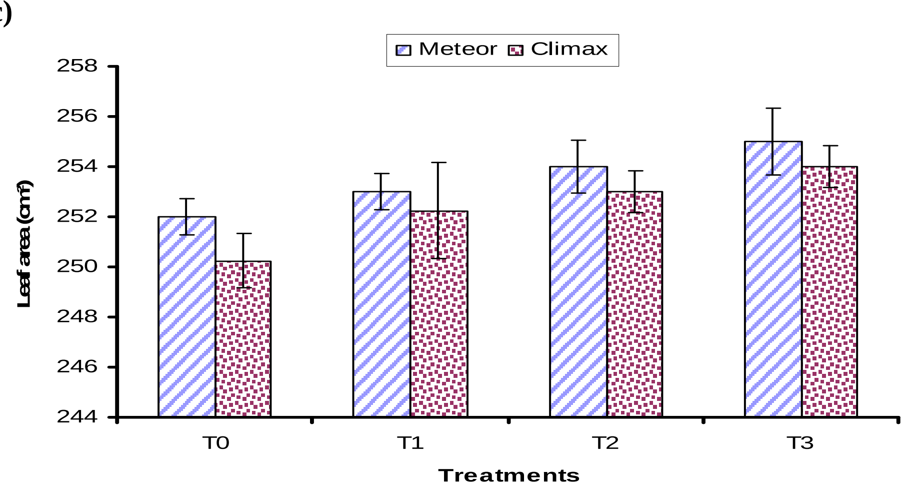


Fig.4.21:- **Qualitative and Quantitative response on (a) Main stem length (cm) (b) Number of leaves and (c) Leaf Area (cm^2) of peas (*Pisum sativum* L.) to judicious applications of irrigation with P and K**

4.4.4. Number of pods per plant

Observations regarding the number of pods per plant were organized and subjected to analysis of variance the results obtained are presented in figure 4.22 (a) which depicted significant results for treatments and their interactions but non-significant among cultivars.

A glance on the results indicated that both cultivars, Meteor and Climax performed 24.50 and 24.18 number of pods per plant respectively and were at the top. Whereas, treatment means showed significant difference among themselves. In this case T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top with 27.50 number of pods, followed by T_2 with (24.50) number of pods per plant, T_1 with 23.25 number of pods per plant, while T_0 (control) remained at the bottom with 22.12 number of pods per plant. Treatments followed a sequence of T_3, $T_{2,}$ T_1 and T_0.

With regard to interaction of the factors, it was found that, Meteor with T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) remained at the top, followed by Climax T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}), whereas Meteor in T_0 were occupied at last two positions. With regard to treatment means, T_4 was better for both Climax and Meteor cultivars. Meteor performed comparatively better than Climax. All other combinations of treatments were in between showing almost similar results. Which revealed the supremacy of T_3 (Irrigation upto flowering+ P120 Kg ha^{-1}+ K100 Kg ha^{-1}).

These results are similar with the findings of Patel *et al*., (1998) who reported that peas cv. Arable gave significantly increased in plant height, number of branches, leaves per plant, number of pods per plant, grains per pod and pod yield when applied 20 kg N/ha + 80 kg P_2O_5/ha + 40 kg K_2O/ha.

4.4.5. Length of pod (cm)

Observations recorded in relation to length of pod (cm) were subjected to analysis of variance and results are presented in figure 4.22 (b). The results revealed significant for cultivars, treatments and their interactions.

In case of cultivars, Climax produced 5.75 cm which Meteor put 5.64 cm length of pod. Whereas, treatment means depicted significant difference among themselves. T_3 (Irrigation upto seed filling + P120 kg ha^{-1}+ K100 kg ha^{-1}) was at the top with 6.61 cm length of pod followed by T_2 (5.61 cm) while, T_0 (control) was at bottom with 5.17 cm length of pod. Treatment mean values followed a sequence of T_3, T_2, T1 and T_0. The interaction of cultivars and treatments showed that Climax with T_3 (Irrigation upto seed filling + P120 kg ha^{-1}+ K100 kg ha^{-1}) was at the top while Meteor was best in T_3 (Irrigation upto seed filling + P120 kg ha^{-1}+ K100 kg ha^{-1}) and occupied at second position. Whereas Climax occupied the last position. In general T_3 (Irrigation upto seed filling + P120 kg ha^{-1}+ K100 kg ha^{-1}) was better for both the cultivars. Climax performed comparatively better than Meteor. All other combination of treatments was showing almost similar results.

Patel *et al*., (1998) who reported that significantly increased plant height, number of branches, leaves per plant, number of pods per plant, grains per pod and pod yield were observed when applied 20 kg N/ha + 80 kg P_2O_5/ha + 40 kg K_2O/ha.

4.4.6. Number of seeds per pod

Data regarding the number of seeds per pod were subjected to analysis of variance and results obtained are presented in figure 4.22 (c) which indicated significant results for cultivars, phosphorus levels and their interactions.

The comparison of cultivars indicated that Climax gave more number of seeds per pod 6.73 as compared to Meteor 5.62. Treatments mean revealed significant difference among themselves. Figure depicted that T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top with 7.23 numbers of seeds per pod followed by T_2 with 5.99, while T_0 (control) was at the bottom with 5.58 number of seeds per pod. Treatments mean followed a sequence of T_3, T_2, T_1 and T_0.

As far as interaction of cultivars are concerned and treatments Climax in T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top, Meteor also performed best in T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}), whereas, Meteor and Climax in T_1 were occupied at last two positions. In general T_3 (Irrigation upto seed filling + P120 kg ha-1+ K100 kg ha-1) was better for both the cultivars. Moreover, Climax performed comparatively better than Meteor. These results indicated that T_3 (Irrigation upto seed filling + P120 kg ha-1+ K100 kg ha-1) was better for both the cultivars. These results are in accordance with the findings of Patel *et al.*, (1998) who reported that peas cv. Arable gave significantly increased in plant height, number of branches, leaves per plant, number of pods per plant, grains per pod and pod yield when 20 kg N/ha + 80 kg P_2O_5/ha + 40 kg K_2O/ha was applied.

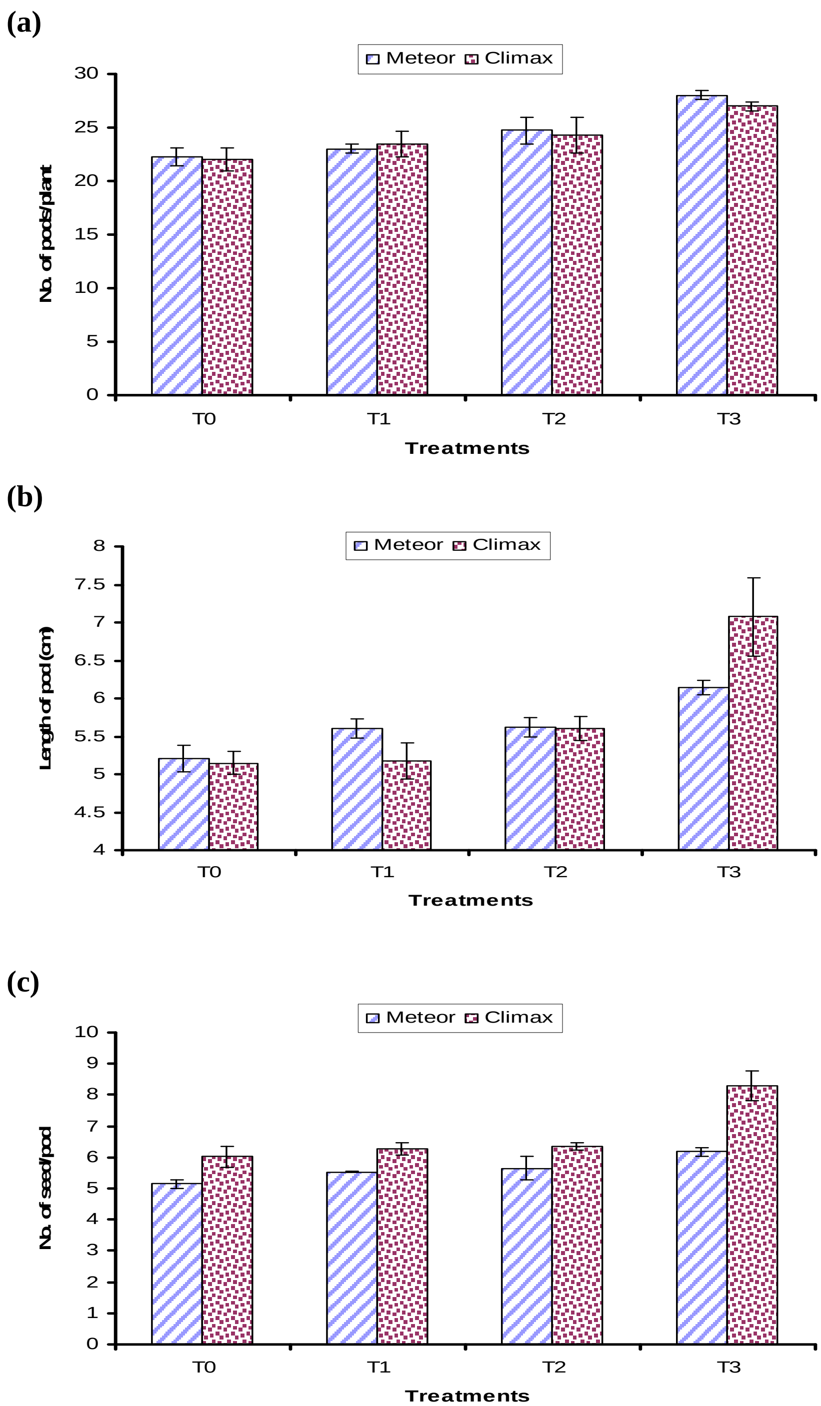


Fig.4.22:- **Qualitative and Quantitative response on (a) Number of pods (b) Length of pod (cm) and (c) Number of seeds per pod of peas (*Pisum sativum* L.) to judicious applications of irrigation with P and K**

4.4.7. 1000 seed weight (g)

Data regarding 1000 seed weight (g) were collected, organized and subjected to analysis of variance which showed significant results for cultivars, treatments and their interactions.

Data regarding to cultivars revealed that Climax ousted with 253.81g to Meteor with 243.81 g 1000 seed weight. Whereas, treatment mean values for phosphorus potassium and irrigation levels depicted significant difference among themselves. In this case T3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top with 251.25 g followed by T_2 (146.38 g), while treatment T_0 remained at the bottom with 246.38 g 1000 weight. Treatment mean values followed a sequence of T_3, T_2, T_1 and T_0 respectively.

Figure portrayed for the interaction of factors, Climax T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top, whereas T_0 (control) stood at the last position. In general T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was better for both cultivars. Moreover Climax showed better results as compared to Meteor. All other combinations of treatments were in between showing almost similar results. These results indicated that irrigation upto seed filling + P120 kg (ha-1) + K100 kg (ha-1) was better for both the cultivars as compared to other combination of treatments for phosphorus, potassium and irrigation. These results are supporting with the findings, Amjad *et al*., (2004) who observed that seed yield, 1000 seed weight and percentage of large sized seeds were increased significantly with the increasing level of P_2O_5.

4.4.8. Seed yield per hac (tons)

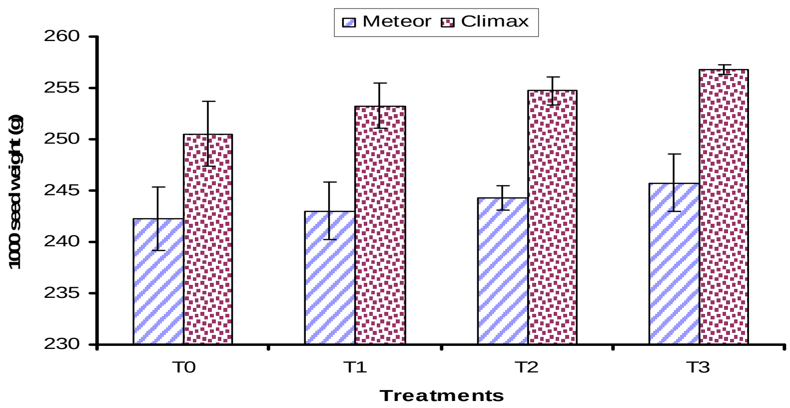
Seed yield of peas is also affected by varying plant nutrition requirements during its critical growth period. The application of fertilizer at the most critical stage is necessary to achieve maximum yield of the crop. In addition, for seed crop the effect of fertilizer on seed nutrient contents are also important.

Data in relation to seed yield per hectare (tons) were subjected to analysis of variance and the results are presented in figure 4.23 (b) which indicated significant results for cultivars, irrigation, phosphorus and potassium levels and their interactions.

Regarding cultivars, Climax showed better 2.24 tons seed yield, while 2.33 tons seed yield was found in Meteor. Treatments mean values showed significant difference among themselves. In this case T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was remained at the top with 2.63 tons seed yield, followed T_2 with 2.33 tons while T_0 (control) remained at the bottom with 2.02 tons. Treatments mean followed a sequence of T_3, T_2, T_1, and T_0.

With regard to the interaction of cultivars and treatments, Climax with T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top, followed by Meteor with T3 (Irrigation upto filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) Whereas, Meteor in T_1, and T_0 (control) occupied the last position. Overall T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) remained better for both the cultivars. Moreover Climax performed comparatively better than Meteor. These results are in line with the findings of Patel *et al*., (1998) who reported significantly increased plant height, number of branches, leaves per plant, number of pods per plant, grains per pod and pod yield when applied 20 kg N ha-1 + 80 kg P_2O_5 ha-1 + 40 kg K_2O ha-1 were applied to peas.

(a)



(b)

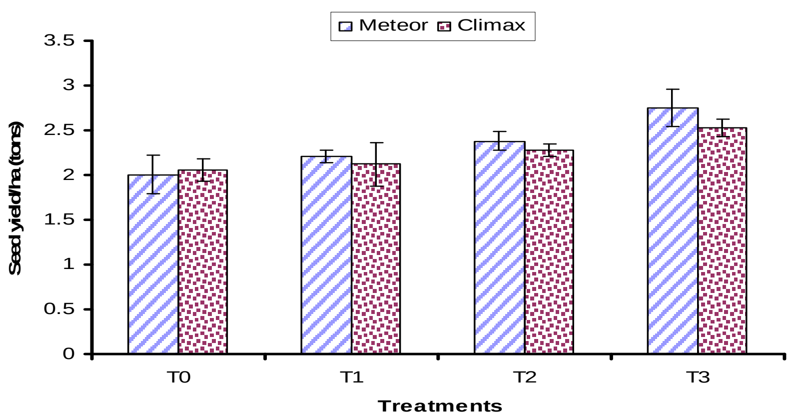


Fig 4.23:- Qualitative and quantitative response on (a) 1000 seed weight (g) and (b) Seed yield ha^{-1}(tons) of peas (*Pisum sativum* L.) to judicious applications of irrigation with P and K

4.4.9. Chemical composition of the plant parts (leaves, Stems and Pods)

4.4.9.1. Chemical composition of peas Leaves

Irrigation, Phosphorus and potassium are important inputs for high quality seed production of peas. They effects on plants are vital. Seed yield in peas is affected much influenced by varying plant nutrition requirements during the critical growth period. The application of fertilizer at the most critical stages is compulsory to achieve maximum yield of the crop. Moreover, for seed crop, the effects of fertilizer on seed nutrient contents are also important.

Data related to chemical composition of the peas leaves were subjected to analysis of variance and results are presented in figure 4.24. Peas leave in which nitrogen, ash and protein showed significant results for cultivars, different nutrient levels and their interactions.

Ash was better in Climax with 14.003% as compared to Meteor with 13.92%, Nitrogen was better in Climax with 3.40% while in Meteor 3.39% and Protein was also better in Climax 24.849% as compared to Meteor protein 24.84%. In case of protein, the treatments means showed that T_3 (27.12%) protein were at the top while, To (control) was found at bottom with 20.73% while the other treatments performed close resemblance in between T_3 and T_0 (control).

Interaction of cultivars and treatments for ash showed that Climax T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top, followed by Meteor with T_3 whereas, Climax in T_3 and Meteor with T_0 (control) were occupied at last two positions. T_3 performed better for both the cultivars. All other combination of treatments was in between by showing similar results.

The interaction of cultivars and treatments for Nitrogen showed that Meteor with T_3 at the top while Climax with the same treatment was 2nd whereas Climax and Meteor with T_0 were at last two positions. In general T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) remained better for both cultivars. All other combination of the treatments was remained in between showing almost identical results.

Interaction of cultivars and treatments for Protein showed that Meteor with T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top, Climax with T_3 2nd whereas, Meteor and Climax with T_0 were at the last two positions. In general T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) performed better for both the cultivars. These results in agreement with the findings of Kanaujia *et al.*, (1997) who reported that effects of P, K and rhizobium on growth yield and quality of peas and found significant growth and nodulation increase with the increasing of P and K levels and confirmed that the level of 60 kg P and K ha^{-1} was the best.

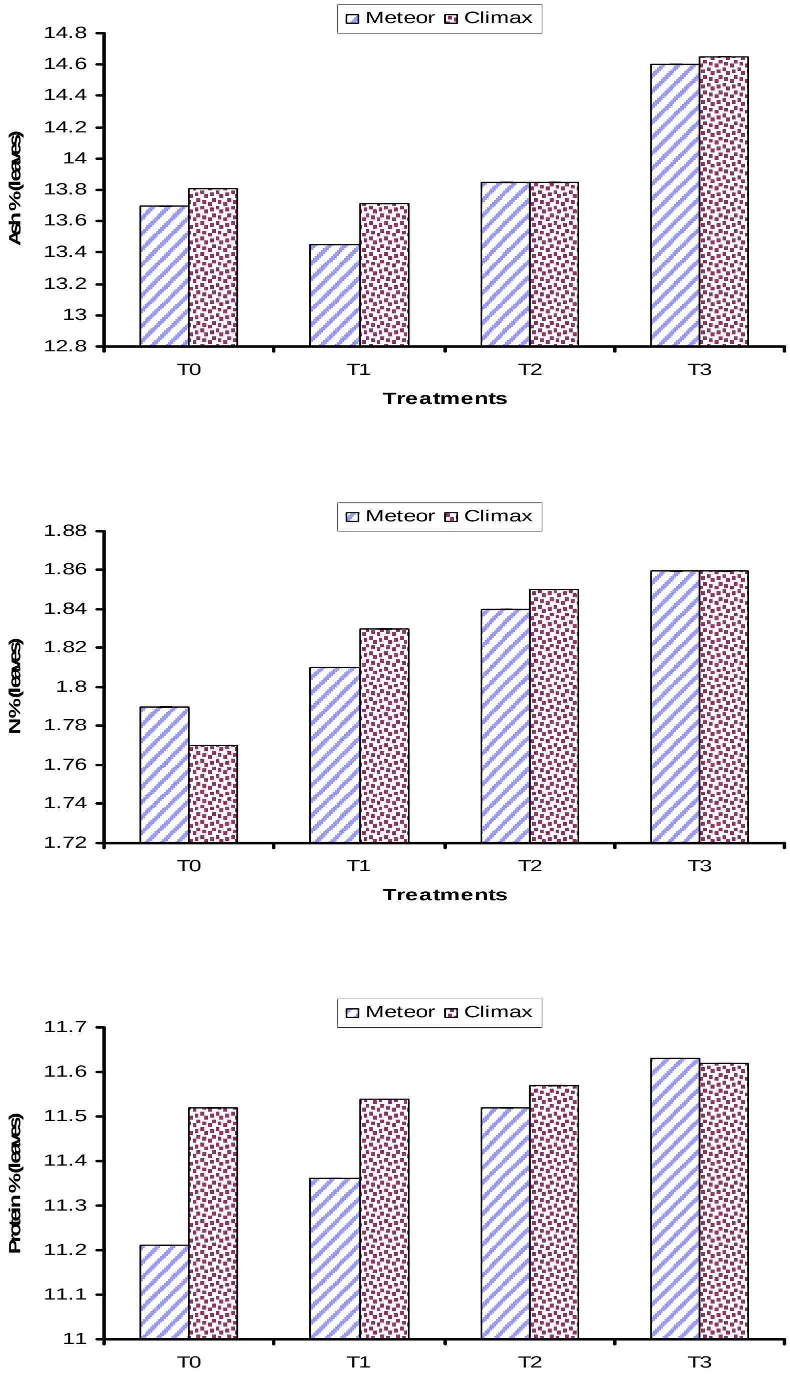


Fig. 4.24:- **Qualitative and Quantitative response on chemical composition (Ash, Nitrogen and Protein) of peas leaves to judicious applications of irrigation with P and K**

4.4.9.2. Chemical composition of peas Stems

Seed yield in peas is also affected by varying plant nutrition requirements during its critical growth period. The application of fertilizer is most important for growth and pre-requisite to get maximum yield of the crop. In addition, for seed crops the effects of fertilizer on seed nutrient contents are also important.

Data regarding chemical composition of the peas stems were subjected to analysis of variance and results are presented in figure 4.25. Which indicated significant results for cultivars, irrigation, phosphorus, potassium and their interactions.

Ash was better in Climax with 11.97% as compared to Meteor with 11.72%. Ash was found high with T_3 12.24% and found at bottom with T_0 11.59% while, other treatments showed results in between T_3 and T_0. Interaction of cultivars and treatments for ash revealed that Meteor with T_3 was at the top, followed by Meteor with T_3 whereas; Meteor with T_0 occupied at the last position. In general T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) performed better for both cultivars.

Nitrogen was better in Climax with 1.347% as compared to Meteor with 1.33%. Nitrogen was high in T_3 with 1.35% but at the bottom in T_0 with 1.31% while other treatments gave results in between T_3 and T_0. The interaction of cultivars and treatments for Nitrogen showed that Climax in T3 was at the top, whereas Climax and Meteor with T_0 were at the last position. T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) performed better for Climax.

Protein was better in Climax with 8.37% as compared to Meteor with 8.34%. Protein level was high in T_3 with 8.46% but T_0 was at the bottom with 8.19% while, other treatments showed results in between T_3 and T_0. The interaction of cultivars and treatments for Protein showed that Meteor with T_3 was at the top while Climax with T_5 was at second; Meteor with T_1 was at the last position. T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) remained better for both cultivars. All other combinations remained in between by showing at most similar results. These results are in agreement with the findings of Kanaujia *et al*., (1997) who evaluated the effect of P, K and rhizobium on growth, yield and quality of peas cv. Lincolin and reported that the growth and nodulation were significantly with the increasing of levels of P and K (0, 30, 60, 90 Kg ha^{-1}) alone and found the best of P and K was 60 Kg ha^{-1}.

Seeds from plants supplied with additional nitrogen might be more vigorous than control seeds. In wheat and other grasses there were strong correlations between increases in grain protein content associated with nitrogen fertilizer and the production of more vigorous seedlings? Application of nitrogen fertilizer increased the quality of proteins to a greater degree than all other amino acids. Similarly findings have been reported by (Trachuk, 1966; Ries and Everson, 1973; Ene and Bean, 1975).

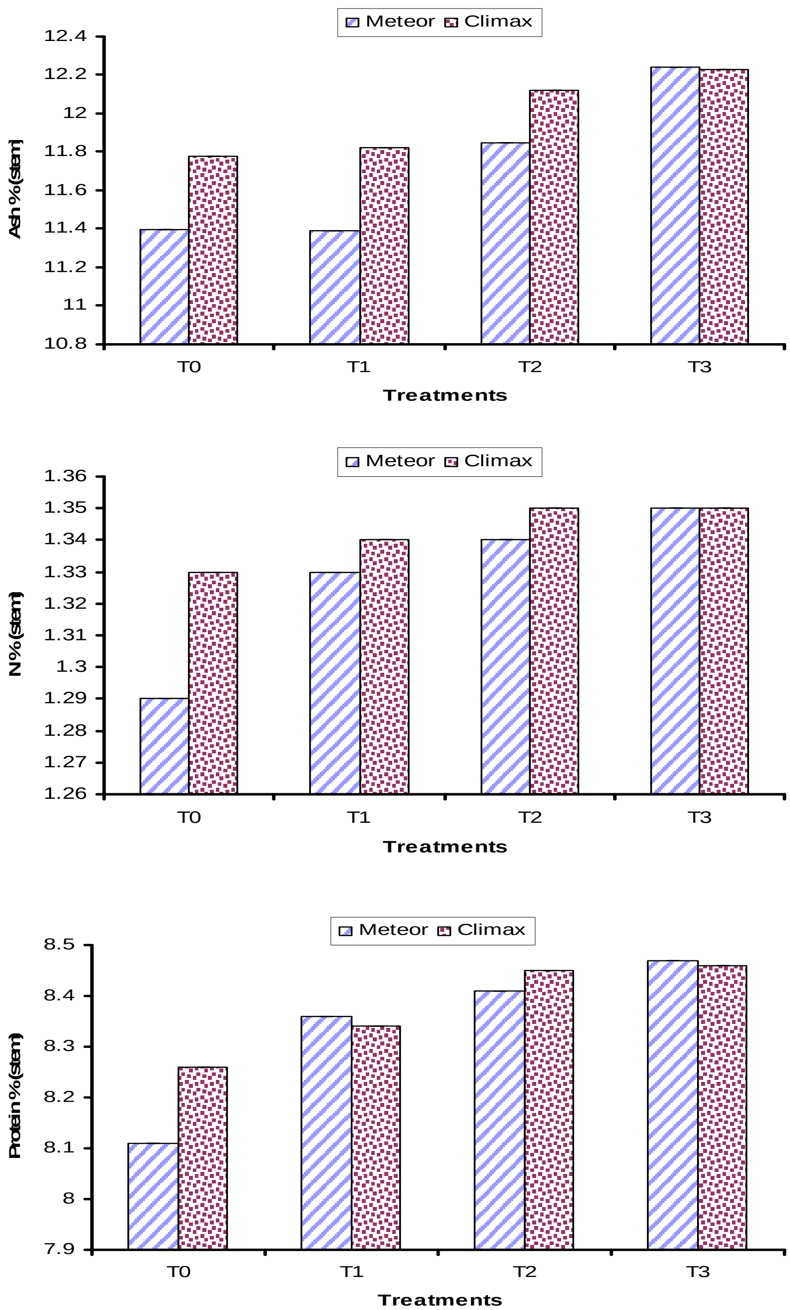


Fig.4.25:- **Qualitative and Quantitative response on chemical composition (Ash, Nitrogen and Protein) of peas stems to judicious applications of irrigation with P and K**

4.4.9.3. Chemical composition of peas Pod + Seeds

Data pertaining to chemical composition of the peas pods + seeds were subjected to analysis of variance and results obtained are presented in figure 4.26. Chemical composition (nitrogen, ash and protein) of pod + seeds were determined showed significant results for cultivars, treatments and their interactions.

Ash was better in Meteor with 4.57% as compared to Climax with 4.56%. Ash was high in T_3 with 4.57% but T_0 was at bottom with 4.55% while other treatments produced results in between T_3 and T_0 (control). The interaction of cultivars and treatments for ash revealed that Meteor with T_3 was at the top followed by Climax with T_3 and occupied at last second position whereas; Climax and Meteor with T_0 (control) occupied at last two positions. In general T_3 performed better for both the cultivars.

Nitrogen was better in Climax with 3.43% as compared to Meteor with 3.37%. Nitrogen level was high in T_3 (3.45%) but T_0 was at bottom with 3.37% while, other treatments showed results in between T_3 and T_0. The interaction of cultivars and treatments for Nitrogen depicted that Climax with T_3 was at the top while, Meteor with T_3 occupied at second whereas, Meteor with T_0, T_1 and T_2 were occupied at last positions. T_3 was remained better for both the cultivars.

Protein was better in Climax with 21.32% as compared to Meteor with 21.28%. Protein was significantly high in T_3 with 21.63% but T_0 was at the bottom with 20.94% while other treatments gave results in between T_3 and T_0. The interaction of cultivars and treatments for Protein showed Meteor with T_3 was at the top, followed by Climax with T_3 whereas, Meteor with T_1 and T_2 occupied at last two positions. The results indicated that T_3 remained better for both the cultivars. All other combinations of treatments remained in between and showing almost similar results.

These results are supported by Kanaujia *et al*., (1997) who evaluated the effect of P, K and rhizobium on growth, yield and quality of peas cv. Lincolin and reported that the growth and nodulation were significantly increased with the increasing levels of P and K (0, 30, 60, 90 Kg ha^{-1}) alone and found P and K with 60 Kg ha^{-1}, was the best.

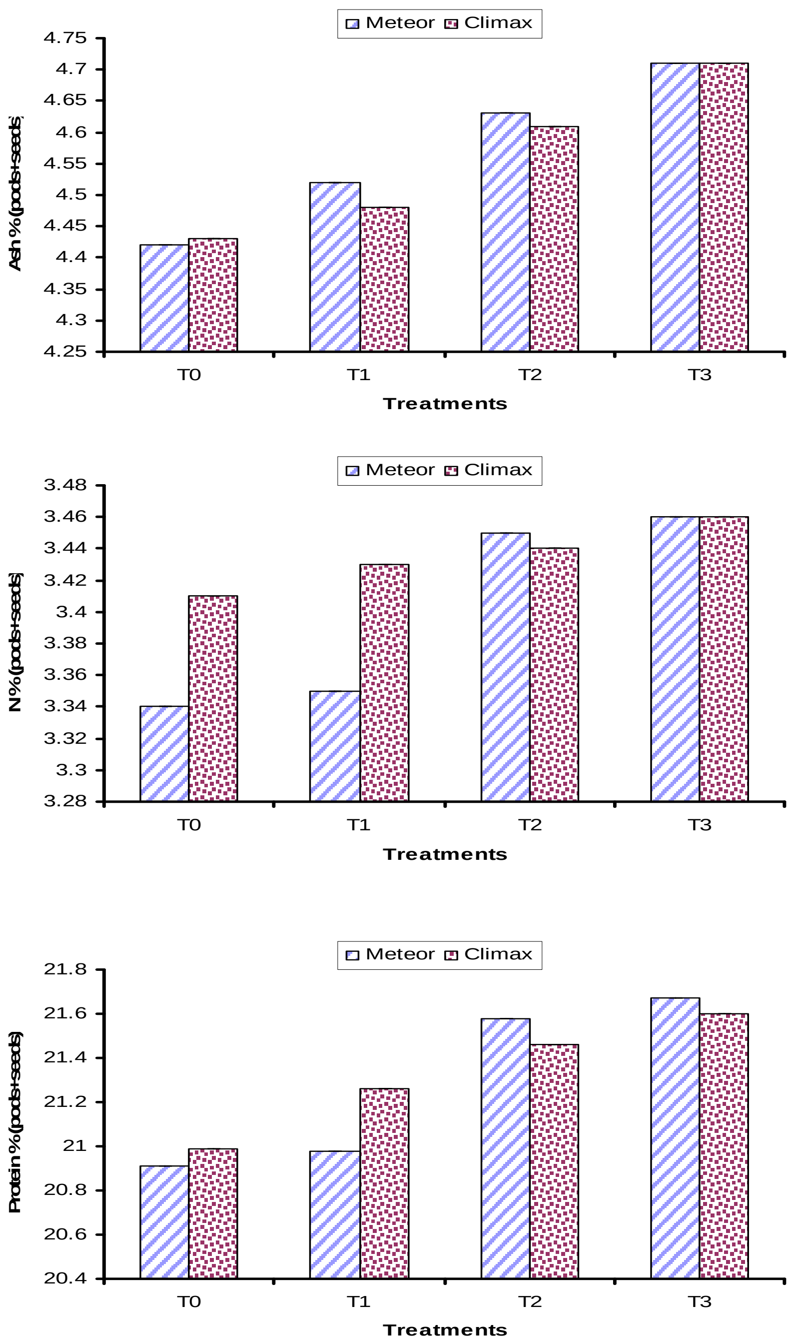


Fig.4.26:- **Qualitative and Quantitative response on chemical composition (Ash, Nitrogen and protein) of Peas Pod + Seeds to judicious applications of irrigation with P and K**

4.4.10. Seed quality parameters

4.4.10.1. Seed nutrient concentration (N, P, K and protein contents)

Seed nutrient concentration in peas is also affected by varying plant nutrition requirements during its growth period. The application of fertilizer at critical stage is compulsory to achieve maximum yield for the crop. In addition, for seed crop the effect of fertilizer on seed nutrient contents are also important.

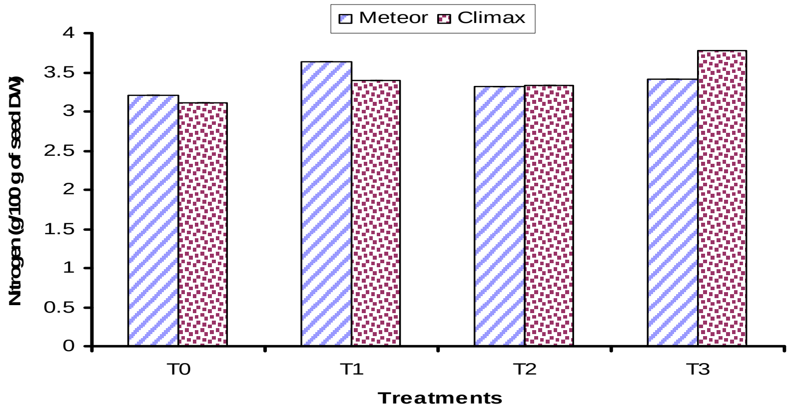
Data regarding chemical composition of peas seed nutrient concentration were subjected to analysis of variance and results obtained are presented in figure 4.27(a,b) which indicated that nitrogen, ash and protein showed significant results for cultivars, treatments and their interactions.

Nitrogen was slightly higher in Climax with 3.40% as compared to Meteor with 3.39%. Nitrogen was high in T_3 3.60% but T_0 was at the bottom with 3.17% while other treatments showed results in between T_3 and T_0. The interaction of cultivars and treatments for Nitrogen revealed that Climax with T_0 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top with T_3, whereas Climax and Meteor with T_0 were found at last two positions. T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was better for Climax and T_1 was better for Meteor.

Phosphorus was better in Climax with 0.34% as compared to Meteor with 0.32%. Phosphorus was high in T_3 with 0.38% while, T_0 was at the bottom with 0.25%. The interaction of cultivars and treatments depicted that Climax with T_3 was at the top, Meteor with T_3 occupied at second position whereas, Meteor and Climax with T_1 were at last two positions.

Potash was better in Climax with 0.89% as compared to Meteor with 0.73%. Potash was high in T_3 with 0.95% but at showed at bottom with T_0 (0.57%) while, other treatments showed results in between T_3 and T_0. The interaction of cultivars and treatments for potash showed that Climax with T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top while Meteor with T_3 was occupied at second, whereas Meteor and Climax with T_0 were found at the last two positions.

Protein was greater in Climax with 24.84% as compared to Meteor with 24.49%. Protein was high in T3 with 27.12% while, T_0 was found at bottom with 20.73%. The interaction of cultivars and treatments for Protein showed that Climax with T_3 was at the top. Meteor with T_3 was secured second position whereas, Meteor and Climax with T_0 (control) were at last two positions. T_3 gave better performance for both the cultivars. All other combinations of treatments were remained in between showing almost identical results. Phosphorus is needed for growth and N fixation which might have contributed in this parameter of study. These results are in line with the findings of Kanaujia *et al*., (1997) who reported the effect of P, K and rhizobium on growth, yield and quality of peas and reported that the growth and nodulation were significantly increased with the increasing levels of P and K (0, 30, 60, 90 Kg ha^{-1}) alone which also increased the seed yield and quality.



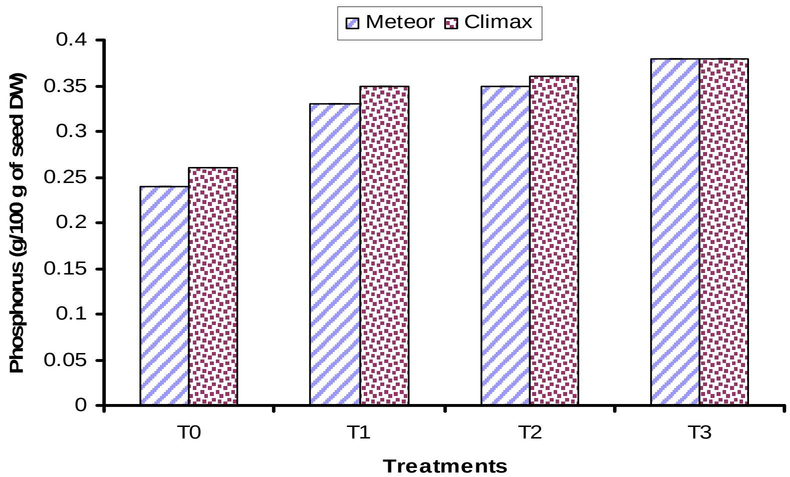
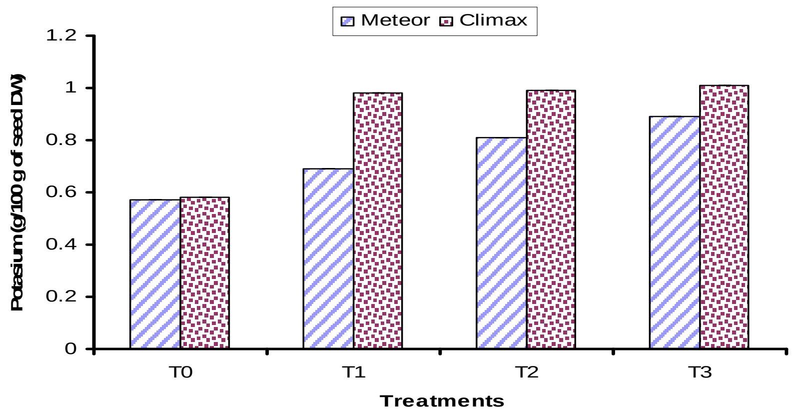


Fig.4.27 (a):- Qualitative and Quantitative response on seed nutrient concentration (Nitrogen and Phosphorus) of peas (*Pisum sativum* L.) **to judicious applications of irrigation with P and K**



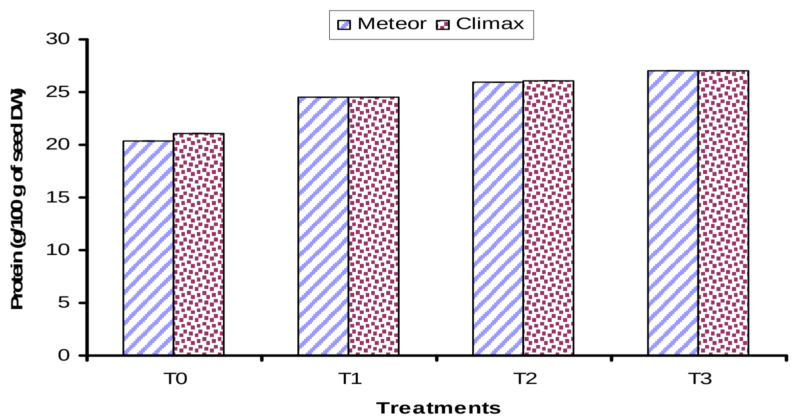


Fig.4.27 (b):- Qualitative and Quantitative response on seed nutrient concentration (Potash and Protein) to judicious applications of irrigation with P and K

4.4.10.2. Electrical conductivity test

Cultivars showed Climax with 23.93 while Meteor with 19.56 electrical conductivity. As far as treatments are concerned that T_3 (Irrigation upto w seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top position, followed by T_2, whereas, T_0 and T_1 occupied the last two positions. Moreover, treatments mean followed a sequence of T_3 (23.25), T_2 (22.12), T_1 (21.50), and T_0 (20.12).

Regarding the interactions of cultivars and treatments, Climax with T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 k ha-1) was at top, followed by T_2 in Meteor while T_5 remained in between whereas; Meteor with treatments T_1 and T_2 occupied the last two positions.

Above results are in line with the findings of Bhopal (1991) who observe the response of garden peas to N and P application and reported in vigorous vegetative with increasing rate of N upto 40 kg N/ha and then declined at 60 kg N/ha.

4.4.10.3. Emergence (%)

Data were collected and subjected to statistical analysis of variance and results are presented in figure 4.28 (b) which showed Climax with 90.50% was better than Meteor with 85.75%.

Treatments mean showed T_3 was at top position followed by T_2 whereas; T_0 and T_1 occupied at last two positions. Treatments mean followed a sequence of T_3 (97.37), T_2 (87.37).

With regard to interaction of cultivars and treatments, Climax was superior with T_3 followed by Meteor with T_3. Whereas, Meteor with T_0 occupied at the last position. These results are inline with the findings of Bhopal (1991) who observed vigorous vegetative growth at highest N rate and the yield was found increased with increasing P rate upto 60 Kg ha^{-1} and then declining with highest P rate.

4.4.10.4. Germination (%)

Data for this parameter were collected and subjected to statistical analysis of variance and results obtained are presented in figure 4.28 (c) which revealed non-significant results for cultivars but significant results for phosphorus levels and their interactions.

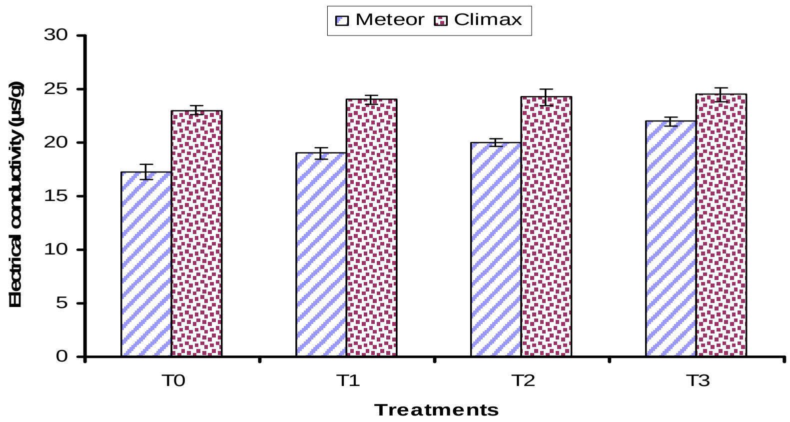
Meteor performed comparatively better than Climax under the aspect of germination percentage with 94.50 and 93.81 respectively.

As far as germination is concerned, T_3 occupied at the 1st position, followed by T_2 where as, T_0 (control) occupied at last position by showing less germination.

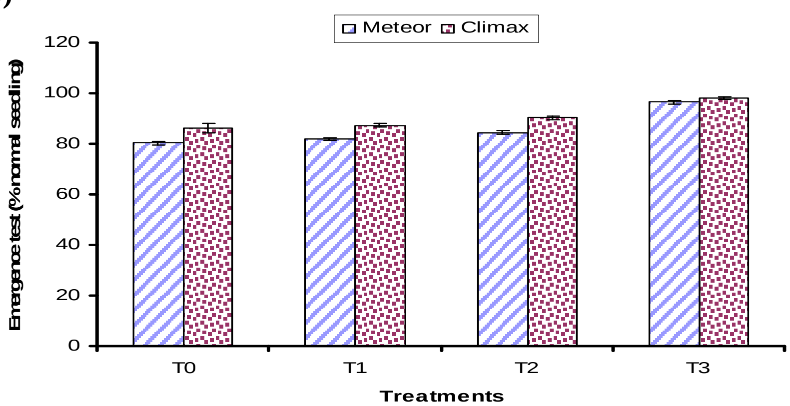
Moreover, treatments mean values followed the sequence of T_3 (96.25), T_2 (94.25), T_1 (93.50) and T_0 (92.62).

The interaction of cultivars and treatments are concerned, Meteor with T_3 was at the top, followed by Climax in T_3 whereas Climax in T_0 and T_1 occupied at the last 2 positions. These results are inline with the findings of Cutcliffe and Munro (1980) who stated that the effects of NPK on peas crop and reported maximum germination was found 85-95% by increasing the rate of N and P.

(a)



(b)



(c)

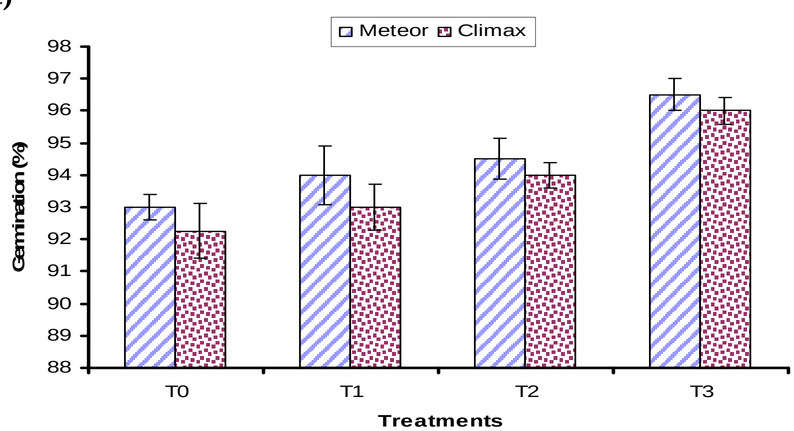


Fig.4.28: Qualitative and Quantitative response on (a) Electrical conductivity (µs / g) (b) Emergence% and (c) Germination% of peas to judicious applications of irrigation with P and K

Conclusion:

This experiment was planned to assess the effects of different combinations of phosphorus, potash and irrigation and their interactions, which individually assess their efficacy during earlier experiments. In case of cultivars, Climax gave better results 2.24 tons seed yield as compared to Meteor with 2.33 tons ha^{-1}seed yield. T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was at the top with 2.63 tons ha^{-1}seed yield, followed by T_2 with 2.33 tons ha^{-1} while, T_0 (control) was found at the bottom with 2.02 tons ha^{-1}. Treatments mean followed a sequence of T_3, T_2, T_1, and T_0. As far as seed vigour tests showed that T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) was better for both cultivars. Different chemical composition tests of leaves, stems and pods were observed. It is found that Climax was better as compared to Meteor. It is concluded that Climax cultivar with T_3 (Irrigation upto seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1}) performed better as compared to other levels of phosphorus, potash and Irrigation.

4.5. EXPERIMENT NO.5:-

EFFECTS OF DIFFERENT SEED MOISTURE CONTENTS AT HARVEST ON PEAS SEED QUALITY.

To determine the optimum seed moisture contents at which the seed quality is its best at the time of harvesting. Pods were harvested by hand from each plot when their seed achieved desired seed moisture contents as varying from 15 to 45 % per treatment. .The present research was conducted to study the relationship between moisture contents and optimum seed harvest time for maximum seed quality

4.5.1. Seed fresh weight per plant (g)

Results depicted significant differences for Cultivars, treatments and their interactions. Climax cultivar attained maximum seed fresh weight 89.51 g whereas, Meteor attained 74.67 g fresh weight per plant. A perusal of mean values for treatments, it was observed that seed harvested at 45% seed moisture contents attained 88.86 g fresh weight per plant, followed by seed harvested at 40% seed moisture contents with (85.70 g) and M_3 (Seed harvested at 35 % seed moisture contents) with (80.48g) while M_7 (Seed harvested at 15% seed moisture contents) attained (77.71 g) fresh weight per plant. As the interaction of V x M is concerned, the combination of V_2M_1 attained maximum fresh weight of (96.46 g) followed by V_2M_2 (93.60 g), V_2M_3 (85.12 g) and V_1M_6 with (71.28 g) in descending order as per their performance of the aspect of study while V_1M_7 produced the lowest fresh weight per plant with (70.12 g). Harvesting of seed crop at the proper time is very important for seed quality. Seeds must be harvested when they get the maximum viability and vigour. Afterwards it declined (Harrington, 1972). Seeds harvested too early, at higher seed moisture contents, tend to deteriorate more quickly and also get mechanical damage during processing due to their soft seed coat. Moreover they are more susceptible to fungus infection during storage. They also show diminished seed viability.

Large seeds, such as legumes, if harvested too late become over dry. At seed moisture contents below 15% they tend to become fragile and easily damaged during threshing. The ideal harvesting time is before loss of mature seeds from shattering, lodging, and mechanical seed damage (Copeland and McDonald, 1995).

There was a gradual increase in seed dry weight by reduction of seed moisture contents. However after attaining 30% seed moisture contents, seeds did not show any increase in their dry weight, even when their moisture contents decreased to 30 and 20%. In this study mass maturity stage occurred when seeds attained 30%

moisture contents, and there was no further increase in dry weight for further loss of seed moisture contents. The results of the seed quality tests showed that at 40% seed moisture contents seed achieved the maximum dry weight, but not the maximum seed quality. They attained maximum seed quality after further maturity, at a time when they attained 30%seed moisture contents. Afterward, at 20% seed moisture contents, seed quality declined. These results are agreement with Ellis and Pieta-Filho, (1992); Ferguson, (1993) and Ellis *et al*. (1993).

The results of seed quality tests showed that seeds harvested too early, at 45% moisture contents had very low dry weight and which were under seed filing stage, Consequently very low seed quality .They were also found to be infected by fungus, during accelerated aging process, as found by McDonald, and Copeland (1997b).

More recently, it has been reported that maximum seed quality (vigour) does not occur until some time after physiological maturity (Ellis and Pieta-Filho, 1992; Zanakis *et al*., 1994). They concluded that mature seeds of soybean and corn did not attained maximum ability to survive storage (Potentional longevity) until sometime after physiological maturity. Hence they now refer to this stage as mass maturity, rather than physiological maturity (Ellis and Pieta-Filho, 1992). In such case seed quality (vigour) may continue to increase even after the seed has reached maximum seed dry weight (mass maturity).They achieve physiological maturity and maximum seed vigour at same later stage, after maximum, seed dry weight (mass maturity) but before harvest maturity, the stage at which a grain crop is harvestable i.e. usually 10-15 % seed moisture contents (fresh weight basis). Ferguson (1993) found that in different cultivars of combining peas maximum seed quality were attained 14 to 19 days after the stage of maximum seed dry weight. High seed yield were only achieved if the crop is harvested when the number of ripe inflorescences is at a maximum, as florets per inflorescence, seeds per floret, and seed weight are considered to remain constant over the harvest period and are not influenced by harvest date.

Harrington (1972) also suggested that maximum seed quality (viability and vigour) is attained at physiological maturity (the end of the seed filling period) and after that viability and seed vigour declined. This opinion is accepted by many physiologists for many different crop species (Chen *et al*., 1972; Maguire, 1977;

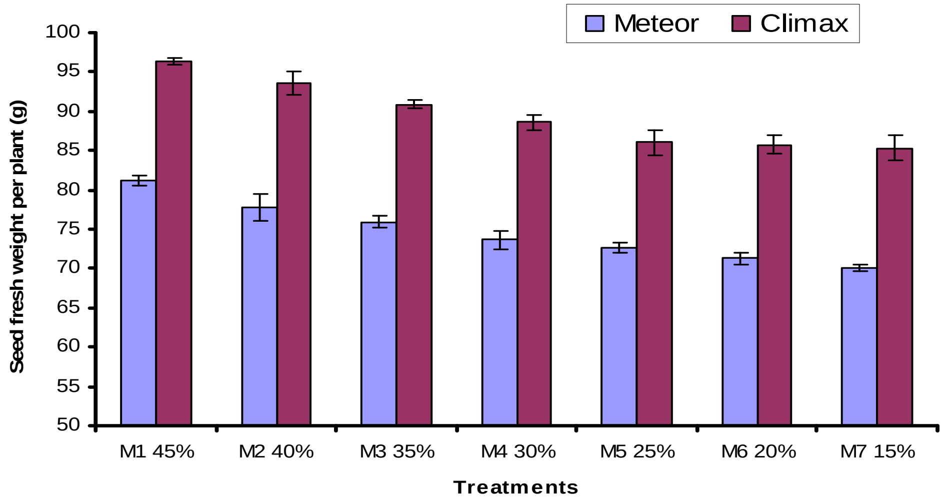


Fig.4.29:- Effects of different seed moisture contents on Seed fresh weight per plant

4.5.2. Seed dry weight per plant (g)

Data on seed dry weight per plant are shown in figure 4.30. Which indicated significant results for years, Cultivars and treatments yet their interaction was found to be non-significant.

Whereas, the mean values for Cultivars, it was observed that Climax Cultivar attained 62.07 g seed dry weight per plant while Meteor attained 60.78 g seed dry weight per plant As far as the mean values for treatments are concerned, it depicted that the crop harvested at 35% moisture contents attained maximum seed dry weight of 64.17 g followed by seed harvested at 30 % with 62.69 g and seed harvested at 40% with 62.49 g of seed dry weight in descending order as per their performance while seed harvested at 15 % attained the lowest position with 58.82 g of seed dry weight per plant.

Maximum seed viability and seed vigour might be achieved if seeds are harvested at the correct stage of maturity. If harvesting is delayed seed quality may be declined due to adverse environmental conditions such as high temperature, high humidity, rainfall, over drying, attacks by diseases, pests or damage by birds and animals. The ideal harvesting time is before loss of mature seeds from shattering, lodging and mechanical seed damage (Copeland and McDonald, 1995). A seed crop should be harvested soon after achieving the maximum seed quality.

Harrington (1972) also suggested that maximum seed quality (viability and vigour) is attained at physiological maturity (the end of the seed filling period) and that after that viability and seed vigour declines. This opinion is accepted by many physiologists for many different crop species (Chen *et al*., 1972; Maguire, 1977).

In different cultivars of combining peas maximum seed dry weight and seed quality did not decrease before harvest maturity (Ferguson, 1993). Sanhewe and Ellis (1996) observed that maximum seed quality (potential longevity) was attained at 13-23 days (at 30/24°C) or 34 (at 27/21°C) days after completion of the seed filling stage. Similarly, in soybean (*Glycine max* L. Merill) seed quality continued to increase after attaining maximum seed dry weight (TeKrony *et al*., 1980; Zanakis *et al*., 1994). Ellis and Pieta Filho (1992) have concluded that, to describe the stage of maximum seed dry weight as the term of physiological maturity is misappropriate and suggested that instead of it "Mass maturity" may be used. Physiological maturity explains the physiological quality of seed; hence the term should be used to explain this and not any physical property like dry weight of the seed.

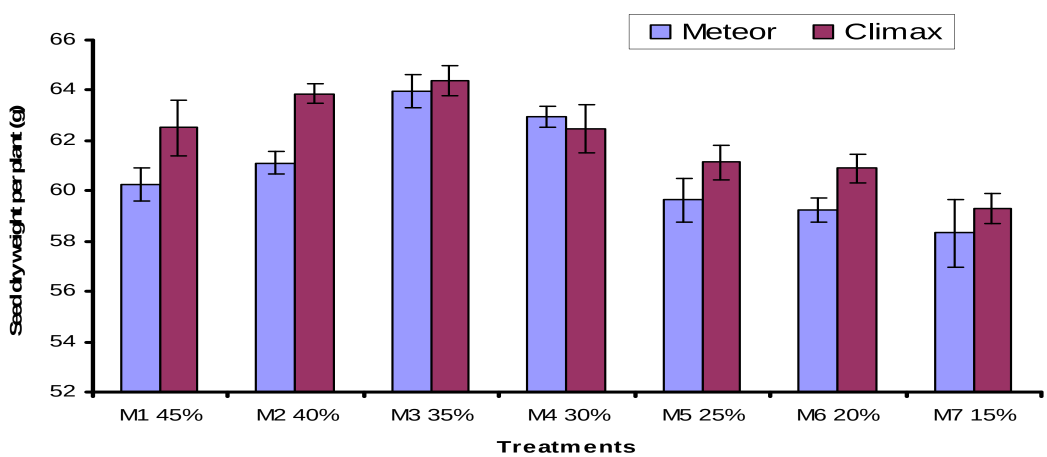


Fig.4.30:- Effects of different seed moisture contents on Seed dry weight per plant (g)

4.5.3. 1000 Seed Weight (g)

Data regarding the 1000 seed weight (g) was collected, organized and subjected to analysis of variance and results are presented in figure 4.31 which indicated significant results for cultivars, moisture contents and their interactions.

Climax cultivar with 241.96 g ousted Meteor with 240.39 g whereas, treatment means for moisture contents showed significant difference among them. In this experiment treatment M_1 (Seed harvested at 45% seed moisture contents) remained at the top with 243.75 g, followed by treatment M_2 Seed harvested at 40% seed moisture contents with 243.00 g, while treatment M_7 (Seed harvested at 15% seed moisture contents) remained at the bottom with 246.38 g. Treatment means followed a sequence of M_1, M_2, M_3, M_4 M_5 M_6 and M_7.

Figure portrayed for the interaction of these factors, Climax with M1 (Seed harvested at 45% seed moisture contents) and M_2 (Seed harvested at 40% seed moisture contents) remained at the top, whereas M_7 (Seed harvested at 15% seed moisture contents) was at the last position. In several treatment M_1 (Seed harvested at 45% seed moisture contents) depicted better for both cultivars. Moreover, Climax gave better results than Meteor. All other combinations remained in between by showing almost similar results.

Maximum seed viability and seed vigour can be achieved when seeds are harvested at the proper stage of maturity. If harvesting is delayed seed quality may be declined due to adverse environmental conditions such as high temperature, high humidity, rainfall, over drying, attacks by diseases, pests or damage by birds and animals. The ideal harvesting time is before loss of mature seeds from shattering, lodging and mechanical seed damage (Copeland and McDonald, 1995; Shaw and Loomis, 1950) as the stage in seed development when the seed reaches its maximum dry seed weight and yield.

These results are in conformity with the findings of Ferguson (1993) who reported that maximum seed quality were attained after14 to 19 days of maximum seed dry weight was attained.

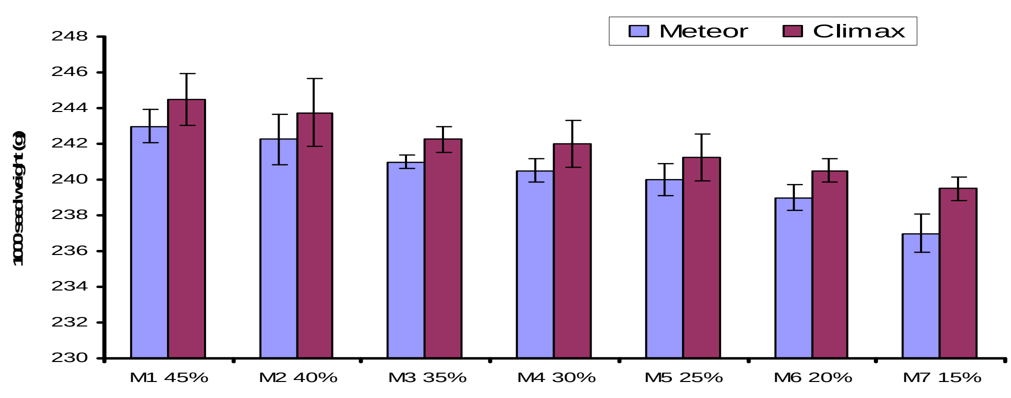


Fig.4.31:- Effects of different seed moisture contents on 1000 seed weight (g)

4.5.4. Germination percentage (%)

Data for the seed quality parameter of Germination were collected through prescribed technique and then subjected for the analysis of variance. Significant differences among the variable were studied which has been described in figure 4.32 which indicated significant results for Cultivars, Packing materials, temperatures and their interactions.

The mean value for the Cultivars, it was observed that Meteor cultivar was better as compared to Climax with respect to the aspect of study with 93.964% and 92.321% Germination respectively. Amongst treatments mean, M_4 with 96.37 ousted all other combination of treatments followed by M_2 and M_1 with 94.12% and 93.87% respectively in descending order while M_5 was recorded 91.00 % which was found at the bottom.

Castillo *et al*., (1992) found that peas seeds harvested at 15% seed moisture contents had nearly double the number of hollow heart seeds than those harvested at 25% moisture contents. Seeds harvested at 40% moisture contents had over 90% germination and were high in vigour as shown by low electrical conductivity and low hollow heart frequency, and little loss of germination after controlled deterioration.

Demir *et al*., (1994) assessed seed quality of snap bean (*Phaseolus vulgaris*) by germination and emergence rates, seed length and seed dry weight, which were maximum when seed moisture contents had decreased to 45-50%. However it was concluded that the optimum harvest time for seed production was when seed moisture contents reached 14%. Further delay resulted in physiological aging and seed loss through shedding.

Germination test gives estimation about field survival of progeny plants from the seed and results can be used to differentiate between different seed lots. The standard germination test is conducted under controlled laboratory conditions. Hence there is no guarantee that the seeds will also give almost the same emergence percentage in the field. Under field conditions testing is normally unsatisfactory, because repetition is not possible. In the laboratory it is possible to provide generally similar conditions as in the field, but these can be controlled constantly during the whole testing period, so that the most regular, rapid and complete germination might occur in most seeds of the testing sample. (The International Seed Testing Association, 1985) rules for seed testing defined the germination percentage test as "The emergence and development from the seed embryo of those essential structures, for the kind of seed being tested, which indicate the ability to develop into a normal plant under favorable conditions in soil".

For Peas (*Pisum sativum* L.) sand or double filter paper is recommended as the germination substrate. The temperature during the test is 20°C, while no light is necessary. The first and final count days are the 5th and 8th day of the test.

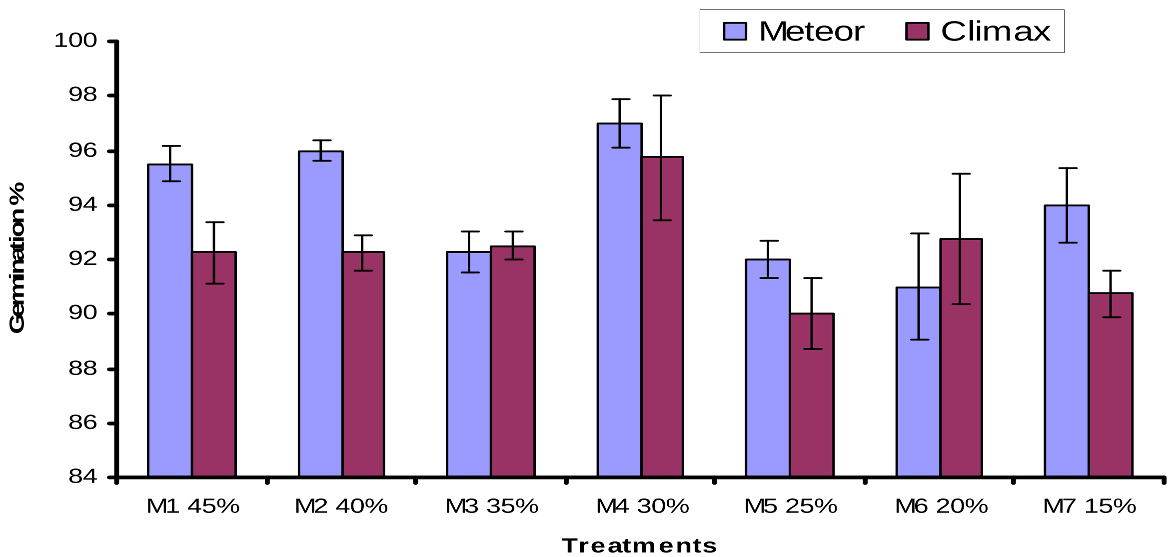


Fig.4.32:-Effects of different seed moisture contents on Germination

4.5.5. Emergence percentage (%)

Data for the seed quality parameter of emergence were gathered through statistical analysis of variance prescribed techniques to identify significant differences among the variable were studied which has been presented in figure 4.33. A glance on the figure indicated significant results for years, Cultivars and treatments.

The mean value for the varieties, it was observed that Climax cultivar was better as compared to Meteor with 89.50% and 87.78% emergence respectively. Amongst treatments mean, M_1 with 91.87% ousted all other combination of treatment followed by M_2 and M_3 with 91 and 90.12 % respectively in descending order while M_7 with 85 % was found at the bottom.

Maximum seed viability and seed vigour may be achieved if seeds are harvested at the proper stage of maturity. A field emergence percentage test gives information about seed vigour and gives more accurate data to predict the storability of the seed lot tested. If the field conditions are optimal, the results of the laboratory germination test usually correlate well with field emergence (Abdella and Roberts, 1969; Perry, 1977; Egli and Tekrony, 1979), but under suboptimal field conditions, the laboratory germination results often overestimate the actual field emergence of seed lots (Tekrony and Egli, 1977; Johnson and Wax, 1978; Yaklich and Kulik, 1979; Naylor, 1981).

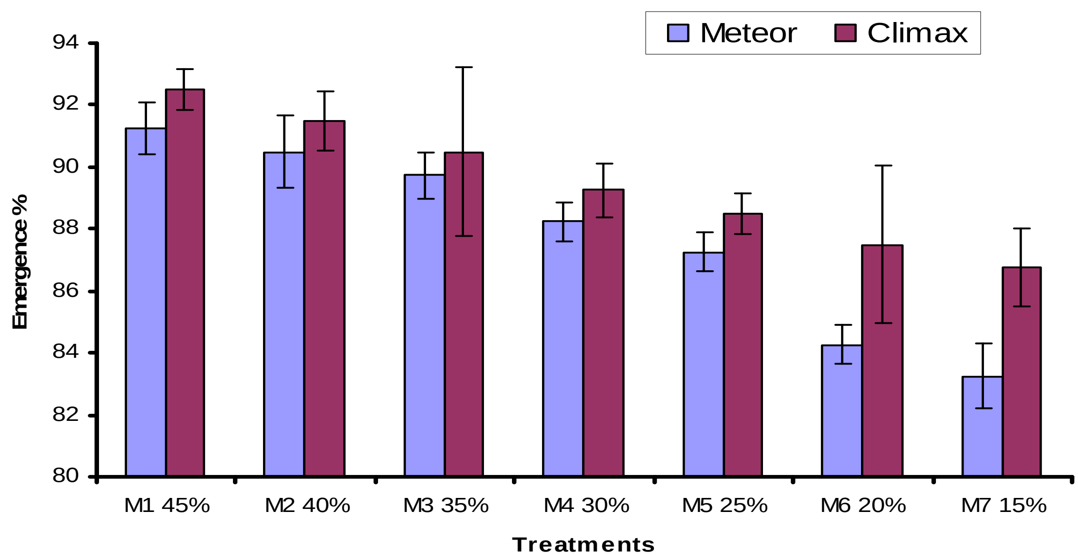


Fig.4.33:-Effects of different seed moisture contents on Emergence

4.5.6. Electrical conductivity test

Informations regarding to the seed quality parameter of electrical conductivity were collected through prescribed methods and subjected to analysis of variance. Significant differences among the variable were studied which has been presented in figure 4.34. A perusal of the figure indicated significant results for years, Cultivars and treatment while all interaction among variables except inheritate of V x I were found to be non-significant.

The mean value for the Cultivars indicated that Climax with 22.21 was better as compared to Meteor with 19.83 electrical conductivity. Amongst treatments mean, M_1 with 23.87 ousted all other combination of treatment followed by M_2 and M_3 with 23.12 and 21.93 respectively in descending order while M_7 was found at the bottom with 18.75 electrical conductivity.

Zanakis *et al*., (1994) reported that mature seeds of soybean and corn did not attained maximum ability to survive storage (Potentional longevity) until sometime after physiological maturity. Hence they now refer to this stage as mass maturity, rather than physiological maturity (Ellis and Pieta-Filho, 1992). In such case seed quality (vigour) may continue to increase even after the seed have reached maximum seed dry weight (mass maturity). They achieve physiological maturity and maximum seed vigour at same later stage, after maximum, seed dry weight (mass maturity) but before harvest maturity, the stage at which a grain crop is harvestable i.e. usually 10-15 % seed moisture contents (fresh weight basis).

Nascimento (1994) found that yellow peas seeds from a late harvest had higher electrical conductivity than green or greenish-yellow seeds. Green seeds had a higher 1000-seed weight and performed best in an accelerated aging test, suggesting the highest viability.

This test was first introduced by Fic and Hibbard in 1925 (Copeland and McDonald, 1995) and adopted for testing of cotton seed viability. The test measures the cell membrane integrity and is based on the premise that low vigour (deteriorated) seeds have poor membrane integrity. During soaking the seeds in water and the imbibitions process seeds having poor cell membrane structure leach (cytoplasmic solutes proteins, sugars, amino acids and other electrolytes) into the soaking water. The solutes with electrolytic properties contain electrical charge that can be measured by an electrical conductivity matter. If seed has low vigour the amount of electrolytes will be more and consequently the electrical conductivity of the soaking media will be higher. On the other hand high vigour seed releases less solutes and show low conductivity. Matthews and Bradnock (1968) proposed the use of this test for peas seeds and the procedure has been standardized by the Processors and Growers Research Organization (P.G.R.O., 1981). This test is also accepted in the UK as an officially recognized test for commercial vining peas seed in addition to the germination test (Hadavizadeh and George, 1988; Parera *et al*., 1995). Bedford (1974) found the relationship between electrical conductivity values and vigour in relation to the field emergence potential of vining peas.

The electrical conductivity test is a rapid, cheap and simple test. Several factors affect the test results. Factors which directly affect the results in peas and soybean are pH, soaking temperature, soaking duration, temperature at evaluation, initial seed moisture contents and seed size (Matthews and Bradnock, 1968; Bradnock and Matthews, 1970; Tao, 1978). The electrical conductivity of the seed leachate, and the amount of free amino acids and sugar were found to be higher from larger seeds than smaller seeds of cowpeas (Paul Ramaswamy, 1979). Hampton *et al*., (1992) suggested the use of a bulk conductivity testing method for large seeds of legumes such as mung bean (*Vigna radiate*), soybean (*Glycone max*) and French bean (*Phaseolus vulgaris* L.). Four replicates of seeds (selected at random) should be kept in 250 ml deionized water at 20°C for 24 hours. The initial seed moisture contents of the seeds should be 10-14%. The effect of test variables such as soaking water volume, seed number and initial seed moisture contents of bulk conductivity for small seeded legumes have been determined by Hampton *et al*., (1994) using two herbage legume species (*Lotus corniculantus* L. and *Lotus ulignous* Schr.). They recommended that bulk conductivity testing for Lotus species should also involve four replicates, soaked in 250 ml deionized water for 24 hours and that the seed moisture contents should be 11-17%.

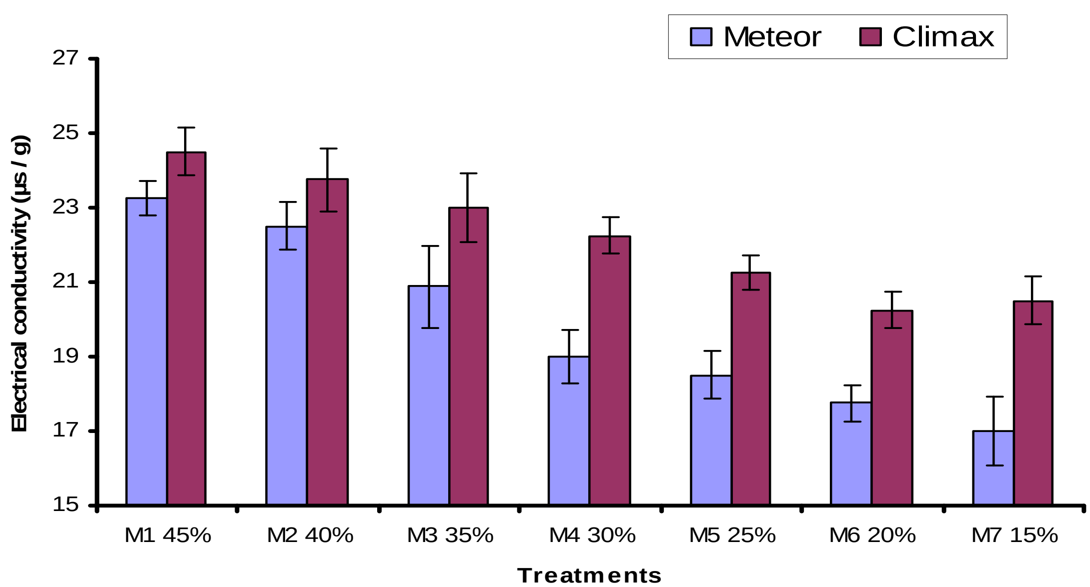


Fig.4.34:- **Effects of different seed moisture contents on Electrical conductivity (µs / g)**

Conclusion:

Seeds were harvested at different moistures contents of 45%, 40%, 35%, 30%, 25%, 20%, and 15% respectively. Seed harvested at 45% moisture contents gave greater 1000 seed weight as compared to other treatments. Different seed vigour tests showed Climax cultivar gave better results in respect to, seed fresh weight, seed dry weight, 1000 seed weight as compared to Meteor. Climax cultivar gave greater seed vigour as compared to Meteor. Seed vigour tests showed that EC % was low in M_1 (45%) and high in M_7 (15%) which means better seed vigour in M_7. Emergence showed better results in M_1 as compared to other treatments which showed almost similar results. Germination test showed that germination was greater in M_4 followed M_3, M_2, M_1 and remaining treatments showed lowest Germination. It is concluded that peas crop harvested at 25% moisture contents, gave better results as compared to other levels of moisture percentage.

4.6. EXPERIMENT NO.6:

EFFECTS OF PACKING MATERIALS AND STORAGE CONDITIONS ON PEAS SEED QUALITY

The effect of Packing materials and storage behavior on peas seed quality was tested. Peas pods were harvested from each treatment shelled and dried until they reached at 12% moisture contents. Seeds were stored at room temperature (25-30°C) and in refrigerator at different temperatures (0°C, 5°C, and 15°C) and 50% humidity was kept constant. Seed vigour test were conducted after six months of seed storage under the said condition.

4.6.1. Germination percentage (%)

Data for this parameter were collected; Subjected to statistical analysis of variance. The results are presented in figure 4.35 which revealed significant results for cultivars, packing materials, temperatures and their interactions.

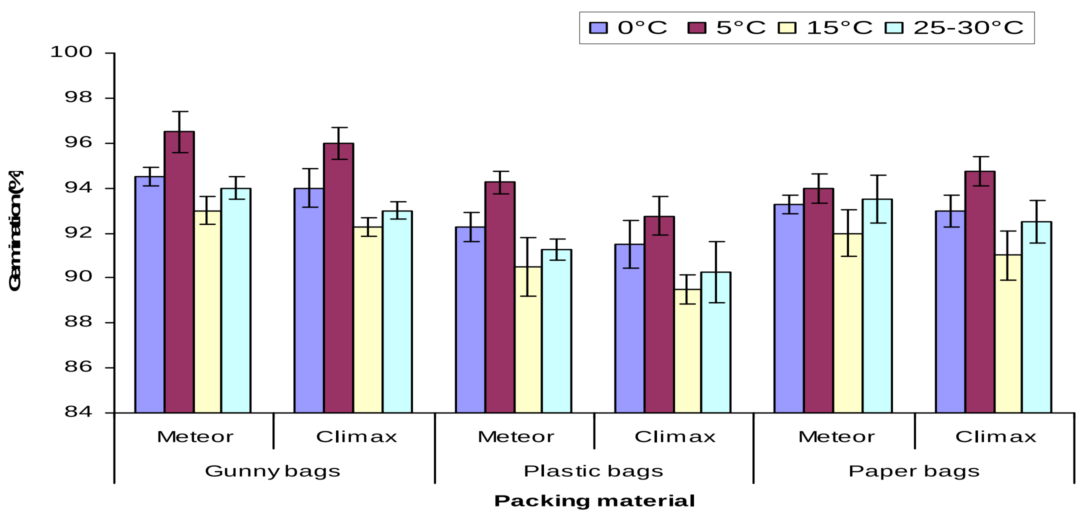


Fig.4.35:- Effects of Packing materials and storage conditions on Germination percentage (%)

Germination was better in Meteor with 93.25% as compared to Climax with 92.54%, as far as the temperature is concerned, the Germination% was high at temperature 25-30°C with 94.70% but low Germination was found at temperature 0°C which was 91.37% while other treatments showed results in between these temperatures. The packing materials gunny bags showed maximum Germination with 94.15% followed by paper bags with 93.00% and plastic bags with 91.53% respectively. Interaction between cultivars and packing materials depicted that

Germination was high, Meteor packed in gunny bags (94.50%) and low in Climax with plastic bags (91.00%) and other results showed in between. Interaction between cultivars and temperatures showed that Germination was high in Meteor at temperature 25-30°C (94.91%) and low in Climax at temperature 0°C (90.91%) and other combinations of treatments were in between. The interaction of cultivars, packing materials and temperatures gave high Germination in Meteor with gunny bags at temperature 0°C (96.50%) and low in Climax with plastic bags at temperature 0°C (96.50%) and the mean while of other variable were intermediate between these results. During seed storage, the rate of deterioration of seed may increase if the relative humidity of the store is increased, because it increased the seed moisture contents. This can be observed by inducing accelerated ageing in seeds adjusted to different seed moisture contents. The effects of different deterioration rates can be observed in germination tests. Seeds at higher moisture contents will be found deteriorated more rapidly and a rapid decrease in their germination percentage with excessive storability (Harrington, 1972). These results are in accordance with the findings of Palnisamy and Karivaratharaju (1990) who found in tomato that humidity level, storage period and different genotypes were found affect seed deterioration in tomato.

Ferguson (1988) observed that soybean seeds stored at 10ºC (temperature normally utilized in a cold chamber) had a reduced physiological potential when evaluated by germination and accelerated aging tests; however, this reduction was not detected by the electrical conductivity test. Mills and woods (1994) found that in peas (*Pisum sativum* L.) and white bean (*Phoseolus vulgaris* L.) deterioration assessed by electrical conductivity and germination percentage, the occurrence of fungi was increased by increasing the moisture contents and storage temperature of the stored seeds.

According to Guberac *et al*., (1997) relative air humidity and high storage temperature are negatively correlated with peas seed longevity and germination. Temperature and moisture contents of the seed are major factors in determining viability in storage. Seeds that can be stored in a state of low temperature and moisture contents (MC of 1-8%) are called orthodox (Roberts and Abdalla, 1968). In soybean, optimum storage conditions were found to be at temperatures of 25-30°C and relative humidity of 55-65% (Nkang and Umoh, 1997).

In peas, Eurotium levels after 147 days were low except at high moisture contents. In peas, Eurotium levels were higher but peasked at intermediate moisture. Beans suffered severe germination loss under less extreme conditions than peas. There were strong associations among most of the storage quality parameters studied, except for some fungi that occurred at low levels.

4.6.2. Electrical conductivity test

Data regarding electrical conductivity were collected and then subjected to statistical analysis of variance. The results are presented in figure 4.36 which revealed significant results for cultivars, temperatures, packing materials and their interactions.

Electrical conductivity was high in Meteor with 23.91 as compared to Climax with 26.60. As far as temperature is concerned, the electrical conductivity high at temperature 05°C (16.50) but low electrical conductivity was found at temperature 25-30°C (38.83) while other treatments showed results in between these temperatures. Packing materials showed electrical conductivity high in plastic bags 23.03 followed paper bags with 25.75 and gunny bags with 27 simultaneously. Interaction between cultivars and packing materials depicted that electrical conductivity was high Meteor with plastic bags with 21.62 and was low in Climax with paper bags with 27.12 and other results were found similar.

Interaction between cultivars and temperatures showed that electrical conductivity high in Meteor at temperature 0°C (14.50) and low in Climax at temperature 25-30°C (40.50) and other results showed in between. Interaction between cultivars, packing materials and temperatures showed that electrical conductivity high in Meteor with plastic bags at temperature (25-30°C) (12.50) and low in Meteor with plastic bags at temperature 25-30°C (12.50) and other results showed in between these results. It is important to store the seeds in waterproof containers/dehumidified atmosphere. If the storage relative humidity is high seed gain moisture and if they are later brought out to a higher temperature they could deteriorate because of their high moisture contents. For small batches of seeds, e.g. in *gene banks*, seeds could be kept immersed in liquid nitrogen (Bewley and Black, 1985).

Roberts and Abdalla, (1968) stated that it is important to store seeds under conditions that cause the minimum reduction of potential germination and vigour. For satisfactory long term storage a cold store with temperature and relative humidity not exceeding 10°C and 50% respectively is required. For storage of upto one year the temperature and relative humidity should not exceed 25°C and 50%.

Mills and Woods, (1994) found that in peas (*Pisum sativum* L.) and white bean (*Pisum valgaris* L.) deterioration assessed by electrical conductivity (Ferguson, 1988). Fessel (2001) sought to confirm the influence of storage at 10ºC on electrical conductivity.

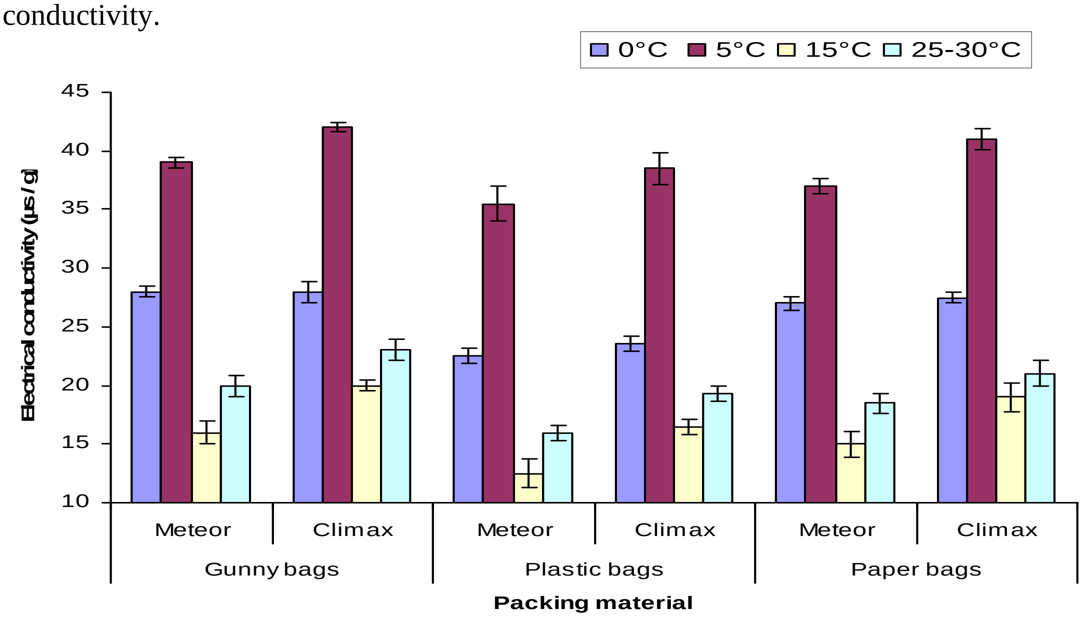


Fig.4.36:- Effects of packing materials and storage conditions on Electrical conductivity

4.6.3. Emergence percentage (%)

The information for this parameter were collected and subjected to statistical analysis of variance and results are presented in figure 4.37, which indicated significant results for cultivars, Temperatures, packing materials and their interactions.

Emergence percentage % was high in Climax 91.60% as compared to Meteor with 90.66%, as far as temperature is concerned, the emergence percentage % was high at temperature 0°C (95.08%) but low emergence percentage % was found at temperature 25-30°C (85.54%) while other treatments showed results in between these temperatures. Packing materials showed emergence percentage % was high in gunny bags 92.53% followed paper bags 90.90% and plastic bags 89.96% respectively. Interaction between cultivars and packing materials depicted that emergence percentage was high Climax with gunny bags 92.81% and low in Meteor with plastic bags 92.81% and other results showed in between. The interaction between cultivars and temperatures revealed that emergence percentage % was high in Climax at temperature 0°C (95.08%) and low in Meteor at temperature 25-30°C (90.91)%. Interaction between cultivars, packing materials and temperatures showed that emergence percentage % was high in Meteor with gunny bags at temperature 0°C (98.25%) and low in Meteor with Gunny bags at temperature 25-30°C (83.25%) and other results showed in between these results.

These results are in lined with Dickie and Pritchard (2002) who stated that different aspects like optimal storage temperature determining the storage category and optimal storage conditions for a crop species (Mills and woods, 1994).

Roberts and Abdalla, (1968) stated that usually seed is stored from harvesting until sowing. This can be a short or a long time but it is important to store seeds under conditions that cause the minimum reduction of vigour potential.

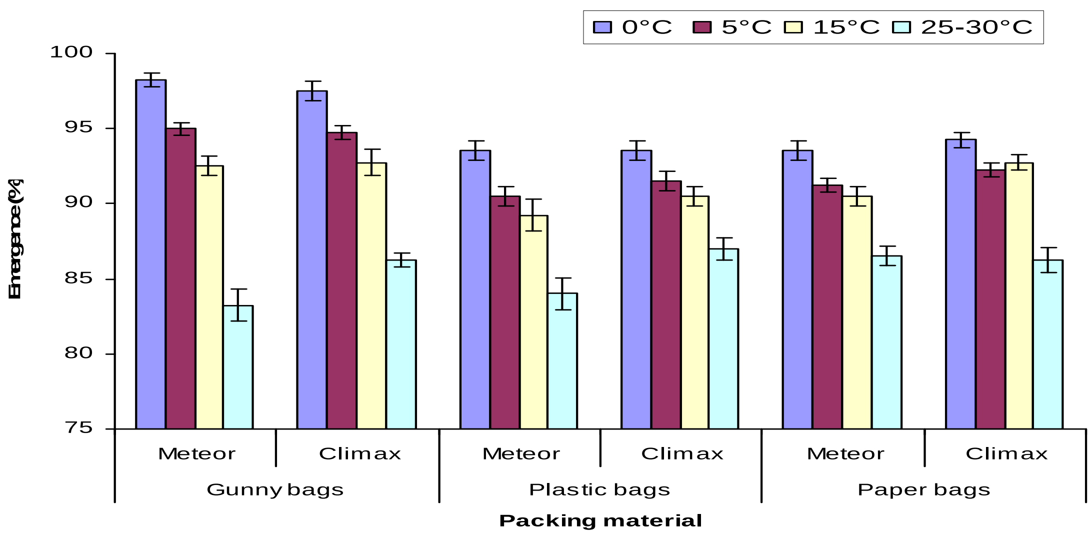


Fig.4.37:- Effects of Packing materials and storage conditions on Emergence percentage (%)

4.6.4. Seed nutrient concentration (N, P, K and protein contents)

The observations regarding to chemical composition of the peas seed were collected to analysis of variance and results are presented in figure 4.38 (a,b). It indicated that nitrogen, phosphorus, potash and protein have significant results for cultivars, packing materials, temperatures and their interactions.

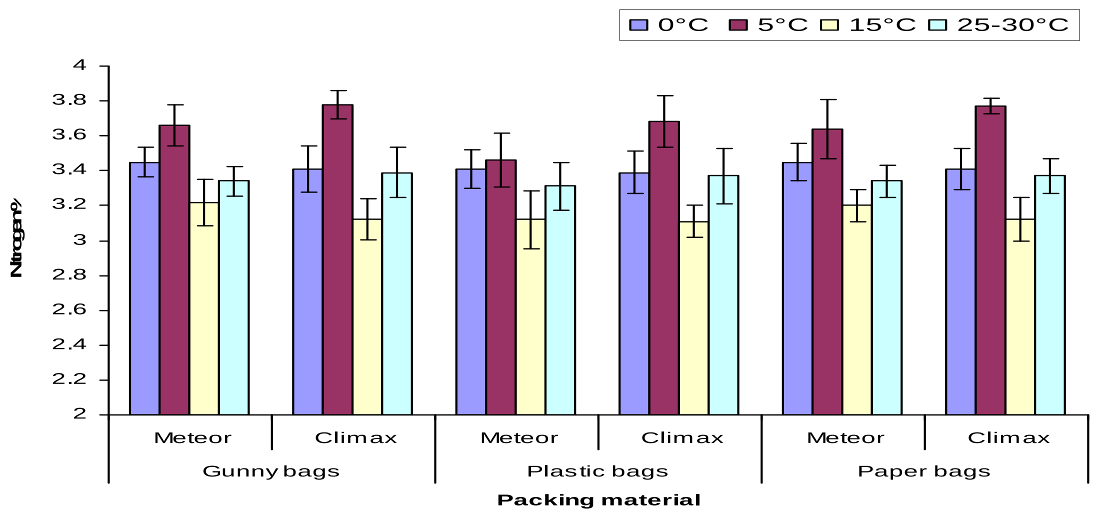
Nitrogen was high in Meteor with 3.38% as compared to Climax with 3.41%, as far as temperature is concerned, the nitrogen was high at temperature (25-30°C) (3.66%) but low nitrogen was found at temperature 0°C (3.14%) while other treatments showed results intermediate between these temperatures. Packing materials showed nitrogen was high in gunny bags with 3.42% followed paper bags with 3.41% and plastic bags with 3.35 %. Interaction between cultivars and packing materials depicted that nitrogen was high in Climax with 3.42% in gunny bags and low in Meteor in plastic bags with 3.32% and other results showed in between. Interaction between cultivars and temperatures showed that nitrogen was high at temperature (25-30°C) (3.74%) and low in Meteor at temperature 5°C (3.11%). Interaction between cultivars, packing materials and temperatures showed that nitrogen was high in Climax in gunny bags at temperature (25-30°C) with 3.78% and low in Meteor with plastic bags at temperature 0°C (3.11%).

Phosphorus was slightly higher in Climax with 0.33% as compared to Meteor with 0.32%, as far as temperature is concerned, the phosphorus was high at temperature 25-30°C (0.37%) but low phosphorus was found at temperature 0°C (0.25%) while other treatments were showed almost similar results. Packing materials revealed that phosphorus was high in gunny bags with 0.33% followed paper bags with 0.32% and plastic bags with 0.32% respectively. Interaction between cultivars and packing materials depicted that phosphorus high in Climax with gunny bags with 0.34% and low in Meteor in plastic bags with 0.32%. Interaction between cultivars and temperatures showed that phosphorus high in Meteor at temperature (25-30°C) (0.37%) and low in Meteor at temperature 0°C (0.24%). Interaction between cultivars, packing materials and temperatures showed that phosphorus high in Climax with gunny bags at temperature (25-30°C) (0.38%) and low in Meteor with plastic bags at temperature 0°C (0.38%).

Potash was high in Climax with 0.84% as compared to Meteor with 0.73%, as far as temperature is concerned, the potash was high at temperature 15°C (0.79%) but low potash was found at temperature 25-30°C (0.78%) while similar results were obtained in other treatments. Packing materials revealed potash was high in gunny bags with 0.81% followed plastic bags with 0.79% and paper bags with 0.76% simultaneously. Interaction between cultivars and packing materials depicted that potash was high in Climax in gunny bags with 0.87% and low in Meteor with paper bags with 0.71%. Interaction between cultivars and temperatures showed that potash was high in Climax at temperature (25-30°C) (0.99%) and low in Meteor at temperature 0°C (0.57%) and other results showed in between. Interaction between cultivars, packing materials and temperatures showed that potash was high in Climax with gunny bags at temperature 0°C (1.01%) and low in Meteor with paper bags at temperature 5°C (0.56%) whereas, other results showed in between these results.

Protein was high in Climax with 23.96% as compared to Meteor with 23.81%, The mean values of temperature depicted that protein was high at temperature 25-30°C (26.74%) but low protein was found at temperature 0°C (20.45 %) while other treatments showed almost similar results. Packing materials showed protein was high in gunny bags with 24.39% followed paper bags with 23.91% and plastic bags with 23.34%. Interaction between cultivars and packing materials depicted that Protein was high in Climax with gunny bags with 24.63% and low in Meteor in plastic bags with 23.15%. Intermediate results were found in other treatments. Interaction between cultivars and temperatures revealed that protein was high in Climax at temperature (25-30°C) (26.78%) and low in Meteor at temperature 0°C (20.13%). Interaction between cultivars, packing materials and temperatures showed that protein was high in Meteor with gunny bags at temperature 0°C (27.15%) and low in Meteor with paper bags at temperature 0°C (20.13%) and other results were showed intermediate between other treatments.

These result are in accordance with Nkang and Umoh, (1997) who reported that spoilage increased as temperature and moisture increased, as shown by rate of development of off-odor, and FAV, electrical conductivity and germination levels. Off-odors developed more rapidly in the peas than in the beans at the same temperature and comparable initial moisture contents.



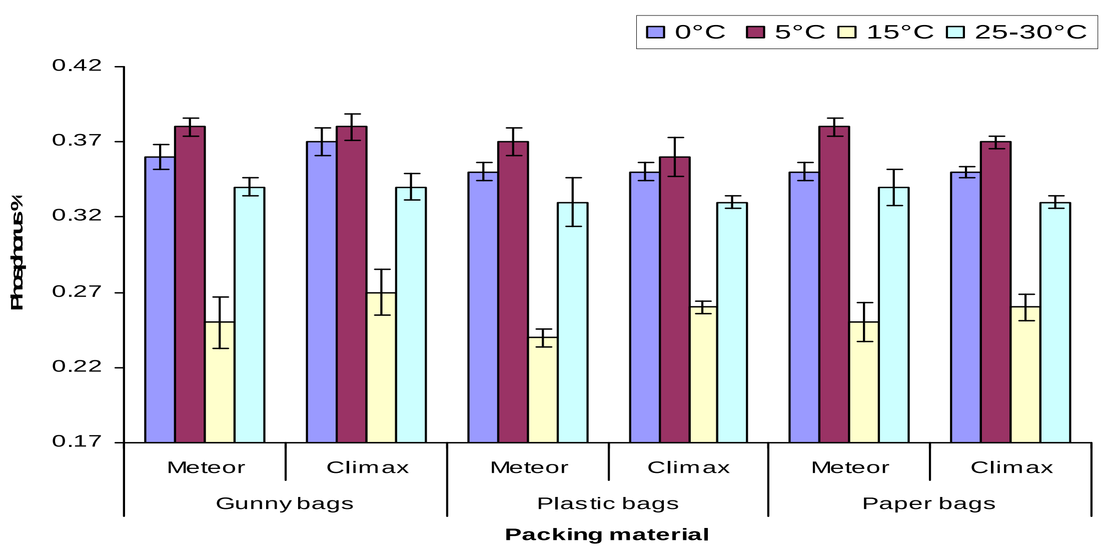
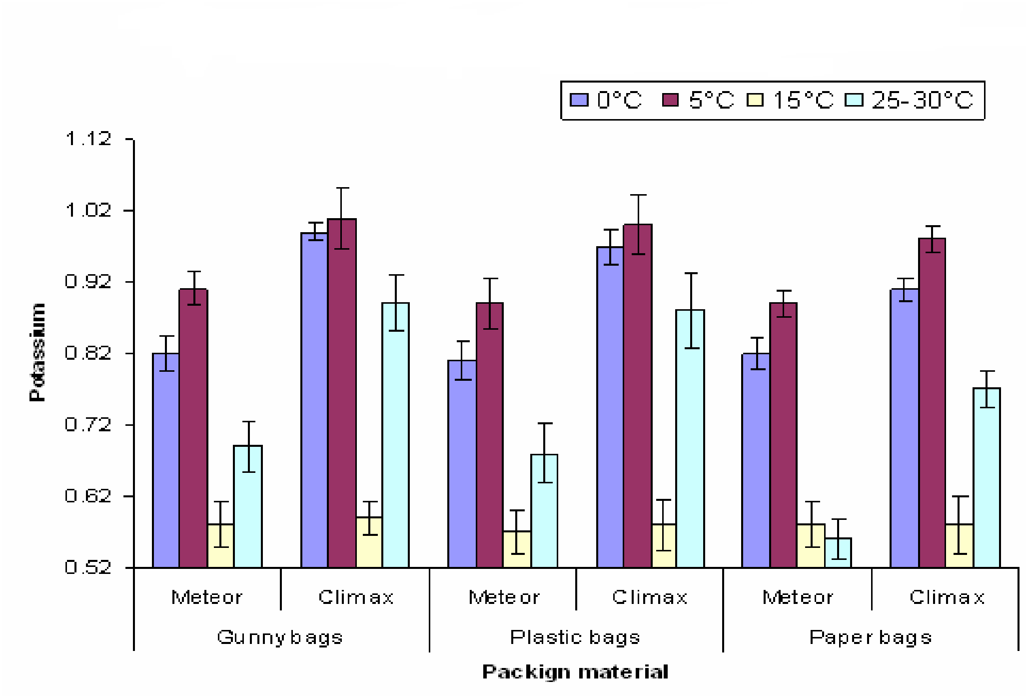


Fig.4.38 (a):- Effects of packing materials and storage conditions on seed nutrient concentration (Nitrogen and Phosphorus)



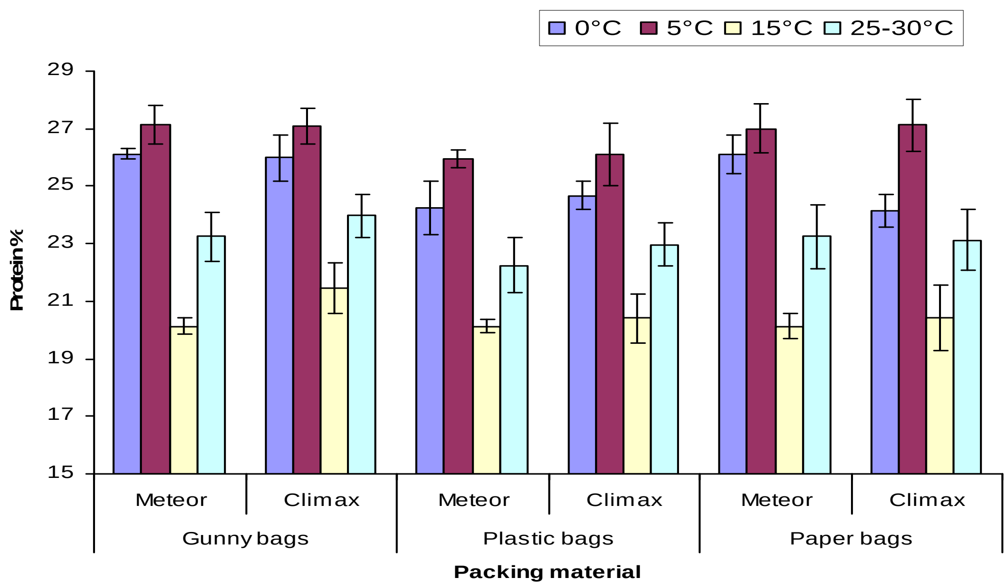


Fig.4.38 (b):- Effects of packing materials and storage conditions on seed nutrient concentration (Potash and Protein)

Conclusion:

Different temperature regimes like, 0°C, 5°C, 15°C and 25-30°C and different packing materials like, gunny bags, plastic bags and paper bags were studied. Temperature regime 5°C gave better results as compared to other temperature regimes (0°C, 15°C and 25-30°C). Chemical composition of peas seeds were showed that Nitrogen was greater in gunny bags with 3.418% as compared to plastic bags with 3.325% and paper bags with 93.325% respectively. Phosphorus gave better results for gunny bags as compared to other packing materials. Phosphors % was greater in seeds that stored at the 5°C as compared to other temperature regimes. Emergence gave better results for Climax with 92.813% as compared to Meteor with 92.250% respectively. Packing materials showed that germination% was high in seeds that were packed in gunny bags with 92.250% as compared to plastic bags with 89.313% and paper bags with 90.438%. Climax gave better results as compared to Meteor cultivar. It is concluded that peas seeds stored at 5°C in gunny bags gave better performance with respect to seed quality and vigour.

CHAPTER V

SUMMARY

These research studies were undertaken to observe growth and yield characteristic of peass crop with different management practices on a promising peass cultivars "Climax and Meteor". For this purpose, various experiments of Irrigation, fertilizer, maturity and storage were carried out. Various physio-chemical characteristics of peass crop and seed were studied. The details of these experiments are summarized below:

EXPERIMENT NO. 1:

EFFECT OF VARYING IRRIGATION FREQUENCIES ON GROWTH, SEED YIELD, VIGOUR AND QUALITY OF PEASS CROP.

This experiment was undertaken with respect to two peass cultivars "Meteor and Climax" with irrigation intervals I_0, I_1, I_2 and I_3 were studied. The parameter of main stem length indicated supremacy of Climax as compared to Meteor in both the years studied. Whereas, irrigational level I_3 (Irrigation upto seed filling) was observed better with maximum main stem length 58.000 cm during year 2006-07. As far as the characteristics of number of leaves plant $^{-1}$, leaf area and number of pod plant $^{-1}$ are concerned, the Meteor cultivar was observed better than Climax whereas, I_3 (Irrigation upto seed filling) was found superior to all the parameters studied. With the aspect of germination percentage, Meteor gave better results than Climax while, I_0 (irrigated as needed by crop) was observed at the top. The characters of Electrical Conductivity and emergence percentage were superior with Climax cultivar during both the years of studied; While, Meteor was statistically at par with climax in relation to EC during year 2006-07. I_3 (Irrigation upto seed filling) again produce better results as compared to other variables studied. As far as the parameters of number of seeds, seed fresh weight plant $^{-1}$, seed dry weight plant $^{-1}$, seed yield ha^{-1}, Climax gave excellent results comparable with Meteor during both years of studied. The irrigational intervals again showed Io with the best performance as compare to other variable studied.

EXPERIMENT NO.2:

INFLUENCE OF DIFFERENT PHOSPHORUS LEVELS ON PEASS SEED YIELD AND QUALITY.

Variety Climax exhibited more stem length per plant and number of leaves plant $^{-1}$ than Meteor whereas; both were at par with respect to leaf area (cm^2) plant $^{-1}$ and number of pods plant^{-1}. P_2O_5 at 120 kg $P_2O_5ha^{-1}$ influenced positively stem length, number of leaves, leaf area and number of pods plant^{-1} and was noted significantly better than all other levels of the element studied at 5% level. It was followed by the higher doses of 140 $P_2O_5ha^{-1}$ and 160 kg $P_2O_5ha^{-1}$ in all these parameters except in case of leaf area which was more than these, where 100 kg $P_2O_5ha^{-1}$ than on no fertilizer was applied. However, all the doses of phosphorus above than 120 kg $P_2O_5ha^{-1}$ were inferior to higher levels (140 $P_2O_5ha^{-1}$ and 160 kg $P_2O_5ha^{-1}$) with respect to those characteristics. It is note worthily that leaf area was reduced progressively by doses higher than 120 kg P_2O_5 ha^{-1} even in comparison with 100 kg and 0 kg levels whereas response to other parameters with the latter dose was the lowest of all other treatments. 80 kg $P_2O_5ha^{-1}$ stands at par with 100 kg $P_2O_5ha^{-1}$ about number of leaves and number of pods plant $^{-1}$on one hand while on the other it (80 $P_2O_5ha^{-1}$) does not vary from 60 kg$P_2O_5ha^{-1}$ doses about no. of leaves plant $^{-1}$. The least response to stem length, number of leaves plant $^{-1}$ and number of pods plant $^{-1}$ was recorded from 0 levels. 0 & 100 kg $P_2O_5ha^{-1}$ stand at par with respect to leaf area. It may be concluded that the best dose for morphological characters is 120 kg $P_2O_5ha^{-1}$ which if exceeded or reduced negatively influenced these parameters. The poorest response was recorded by control as it reduced stem length, number of leaves pods plant $^{-1}$ but enhanced leaf area in comparison with 140/100 kg$P_2O_5ha^{-1}$.

Application of 120 kg $P_2O_5ha^{-1}$promoted more vegetative characters than all other treatments but was at par with 140 and 160 kg/ha^{-1} with respect to number of seeds/pod. Similarly the latter 2 high levels did not vary significantly from 100 doses with respect to length of pod/plant, 1000 seed weight and seed yield. However, these produced more length of pod and number of seeds pod^{-1} than 100 kg$P_2O_5ha^{-1}$. The latter level did not influence length of pod & no. of seeds pod^{-1} in comparison with 60 and 80 kg $P_2O_5ha^{-1}$ but it positively affected the other characters. As expected 0 level occupied the lowest position of all the treatments in 1000 seed weight but surprisingly it stood at par with 80 kg and 60 kg doses in case of seed yield and length of pod respectively. The enhanced seed production by 120 kg$P_2O_5ha^{-1}$ applications may be attributed to improvement of components of yield (length of pod, number of seeds pod^{-1} and seed weight). The performance of these components of yield by 120 kg $P_2O_5ha^{-1}$ than other levels was reinforced by more stem length, leaf area, number of leaves and number of pods $plant^{-1}$ noted earlier in this case.

Climax excelled Meteor in all parameters except nitrogen where the latter produced more N than the former. The highest dose of 160 kg $P_2O_5ha^{-1}$ recorded maximum phosphorus, potash and protein of all other levels and was followed by 140 kg $P_2O_5ha^{-1}$ in these respects. While nitrogen was the highest in 100 kg $P_2O_5ha^{-1}$ to be followed by 80 kg $P_2O_5ha^{-1}$, 120 kg $P_2O_5ha^{-1}$ dose ranked 3^{rd} to the other 2 high levels of P_2O_5 with respect to phosphorus, potash and protein but stood at par with 160 kg and better than 140 kg $P_2O_5ha^{-1}$ in case of nitrogen. There is no sequence in nitrogen % in response to applied phosphorus levels as 100 kg $P_2O_5ha^{-1}$ produced the highest % of N followed by 80 kg $P_2O_5ha^{-1}$ whereas the levels of 120 kg $P_2O_5ha^{-1}$ and 160 kg $P_2O_5ha^{-1}$ were at par with 60 kg kg $P_2O_5ha^{-1}$ while 140 kg $P_2O_5ha^{-1}$ recorded N next to control as the lowest level of element did not seem to have influenced absorption of nitrogen and minerals. However, there is visible pattern of phosphorus, potash and protein i.e. they decrease progressively in relation to reduction in dose of P_2O_5. The minimum response to these pursuits from 0 level of P_2O_5 is quite comprehensible. It may be deduced from above that the highest dose of P_2O_5 (160 kg $P_2O_5ha^{-1}$) converted N into protein more efficiently than other levels besides accounting for high levels of P_2O_5 and potash in the seeds. Similar pattern is followed by the next dose (140 kg $P_2O_5ha^{-1}$) whereas a consistent pattern is followed under 120 $P_2O_5ha^{-1}$ doses. The highest levels of N and protein in leaves receiving 120 kg P_2O_5 ha^{-1} did not contribute to simultaneous enhancement of these items into peass seed.

Protein and ash are more in Climax than Meteor whereas the latter surpassed the former in N% (like peass seed). The highest levels of N, protein and ash were recorded where P_2O_5 at 120 kg ha^{-1} was applied. The next treatment in order was 100 kg P_2O_5 ha^{-1} in all the 3 characters. The response from this treatment was at par with 140 kg P_2O_5 ha^{-1} with respect to protein and ash while N% in this case was even less than control.

Amazingly control stands at par with 80 kg $P_2O_5ha^{-1}$and 100 kg P_2O_5 doses in N and even better than 60 kg P_2O_5 ha^{-1}. The application of 80 kg $P_2O_5ha^{-1}$ produced N and protein similar to 100 kg $P_2O_5ha^{-1}$. The predictable response falls amongst levels ranging from 80 kg $P_2O_5ha^{-1}$ to 140 kg $P_2O_5ha^{-1}$ whereas it is way word at 60 kg $P_2O_5ha^{-1}$and 160 kg $P_2O_5ha^{-1}$.

Climax is superior to Meteor only in terms of ash above as both at par in nitrogen and protein. Nitrogen level in stem is maximum where 60 kg $P_2O_5ha^{-1}$ was applied whereas protein and ash are at peassk in stems receiving 120 kg $P_2O_5ha^{-1}$. The latter dose is at par with 140 kg $P_2O_5ha^{-1}$ with respect to nitrogen % in stems. The highest dose of 160 kg $P_2O_5ha^{-1}$ was only above control in terms of N % and protein but it succeeds 120 kg $P_2O_5ha^{-1}$ dose in ash. The lowest % of nitrogen, protein and ash in stems pertained to control plants. It seems that application of least dose of 60 kg $P_2O_5ha^{-1}$ was not sufficient level for translocation of nitrogen from leaves to seeds thereby accumulating more nitrogen in stems. The synthesis of protein was more, in stems where 120 kg$P_2O_5ha^{-1}$ was applied followed by 100 and 140 kg $P_2O_5ha^{-1}$. Similarly the same dose excelled all others in ash accumulation but was surprisingly succeeded by 160 kg $P_2O_5ha^{-1}$ instead of 100 and 140 kg $P_2O_5ha^{-1}$ levels. The latter 2 treatments are at par with each other in ash but rank next to 160 kg $P_2O_5ha^{-1}$.

The highest values of N %, protein % and ash % were recorded in pod and seed were 120 kg of $P_2O_5ha^{-1}$ was applied which may be attributed to facilitation of nitrogen and mineral movement from other plant parts to pods, seeds and accelerating the pace of photosynthesis. The preceding and succeeding doses (100 & 140 kg $P_2O_5ha^{-1}$) accumulated N% next to 120 kg $P_2O_5ha^{-1}$ but did not result into corresponding enhancement in protein contents. 140 kg $P_2O_5ha^{-1}$ application superseded 100 kg $P_2O_5ha^{-1}$dose in protein and ash % unexpectedly. The highest level of P_2O_5 (160 kg) although effective in protein synthesis as it ranked next to 120 kg $P_2O_5ha^{-1}$ dose but in term of N% and ash% was only above control.

Seed vigour tests showed that electrical conductivity was high in Climax but emergence% and germination% were at par in both cultivars. Electrical conductivity showed almost similar results except 120kg $P_2O_5ha^{-1}$. Emergence% was high in 120kg than other levels of P_2O_5. Germination %was at par in control and 120kg $P_2O_5ha^{-1}$. All the other treatment also showing better results in respect to seed vigour.

EXPERIMENT NO.3:

INFLUENCE OF DIFFERENT POTASH LEVELS ON PEASS SEED YIELD AND QUALITY OF PEASS CROP.

Vegetative characters like, main stem length, number of leaves plant^{-1}, leaf area, number of pods plant^{-1}and length of pod showed significant results and superiority was shown in Climax as compared to Meteor. These vegetative parameters are significant for 100 kg $P_2O_5ha^{-1}$ as compared to other levels of potash. The dose of 120kg $P_2O_5ha^{-1}$ also showing better results after 100kg $P_2O_5ha^{-1}$. The lowest performance was observed in the control. High doses 140kg $P_2O_5ha^{-1}$ and 160 $P_2O_5ha^{-1}$ showing statistically at par each other in main stem length, number of leaves/plant and number of pods plant $^{-1}$.100Kg $P_2O_5ha^{-1}$ showed significant performance for vegetative parameters than other combinations of treatments. Seed yield ha^{-1} showed better results in climax as compared to Meteor. The yield enchantment characteristics like, number of seeds/pod, 1000 seed weight and seed yield/ha were dominant in 100kg $P_2O_5ha^{-1}$ as compared to other levels. Seed yield in comparison of cultivar was found almost similar results with Climax had a minute edge over meteor. Lowest seed yield was found in 40kg $P_2O_5ha^{-1}$ and at par in between 140kg $P_2O_5ha^{-1}$ and 160kg $P_2O_5ha^{-1}$. Protein% was at par in between Climax and Meteor but nitrogen, phosphorus and potash were showed minute difference in climax and Meteor seeds. 100kg $P_2O_5ha^{-1}$ had showing more concentration for all parameters studied but 140kg $P_2O_5ha^{-1}$ and 160kg $P_2O_5ha^{-1}$ were at behind as comparison to 100kg $P_2O_5ha^{-1}$. A minute difference was observed among all treatments but lowest concentration was found in 40kg $P_2O_5ha^{-1}$.

Peass leaves chemical composition showed that nitrogen, protein and ash was high in Climax as compared to Meteor. Nitrogen was high in 100kg $P_2O_5ha^{-1}$ but close to 140kg $P_2O_5ha^{-1}$ and remaining showing decreasing not significantly. Protein was high in 100kg $P_2O_5ha^{-1}$ while other treatment shown minute difference among each other Ash was showing non significant result but was better in 100kg $P_2O_5ha^{-1}$.

Peass stem chemical composition showing that nitrogen and protein was better in Climax but ash was at par in between Climax and Meteor. Nitrogen shown non significant results in control, 40kgP_2O_5ha^{-1}, 60kgP_2O_5ha^{-1}and 140kgP_2O_5ha^{-1} respectively. 80kgP_2O_5ha^{-1}, 100kg P_2O_5ha^{-1} and 120kg P_2O_5ha^{-1} had almost similar results but high in 100kg P_2O_5ha^{-1}. Protein and ash had non significant result in all levels but better results were obtained in 100 kg P_2O_5ha^{-1}.

The highest values of N %, protein % and ash % were recorded in pod + seeds were 100 kg of P_2O_5ha^{-1} was applied which may be attributed to facilitation of nitrogen and movement from other plant parts to pods, seeds and accelerating the pace of photosynthesis. The succeeding doses (100 & 120 kg P_2O_5ha^{-1}) accumulated N% next to 140 kg P_2O_5ha^{-1}but did not result into corresponding enhancement in protein contents. 140 kg P_2O_5 ha^{-1} application superseded 100 kg P_2O_5ha^{-1}dose in protein and ash % unexpectedly. The highest level of P_2O_5 (160 kg P_2O_5ha^{-1}) although effective in protein synthesis as it ranked lowest as compared to other treatments.

Different seed vigour tests were also performed to observe the vigour and quality of cultivars. EC % and emergence % was greater in Climax cultivar but germination % was greater in Meteor Cultivar. The treatments show that T_5 (K 100kg P_2O_5ha^{-1}) giving a better results followed T_4 (80 kg P_2O_5ha^{-1}) and T_6 (K 120 kgP_2O_5ha^{-1}) and all the other remaining treatments showed inferior results.

EXPERIMENT NO.4:

QUALITATIVE AND QUANTITATIVE RESPONSE OF PEASS (*Pisum sativum* L.) TO JUDICIOUS APPLICATIONS OF IRRIGATION WITH P AND K.

Climax exhibited more stem length plant^{-1} but number of leaves plant^{-1}, leaf area, and no. of pods plant $^{-1}$ were better in Meteor. T_3 influenced positively on stem length, number of leaves, leaf area and number of pods plant^{-1} and was noted significantly better than all other levels of combinations studied at 5% probability level. It was followed by T_2, $T_1$and T_0. However, all above combinations were worse with respect to the characteristics studied. T_0 and T_1 remain statistically at par with respect to number of pods plant $^{-1}$. The least response to main stem length, number of leaves plant $^{-1}$, leaf area and number of pods plant $^{-1}$ were recorded from 0 levels. It is concluded that the best dose for morphological characters is T_3 (irrigation upto seed filling + 100 kg k_2O ha^{-1} +120 kg P_2O_5 ha^{-1}). The worse response was recorded by T_0 (control) as it reduced stem length, number of leaves pods plant $^{-1}$, leaf area and number of pods plant $^{-1}$.

Climax gave better response as well to yield parameters as compared to Meteor. The yield characters like, length of pod, number of seeds/pod and 1000 seed weight were significantly superior in T_3 (irrigation upto seed filling +120 kg P_2O_5 ha^{-1}+ 100kg k_2O ha^{-1}) as compared to other levels of treatments. A narrow difference was observed in T_2, $T_1$and T_0 in respect to pod length. T_1 and T_2 were at par in number of seeds per pod. 1000 seed weight and seed yield which was found gradually increased from T_0 to T_3. T_0 was observed at the lowest position. The performance of yield components was reinforced by T_3 (irrigation upto seed filling +120 kg P_2O_5 ha^{-1}+ 100kg k_2O ha^{-1}) than other levels which were more stem length, leaf area, number of leaves and number of pods plant $^{-1}$ as noted earlier in this case.

Seed composition shown Climax excelled Meteor in all parameters. T_3 recorded maximum phosphorus, potash and protein as compared to other levels and followed by T_2, $T_1$and $T_{0.}$ While nitrogen was maximum in T_3, followed by T_1, T_2 and T_0. As far as the phosphorus, potash and protein are concerned, a gradual increase was observed from T_0 to T_3. There is no sequence in nitrogen % in response to different combination of irrigation, phosphorus and potash. However, there is visible pattern of phosphorus, potash and protein i.e. they increase progressively as increase in the dose of P_2O_5 and k_2O. High levels of P_2O_5 and potash significantly increased phosphorus and potash% in the seeds.

Nitrogen, protein and ash %age were more in Climax than Meteor leaves. The highest levels of N, protein and ash were recorded in T_3 where irrigation upto seed filling +120 kg P_2O_5 ha^{-1}+ 100 kg k_2O ha^{-1} was applied. The next treatment was T_2 (irrigation upto seed filling +120 kg P_2O_5 ha^{-1}) in all the three leave characters. The predictable response falls in levels ranging from T_0 to T_3.

Climax is superior to Meteor in terms of ash, nitrogen and protein% in stems. Nitrogen level in stems was high where irrigations upto seed filling +120 kg P_2O_5 ha^{-1}+ 100 kg k2O ha^{-1} were applied. Whereas protein and ash were at peassk in stems receiving as in T_3. The latter doses were at par with T_2, T_1 and T_0 with respect to nitrogen % in stems. The lowest % of nitrogen, protein and ash in stems pertained to control plants. It seems that best combination of irrigation, phosphorus and potash succeeded for maximum stems chemical concentration.

The highest values of N %, protein % and ash % were recorded in pod + seeds irrigation upto seed filling +120 kg P_2O_5 ha^{-1}+ 100kg k_2Oha^{-1} were applied which may be attributed to facilitation of nitrogen and mineral movement from other plant parts to pods, seeds and accelerating the pace of photosynthesis. The T_3 although effective in protein and ash while all other combination showed at par performance.

The tests of seed vigour showed that electrical conductivity and germination % were better in Meteor but emergence% was good in Climax. Emergence and germination %was gradually increased from T_0 to T_3. The best results were obtained in T_3 (irrigation upto seed filling +120 kg P_2O_5 ha^{-1}+ 100kg k_2Oha^{-1}). All the other treatments also showed better results with respect to seed vigour.

EXPERIMENT NO.5:-

EFFECTS OF DIFFERENT SEED MOISTURE CONTENTS AT HARVEST ON PEASS SEED QUALITY.

Climax exhibited more seed fresh weight, seed dry weight and 1000 seed weight plant $^{-1}$ as compared to Meteor. The crop harvested at 45% moisture contents had high seed fresh weight, followed by other treatments like, 0, 40%, 35%, 30%, 25% and 20% and 15% in descending order as per their performance. Seed dry weight plant $^{-1}$ was found maximum at the crop which was harvested at 35% moisture contents. The worse response was recorded from the crop harvested at 15% moisture contents. The crop harvested at 40% moisture contents had at par with the crop harvested at 30% moisture contents in respect to seed dry weight. The seed dry weight of the crop harvested at 25% and 20% moisture contents produced almost similar results. The crop harvested at 45% moisture contents had the lowest seed dry weight. More response of 1000 seed weight was observed in 45% moisture contents and the worst result was recorded in 15% moisture contents. The crops harvested at 35% and 30% moisture contents were at par with respect to 1000 seed weight. Gradual decrease was seen in treatments from 45% to 15% moisture contents. In 1000 seed weight the crops harvested at 25% and 20% had minute difference as compared to other treatments.

The seed vigour showed the supremacy in Climax with respect to electrical conductivity test but emergence and germination % were showed vigour better in Meteor. The high electrical conductivity was found at 15% moisture contents but the lowest electrical conductivity was observed in crop harvested at 55% moisture contents. Other treatments were in between for electrical conductivity The emergence % was high at 45% and worst emergence percentage was found where the crop were harvested at 15% moisture contents. Germination percentage was found maximum in that crop which was harvested at 30% moisture contents. The crop harvested at 25% and 20% showing almost similar results than other treatments. The better germination % was observed in other treatments as compared to 20% and 25%.

EXPERIMENT NO.6:-

EFFECTS OF PACKING MATERIAL AND STORAGE CONDITIONS ON PEASS SEED QUALITY.

Germination % was high in Meteor than Climax. Gunny bags packing material showed better response than plastic bags and paper bags. Germination % was high at 5°C than other temperature regimes followed by 0°C, 25°C and 15°C respectively. In plastic bags and paper bags, the germination showed superseding results at 5°C as compared to other temperature regimes. The poorest response occurs at 15°C and 25°C. Electrical conductivity was better in Climax as compared to Meteor. EC % showing better results at 25°C which means high seed vigour as compared to others. Poorest response observed in gunny bags and plastic bags at 5°C and in paper bags at 0°C. The other temperatures regimes showing results in between. Emergence % showed results superior with Climax over plastic and paper bags. At 0°C all three packaging material like gunny bags, plastic bags and paper bags gave better performance as compared to other temperature regimes. Lowest response was seeing at 25°C but other temperature regimes shown in between these. Nitrogen % was more in Climax than Meteor. High N% was observed at 5°C in all packaging material but at par results were shown in gunny bags, plastic bags and paper bags at 25°C. The lowest nitrogen% was found in all three packaging material at 15°C. Phosphorus % was high in gunny bags and plastic bags in Climax but in Meteor in paper bags. The best phosphorus % results was obtained at 5°C in all three packaging material. The poorest performance was observed at 15°C in gunny bags and plastic bags but in paper bags at 0°C. The other temperature regimes showing almost similar results. Climax showed better results as well for potassium than Meteor stored in gunny bags, plastic bags and paper bags respectively. Gunny bags also giving good response in respect to potassium than the plastic bags and paper bags. The highest results were obtained at 5°C in all packing material used. In gunny bags poorest results were observed at 0°C but in paper bags and plastic bags at 25°C. Climax superior over Meteor in gunny bags and plastic bags but in paper bags Meteor gave better results than Climax. Temperature 5°C significantly better than other temperature regimes followed by 15°C, 25°C and 0°C respectively. The lowest response was observed at 0°C in gunny and plastic bags but in paper bags was at 25°C. In comparison to packaging material gunny bags were at top with paper bags at 5°C.

Overall it is concluded that variety Climax with gunny at 5°C were gave better results than other temperature regimes (0°C, 15°C, and 25°C) and packaging material (plastic bags and paper bags).

Recommendations:

- The Climax cultivar is better than other cultivars of peass.
- Irrigation upto seed filling stage used for peass as compared to other irrigation frequencies.
- Phosphorus level of 120 Kg ha^{-1} can be used for peass cultivars as compared to other levels of phosphorus. Although vegetative growth requires N but for legumes comparatively more phosphorus is needed for growth and N fixation. Excessive dose of phosphorus (140, 160 Kg ha^{-1}) did not gave good result.
- Potassium level of 100 Kg ha^{-1} can be used for better yield in peass cultivars. Excessive dose of potassium (120, 140, 160 Kg ha^{-1}) did not perform well.
- Harvesting at 25% moisture contents was good for peass seeds quality and vigour.
- Peass seeds can be stored at 5°C in gunny bags instead of plastic and paper bags for better vigour and quality.

LITERATURE CITED

AACC. 2000. Approved methods of American association of cereal chemists (10th Ed). Arlington, USA: American Association of Cereal Chemists.

Abdalla, F.H. and Roberts, E.H. 1969. The effect of storage on growth and yield of barley, broad beans and peas. Annals of Botany, 33: 169-184.

Abdul-Baki, A.A. 1980. Biochemical aspects of seed vigour. Hort Science, 15: 765-771.

Acosta-Gallegos, J.A. 1988. Selection of common bean (*Phaseolus vulgaris* L.) genotypes with enhanced drought tolerance and biological nitrogen fixation. Ph.D Diss., Michigan State University, East Lansing. Halterlein, A. J., 1983: Bean. In: I. D. Teare, and M. M. Peet (Eds), Crop Water Relations, pp: 157-185.

Adams, M. W., D. P. Coyne, J. H. C. Davis, P. H. Graham, and C. A. Francis, 1985. Common bean (*Phaseolus vulgaris* L.). In: R. J. Summerfield and E. H. Roberts (Eds), Grain Legume Crops, pp: 433-476.

Ahmad, S. 1973. Effect of different levels of NPK on the different characters of pea. M.Sc. Thesis, Deptt. of Hort., WPAU., Lyallpur.

Amjad, M., M.A. Anjum and N. Akhtar. 2004. Influence of phosphorus and potassium supply to mother plant on seed yield, quality and vigour of pea (*Pisum sativum*). Asian J. Pl. Sci., 3(1): 108-113.

Anderson, J.A.D. and J.G.H. White. 1974. Yield of green peas II. Effects of water and plant density. New Zealand Journal of Experimental Agriculture, 2: 165-171.

Anderson, S.R. 1955. Development of pods and seed of birdsfoot trefoil (*Lotus corniculatus* L.) as related to maturity and seed yields. J. Agron., 47: 483-487.

Anfinrud, M.N. and A.A. Schneiter. 1984. Relationship of sunflower germination vigour test to field performance. Crop Science, 24: 341-344.

Anonymous. 2008. Agricultural Statistics of Pakistan. Ministry of Food, Agri. and Livestock. Govt. of Pakistan, Islamabad. pp: 152-153.

Baigorri, H.S., M.C. Antolin and M. Sanchez-Diaz. 1999. Reproductive response of two morphologically different pea cultivars to drought. Euro. J. Agron., 119-128.

Bedford, L.V. 1974. Conductivity tests in commercial and hand harvested seed of pea cultivars and their relation to field establishment. Seed Sci. Technol., 2: 332-335.

Berg, R.K. and J.Q. Lynd. 1985. Soil fertility effect on growth, yield, nodulation and nitrogen's activity of Austrian winter pea. J. Pl. Nutr., 8: 131-145.

Bewley, J.D. and M. Black. 1985. Seed, physiology of development and germination Plenum Press, New York, pp: 367.

Bewley, J.D. and M. Black. 1994. Seed, Physiology of development and germination 2nd ed. Plenum Press, New York.

Bhatti, I.M and A.H. Soomro. 1994. Seed, Seed technology and Regulations. In: Agricultural inputs and field crop production in Sindh. Agriculture Research Sindh, Hyderabad, Pakistan. pp: 56-69.

Bhopal, S. 1991. Note on response of garden pea to N and P application in North Hills. Indian J. Hort., 47(1): 107-108.

Biddle, A.J. and J.M. King. 1978. Effect of harvesting methods, equipment and weather on pea seed quality. Acta Hort., 83: 77-81.

Birecka, A. and M. Wlodkwski. 1961. Influence of phosphorus content in seeds on the nitrogen accumulation and the growth of peas and yellow lupines. Rocznik Nauk Roloniczyeh, Sera A., 84: 346-367. In: Viability of seeds (Ed. By E.H. Roberts) Syracuse University press, Syracuse: New York.

Bishoni, U.R. and J.C. Delouche. 1980. Relationship of vigour tests and lots to cotton seedling establishment. Seed Science and Technology, 8: 341-346.

Bogdevich, I.M., R.V. Shatalova and S.A. Titova. 1996. Yield and quality mixture of annual grasses depending on the doses of nitrogen fertilizer on dernopodzlic loam soil with different levels of acidity. Agrokhimiya, 1: 31-40.

Boutrina, E.P., B.A. Yagodin and S.N. Feofanov. 1991. Effect of late foliar application of urea and molybdenum on winter wheat grain yield and quality. Agrokhimiya, 4: 17-20.

Boyd, W.J.R., A.G. Gordon and L.J. Lacroix. 1971. Seed size, germination resistance and seedling vigour in barley. Canadian Journal of plant Sciences, 51: 93-99.

Bradnock, W.T. and S. Mattthews. 1970. Assistant field emergence potential of wrinkle-seeded peas. Horticulture Research, 10: 50-58.

Brevedan, R.E. and D.B. Egli. 2003. Short period of water stress during seed filling, leaf senescence and yield of soybean. Crop Science, 43: 2083-2088.

Browning, T. and R.A.T. George. 1983. Effect of mother plant mineral nutrition on seed yield and quality in legumes. International Society for Hort. Sci., 53(6): 4178.

Bustamante, L., M.G. Seddon, R. Don and W.J. Rennie. 1984. Pea seed quality and seedling emergence in the field. Seed Science and Technology, 12: 551-558.

Castillo, A.G., J.G. Hampton and P. Coolbear. 1992. Effect of time and method of harvest on seed vigour in garden peas (*Pisum sativum* L.). J. Appl. Seed Prod., 10: 31-37.

Chapman, H.D. and F. Parker. 1961. Determination of NPK. Methods of soils, plants and waters, Pvt. Div. Agri. Univ. California, USA. pp: 150-179.

Chen, C.C., C.H. Andrews, C.C. Baskin and J.C. Delouche. 1972. Influence of quality of seed on growth, development and productivity of some Horticultural crops. Proceedings of the International Seed Testing Association, 37: 923-939.

Copeland, L.O. and M.B. McDonald. 1995. Principles of Seed Science and Technology (3rd Ed.) Chapman and Hall, New York, pp: 111-126.

Costa, N.D.E.L. and V.T. Paulino. 1992. Potassium fertilization effects pigeon pea (*Cajanus cajan* L.) growth, mineral composition, and nodulation. Nitrogen Fixing Tree Research Reports. 10: 121-122.

Cutcliffe, J.A. and D.C. Munro. 1980. Effects of nitrogen, phosphorus, potassium and lime on yield and maturity of green peas. Canadian J. Pl. Sci., 60(2): 599-604.

Dayan, M.P. 1997. Desiccation and storage of *Anisoptera thurifera* seed in the Philippines. Information Note, ASEAN Forest Tree Seed Centre Project, Muak-Lek, Saraburi, Thailand. pp: 8.

De Souza, P.I., D.B Egli and W.P Bruening. 1997. Water stress during seed filling and leaf senescence in soyabeen. Agronomy J., 89: 807-812.

Delouche, J.C. 1968. Physiology of seed storage. 23rd Corn and Sorghum research. Conference. American Seed Trade Association, pp: 83-90.

Delouche, J.C. 1980. Environment effects on seed development and quality. Horticulture Science, 15:775-780.

Delouche, J.C. and C.C. Baskin. 1973. Accelerated ageing techniques for predicting the storability of seed lots. Seed Science and Technology, 1: 427-452.

Delouche. 1974. Soybean seed storage. Proceedings Southeastern Soybean

Demir, I. 1994. Development of seed quality during seed development in okra. Acta Horticulture, 362: 125-131.

Demir, I. and R.H. Ellis. 1992a. Development of pepper (*Capsicum annum*) seed quality. Annals of applied Biology, 121: 385-389.

Demir, I. and R.H. Ellis. 1992b. Changes in seed quality during seed development and maturation in tomato. Seed Sci. Res., 2: 81-87.

Demir, I., K.E. Cockshull (Ed.), Y. Tuzel (Ed.) and A. Gul. 1994a. Changes in seed quality during seed development in tomato and pepper. Second Symposium on protected Cultivation of Solanacea in mild winter climates, Adana, Turkey, 13-16 April 1993. Acta Horticulture, 366: 221-227.

Demir, I., R. Yammaz and A. Gunay. 1994. Seed moisture content as a determining factor of seed harvest time of snap beans 4F -89. Batch, 23: 59-65.

Desai, B. B., P. M. Kotecha and D.K. Salunkhe. 1997. Seeds handbook. Marcel Dekker, Inc., New York. pp: 627.

Dickie, J.B. and H.W. Pritchard. 2002. Systematic and Evolutionary aspects of desiccation tolerance in seeds. In: M. Black, H. M. Prichard, (Eds) (2002) Desiccation and survival in plants. Drying without dying. CABI Publishing, Oxon. UK. pp: 239-259.

Dornbos, D.L., Jr., R.E. Mullen and R.M. Shibblies. 1989. Crop Science, 29: 476-480.

Dubey, R.P., B.P. Kaistha and R.C. Jaggi. 1999. Influence of irrigation and phosphorus on growth, green pod yield and nutrient uptake of pea in Lahaul valley of Himachal Pradesh, India. J. Agron., 44(1): 137-140.

Duffus, C.M. 1979. Starch synthesis and grain growth. In: Crop Physiology and Cereal Breading. Proceeding of an Edcarpia workshop, wageningn. (Eds.J.H.J.Spiertz and T.H.Kramer) pp: 45-49.

Egli, D.B. and D.M. Tekrony. 1979. Relationship between soyabean seed vigour and yield. Agronomy Journal. 71: 755-759.

El-Habbasha, K.M., S.M. Adam and F.A. Rizk. 1992. Growth and yield of pea (*Pisum sativum* L.) plants as affected by plant density and foliar potassium application. Egyptian Journal of Horticulture, 23(1): 35-51.

Ellis, R.H. and C. Pieta-FIlho. 1992. The development of seed quality in spring and winter cultivars of barley and wheat. Seed Sci. Res., 2: 9-15.

Ellis, R.H. and E.H. Robrts. 1980. Towards a rational basis for testing seed quality. Seed production, pp: 605-635.

Ellis, R.H., I. Demir, L. Pieta, C.D. Filho (Ed.) and F. Corinean. 1993. Changes in seed quality during seed development in contrasting crops. Proceedings of Fourth international Workshop on seeds: Basic and applied aspects of seed biology, Angers, France, 20-24 July, 1992. 3: 897-904.

Ellis, R.H., T.D. Hong and E.H. Roberts. 1987. The development of desiccation tolerance and maximum seed quality during seed maturation in six grain legumes. Annals Bot., 59: 23-29.

Ene, B.N. and E.W. Bean. 1975. Variation in seed quality between certified seed lots of perennial ryegrass, and their relationship to nitrogen supply and moisture status during seed development. Journal of the British Grassland Society, 30: 195-199.

Ericksen, S.H. 2003. Climatic change and desertification: Biophysical processes and livelihood interactions in the dry lands. Annals of Arid Zone, 42: 231-254.

F.A.O. 1984. Seed review, Food and Agriculture Organization of United Nations, F.A.O.U.N. Rome.

F.A.O. 2009. FAO. Production year book, 54(163): 96-97.

Fageria, N.K. 1979. Effect of phosphatic fertilization on growth and mineral composition of pea plants. Agrochimica, 21(1/2): 75-78.

Ferguson, A.J. 1993. The agronomic significance of seed quality in combining peas (*Pisum sativum* L.). Ph.D Thesis, University of Aberdeen.

Ferguson, J.M. 1988. Metabolic and biochemical changes during the early stages of soybeen seed deterioration. Lixington. University of Kuntucky. (Ph.D. Thesis). pp.138.

Fernandes, G. and R.O.P. Rossiello. 1995. Mineral nitrogen in plant physiology and plant nutrition. Plant sciences, 14(2): 111-148.

Fernandez, G. and M. Johnston. 1995. Seed vigour testing in Lentil, bean and Chickpea. Seed Science and Technology, 23: 617-627.

Fessel, S.A. 2001. Condutividade elétrica em sementes de soja em função da temperatura e do período de armazenamento**.** Jaboticabal: UNESP/FCAV, Dissertação Mestrado, pp: 100.

Fougereux, J.A., D. Thierry, F. Ladonne and A. Fleury. 1997. Water stress during reproductive stages affects seed quality and yield of pea. Crop Sci., 37: 1247-1252.

Gangwar, M.S., H.N. Singh, S. Singh, K. Singh and R.A. Gupta. 1998. Nitrogen Phosphorus and potassium requirements for targeted seed production of vegetable pea in U.P. India. Annals of Agri. Res., 19(4): 386-389.

Gataric, D., S. Alibegovic-Grbic, N. Gabocik, V. Krajcovic, and V.M. Zimkova. 1990. The influence of weather conditions and some agronomy on plant development and yield components in seed production of birdsfoot trefoil. pp: 305–308.

George, R.A.T., R.J. Stephens and S. Varis. 1980. The effect of mineral nutrients on the yield and quality of seeds in tomato. In seed production (Ed. P.D Hebblethwaite) pp: 561-567.

Germ, H. 1960. Mehodology of the vigour test for wheat, Rye and Barley in rolled filter paper. Proceedings of international seed Testing Association, 25: 515-518.

Gershon D. (1961). Breeding for resistance to pod dehiscence in birdsfoot trefoil (*Lotus corniculatus* L.) and some studies of the anatomy of pods, cytology and genetics of several *Lotus* species and their interspecific hybrids. [PhD. Thesis.] Cornell University, Ithaca.

Golezani, K.G., A. Soltani and A.A. Tashi. 1997. The effect of water limitation in field on seed quality of maize and sorghum. Seed Science and Technology, 25: 321-323.

Grant W.F. 1996. Seed pod shattering in the genus *Lotus* (Fabaceae): A synthesis of diverse evidence. Can. J. Plant Sci., 76: 447-456.

Guatam, O.P., and D. Lenka. 1968. Response of vegetative reproduction growth to row spacing and seed rate of pea under different fertility and irrigation conditions. Indian J. Agric. Sci., 38: 856-863.

Guberac, V.D. Banaj and D. Horvat. 1997. Kakvoca sjemena lucerne (*Medicago sativa L*.) stocnog graska (*Pisum sativum* L.) nakon pet godina hermetickog skladistenja. Seed Quality of alfalfa (*Medicago sativa* L.) and fodder peas (*Pisum arvense* L.) after 5 years hermetic storage. Sjemenarstvo, 14: 309-315.

Gupta, C.R., S.S. Sengar and J. Singh. 2000. Growth and yield of table pea (*Pisum sativum* L.) as influenced by levels of phosphorus and lime in acidic soil. Veg. Sci., 27(1): 101-102.

Hadavizadeh, A. 1989. The effect of mother plant nutrition on seed yield, quality and vigour in peas (*Pisum sativum* L.).B. Sciences and Engineering, 50(5): 1698B.

Hadavizadeh, A. and R.A.T. George. 1988. The effect of mother plant nutrition on the seed yield and seed vigour in pea (*Pisum Sativum* L.) Cultivar "Sprite". Seed Science and Technology, 16: 589-599.

Haeder, H.E. 1990. Starch formation in wrinkled and fodder peas under the influence of potassium and magnesium nutrition.Verband Deutscher Landwirtschaflicher Untersuchungs Und Forscinungsanstalten Reihe Kongressberichte, 30: 437-442.

Halterlein, A. J., 1983: Bean. In: I. D. Teare, and M. M. Peet (eds), Crop Water Relations, pp. 157Ð185. John Willey & Sons, New York.

Hampton, I.G., D.M. Tekrony. 1995. Handbook of vigor test methods. 3. ed. Zurich: ISTA, pp: 117.

Hampton, J.G., A.L. Lungwangwa and K.A. Hill. 1994. The bulk conductivity test for Lotus seed lots. Seed Science and Technology, 22: 177-180.

Hampton, J.G., K.A. Johnstone and U.V. Eua. 1992. Bulk conductivity test variable for mungbean, soyabean and French bean seed lots. Seed Science and Technology, 18: 677-686.

Hanolo, W., M.A. Pulung, S.S. Harjadi, S. Tjitrosomo, W. Harjadi, W.D. Widodo and Sudarsono.1994. Effect of phosphorus and potassium fertilizers on growth and yield of pea. Acta Hort., 369: 335-339.

Hardy, R.W.F., R.C. Burns, R.R. Hebert, R.D. Holsten, R.D. and E.K. Jackson. 1971. Biological Nitrogen fixation a key to world protein. Plant soil, Special Vol., pp: 561-590.

Harrington, J.F. 1972. Seed storage and longevity. In: Seed Biology, (Ed. T.T. Kozlowski), New York: Academic Press, 3: 145-245.

Heath, M. C., C.J. Pilbeam, B.A. McKenzie and Hebblethwaite, P. D. 1994. In: Expanding the production and use of cool season food legumes (Eds. Muehlbauer, F. J. and Kaiser, W. J.) (Kluwer Academic Publishers, Dordrecht, Netherlands). pp: 771-790.

Heatherley, L.G. 1993. Drought stress and irrigation effects on germination of harvested soybean seed. Crop Sci., 33: 777-781.

Hosnedl, V., J. Behal, P. Horcka, D. Come (Ed) and F. Corbineau. 1993. Problems of using conduct metric tests for pulse seed. Proceedings of the fourth International Workshop on Seeds: Basic and applied aspects of seed biology, France, 20-24 July, 1992. 3: 969-973.

Hosnedle, V. and Z. Ruzickona. 1988. Vigour of pea seeds in relation to ripeness and method of harvesting. Rostlinna Vyroba, 34 (4): 635-640.

Hsio, T.C., W.K. Silk and J. Jing. 1985. Leaf growth and water deficits: Biophysical effects. In control of leaf growth, eds.: N.R. Baker, W.J. Davies and C.K. Ong. Cambridge Univ. Press, Cambridge, pp: 239-266.

Hukheri, S.B. and A.K. Sharma. 1980. Irrigation requirement of field pea for grain. Indian J. Agr. Sci., 50: 157-160.

I.S.T.A. 1985. International rules for seed testing. *Seed Science and technology*, 13: 299-355.

Ibrahim, A.K. 1990. Studies on growth and yield of chickpea. A Ph.D. Thesis, Univ. of Wales, Bangor. U.K.

Isely, D. 1957. Vigour Tests. Proceeding of the Association of Official Seed analysts. 47: 176-182.

James, E., L.N. Bass and D.C. Clarck. 1967. Varietals differences in longevity of vegetable seeds and their response to various storage conditions. Proc. Am. Soc. Hort. Sci., 91: 521-528.

Johnson, A.M., Tanaka, D.L., Miller, P.R., Brandt, S.A., Nielsen, D.C., Lafond, G.P., Riveland, N.R., 2002. Oilseed crops for semiarid cropping systems in the northern Great Plains. Agron. J., 94: 231–240.

Johnson, R.R. and L.M. Wax. 1978. Relationship of soybean germination and Vigour test to field performance. Agronomy Journal, 70: 173-178.

Jonh Mellor Associates, Inc and Asianics Agro-Dev. International (Pvt.) Ltd. 1994. Institutional Reforms to Accelerate Irrigated Agriculture main report, submitted to Government of Pakistan through the Chairman Federal flood Commission Ministry of Water and Power, sponsored by Government of Pakistan and World Bank, Washington, D.C. pp: 250-255

Kanaujia, S.P., K.B. Restogi and S.K. Sharm. 1997. Effect of phosphorus, potassium and rhizobium inoculation on growth, yield and quality of pea cv. Lincolin. Veg. Sci., 24(2): 91-94.

Kasturikrishna, S. and P.S. Ahlawat. 1999. Growth and yield response of pea (*Pisum sativum* L.) to moisture stress, phosphorous, sulphur and zinc fertilizers. Indian J. Agron., 44: 588-596.

Khan, S.A., A.M. Malokra and M. Habib. 1988. In: Matar Ki Kasht, Pumphlet of Department of Agriculture Punjab Lahore, Pakistan.

Knights, E.J. 1993. Seed weathering in chick pea. International chickpea-news Letter, 29: 25-27.

Knott, C.M. 1987. A key for stages of development of the pea (*Pisum sativum*). Ann. Appl. Biol., 111: 233-245.

Knott, C.M. 1996. Control of manganese deficiency in field peas grown for a human consumption. Journal of Agricultural Science, 127(2): 207-213.

Kohli, U.K., I.K. Thakur and Y.R. Shukla. 1992. A note on responses of peas (*Pisum sativum L.*) to phosphorus and potassium application. Hort Sci., 5(1): 59-61.

Koostra, P.T. and J.F. Harringten. 1969. Biochemical effects of age in membrabal lipids of *Cucumis sativus* L. seeds. Proceedings of International Seed Testing Association, 34: 329-340.

Kostov, K., N. Petkov and N. Popov. 1989. Effect of nitrogen, phosphorus and molybdenum fertilizers on development of reproductive organs and yield of winter pea cv. No.11 and its association with nitrogen fixation efficiency. Rasteniev Dni Nauki, 25(6): 40-45.

Lawn, R.J. and W.A. Brun. 1974. Symbiotic nitrogen fixation in soybean I. Effect of photosynthetic source-sink manipulations. Crop Science, 14: 11-16.

Lowe, L.B. and S.K. Ries. 1973. Endosperm protein of wheat seed as a determinant of seeding growth. Plant Physiology, 51: 57-60.

Lysenko, V.F. 1979. Effect of pea nutrition with different forms of nitrogen fertilizers on productivity and protein synthesis. Tez. Doki M VANNHS–kh Radiol, 242. Horticultural Abstracts (1980), 7137.

Maguire, J.D. 1977. Seed quality and germination. In the physiology and biochemistry of seed dormancy and germination. (Ed Khan, A.A.) pp: 219-235.

Martin, R. J. and F.J. Tabley. 1981. Effects of irrigation, time of sowing, and cultivar on yield of vining peas. New Zealand journal of experimental agriculture, 9: 291-297.

Martin, R.J. and P.D. Jamieson. 1996. Effect of timing and intensity of drought on the growth and yield of field pea (*Pisum sativum* L.). N.Z. J. Crop Hort. Sci., 24: 167-174.

Matthews, S. 1977. Field emergence and seeding establishment. In: the physiology of the Garden pea, (Edit Sutcliffe, J.F. and Pate, J.S.) Subsidiary of Harcourt Brace Jovanovich, pp: 84-98.

Matthews, S. and A.A. Powell. 1981. Electrical conductivity test. In: Hand Book of vigour test methods. (Ed. Perry, D.A.). International Seed Testing Association, Zurich, Switzerland. pp: 37-42.

Matthews, S. and Bradnock, W.T. 1968. Relationship between seed exudation and field emergence in peas and French beans. Horticultural Research, 8: 89-93.

Maurer, A.R., D.P. Ormond and H.F. Fletcher. 1968. Response peas to environment. IV. Effect of five soil water regimes on growth and development of peas. Can. J. Plant Sci., 48: 129-136.

McDonald, M.B.J. 1975. A review and evaluation of seed vigour tests. Proceedings of the Association of Official Seed Analysts, 65: 109-139.

McDonald, M.B.J. 1977. A review and evaluation of seed vigour tests. Proceedings of the Association of Official Seed Analysts, 65: 109-139.

McGraw R.L., Beuselinck P.R. 1983. Growth and seed yield characteristics of birdsfoot trefoil. Agron. J., 75: 443-446.

McKenzie, B.A. and G.D. Hill. 1990. Growth, yield and water use of lentils *{Lens culinaris)* in Canterbury, New Zealand. Journal of agricultural science, Cambridge, 114: 309-320.

McNeal, F.H., M.A. Berg and C.F. McGuire. 1971. Productivity and quality response of five species ring wheat genotypes, *Triticum aestivum* L. to nitrogen fertilizer. Agronomy Journal, 69: 908-910.

Mengel, K. and F.A. Kirkby. 1997. Principles of Plant Nutrition (4^{th} Ed.). International Potash Institute, Bern, Switzerland, pp: 685.

Metcalfe, D.S., I.J. Johnson and R.H. Shaw. 1957. The relationship between pod dehiscence, relative humidity, and moisture equilibrium in birdsfoot trefoil, *Lotus corniculatus* L. Agron. J. 49: 130-134.

Milbourn , G.M. and R.C. Hardwick. 1968. The growth of vining peas. The effect of time of sowing. Jour. Agri. Sci., 20(3): 393-402.

Miller, D. E., and D. W. Burke.1983: Response of dry beans to daily deficit sprinkler irrigation. Agron. J., 75: 775-778.

Mills. J.T., S. M. Wood. 1994. Factors affecting life of farm-stored field peas (*Pisum sativum L.*) and white beans (*Phoseolus vulgaris L.*). J. Stored Prod. Res., 30(3): 215-226.

Mushtaq, M., P. Shah, S. Jan and A. Sattar. 1986. Effect of different levels of phosphorus and potash on the emergence of plant height and straw yield of mung bean. Sarhad J. Agric. 2(3): 467-469.

Naeem, A. 2003. Effect of different levels of nitrogen and phosphorus on green pods and seed yield of pea. M.Sc. Thesis, Inst. of Hort. Sci., Uni. Agri., Faisalabad, Paksitan.

Naik, L.B. 1989. Studies on the effect of plant spacing and graded levels of nitrogen, phosphorus and potassium on yield and yield components of mid season garden pea. Indian journal of Horticulture, 46(2): 234-239.

Nascimento, W.M. 1994. Effect of selection on pea (*Pisum sativum* L.) seed quality. Pesquisa Agropecu. Bras, 29(2): 309-313.

Naylor, R.E.L. 1981. An evaluation of various germination indices for predicting differences in seed vigour in Italian ryegrass. Seed Science and Technology, 9: 593-600.

Negi, S.C. 1992. Effect of nitrogen and phosphorus in temperate hill-grown vegetable pea (*Pisum sativum* L.) Ind. J. Agro., 37(4): 772-774.

Nichols, M.A., I.J. Warrington and D.J. Scott. 1978. Pre-harvest treatment effects on some quality criteria of pea seeds. Acta Hort., 83: 113-124.

Nkang, A. and E.O. Umoh. 1997. Six months storability of five soybean cultivars as influenced by stage of harvest, storage temperature and relative humidity. Seed Science and Technology, 25(1): 93-99.

P.G.R.O. 1981. Electrical conductivity test for vining pea seed. In Processors and Growers Research Organization information sheet number 119, Peterborough, UK.

Pacovskoi, R.S.,G.J. Bethlenfalvay and E.A. Paul. 1986. Comparison between P fertilized and mycorrhizal plants. Crop Sci., 26: 151-156.

Padrit, J., J. G. Hampton., M. J. Hill and B.R. Watkin. 1996. The effect of nitrogen and phosphorus supply to the mother plant on seed vigour in garden pea (*Pisum sativum* L.) cv. Pania. J. Appl. Seed Prod., 14: 41-45.

Palanisamy, V. and T.V. Karivarathraju. 1990. Effects of humidity levels and periods of storage on seed quality in different genotypes of tomato. South Indian Horticulture, 38(1): 28-34.

Parera, C.A., D.J. Cantliffe, P.J. Stoffella and B.T. Scully. 1995. Field emergence of shrunken-2 Corn Predicted by single and Multiple-vigour laboratory Tests. J. Am. Soc. Hort. Sci., 120(1): 128-132.

Parsad, R.N., A.K. Multhoo and A.N. Mauryo. 1989. A note on the effect of phosphate fertilization on growth, nodulation and green pod yield of pea. Haryana, India. J. Hort. Sci., 16(1-2): 142-144.

Patel, T.S., D.S. Katare, H.K. Khosla and S. Dubey. 1998. Effect of biofertilizers and chemical fertilizers on growth and yield of garden peas (*Pisum sativum* L.). Ind. Crop. Res. Hisar, 15(1): 54-56.

Pates, J.S. and Flinn, A.M. (1977). Fruit and Seed development. In; The physiology of pea garden, (Ed. Sutcliff., J. F. and Pate, J. S.). Academic Press London.

Paul, S.R. 1993. Effect of different seed size on seed quality, crop growth and seed yield of mesta (*Hibiscus cannabinus*) varieties. Annals of Agric. Res., 14(3): 366-368.

Pearce, M.D., B.P. Marks and J.F. Meullenet. 2001. Effects of post harvest parameters on functional changes during rough rice storage. Cereal Chemistry, 78: 354-357.

Periago, M.A., G. Rose, M.C. Marlinez, F. Rincon, Lopezg, J. Ortuno and F. Rose. 1996. In vitro estimation of protein and mineral availability in green peas as affected by antinutritive factors and maturity. Lebns. Wiss. Technol., 29(5-6): 481-488.

Perry, D.A. 1972. Seed vigour and field establishment. Hort. Absts., 1982, 42: 334-342.

Perry, D.A. 1977. Vigour test for seeds of barley (*Hordeum vulgare*) based on measurement of plumule growth. Seed Sci. & Tech., 5: 709-719.

Perry, D.A. 1978. Report of the vigour test committee, 1974-1977. Seed Sci. & Tech., 6: 159-181.

Pieroni, S.J. and G.K. Laverack. 1994. Determination of harvest date in lotus corriculatus by pods seeds. J. Appl. Seed Production, 12: 62-65.

Pochauri, K.S., Y.P. Singh, R.V. Singh and A.S. Mishra. 1991. Response of gram, lentil and field pea to nodulation and levels of nitrogen and phosphorus. Indian J. of Agron., 22(3): 145-148.

Pollock, B.M. and E.E. Roos. 1972. Seed and seedling vigour. In. Seed Biology Vol.1 (Ed. Kozlowski, T.). pp: 314-318.

Posypanov, G.S. M.V. Kashukoe and B.Kh. Zherukov. 1994. Basic parameter for optimal supply of water, boron and molybdenum to peas and soybean for active symbiotic nitrogen fixation. Izvestiya Timiryazevskol Sel’ Skokhozyaistvennoi Akaemii., 2: 33-42.

Powell, A.A., S. Mathews and M. DE. A. Oliveria. 1984. Seed quality in grain legumes Adances in Appl. Bio., 10: 217-285.

Priestley, D.A., 1986. Morphological, structural and biochemical changes associated with seed ageing. In: Priestley, D.A. (ed.) Seed Aging. pp: 125–95.

Pumphrey, F.V. and R.K. Schwanke. 1974. Effects of irrigation on growth, yield and quality of peas for processing. J. Amer. Soc. Hort. Sci., 99: 104-106.

Qureshi, R.H. and L. Barrett. 1998. The climate. In A handbook Saline Agriculture for Irrigated Land in Pakistan. Australian Centre for International Agricultural Reearch, Canbera, Australia (A.C.I.A.R.). pp: 7-8.

Rae, D. and D.S. Ingram. 1999. The rationale of conservation. In B. G. Bowes, A colour atlas of Plant propagation and conservation London (UK), Manson Publishing. pp: 224.

Raghothama, K.G. 1999. Phosphate acquisition. Annual Rev. Plant Physiol. Mol. Biol. 50: 665-693.

Ramirez-Vallejo, P., and J. M. Kelly, 1998: Traits related to drought resistance in common bean. Euphytica., 99: 127-136.

Rana, N. S. and R.Singh. 1998. Effect of nitrogen and phosphorus on growth and yield of French been (*Phaseolus vulgaris*). Ind. J. Agro., 43(2): 367-370.

Rangaswamy, A., S. Purshothmae and P. Devasenapathy. 1993. Seed hardening in relation to seedling quality characters of crop. Madras Agric. J., 80(9): 535-537.

Rao, B.R., S.P. Singh and E.V.S. Rao. 1983. Nitrogen, potassium and phosphorus studies in pyrethrum (*Chrysanthemum cinerariifolium* L.). J. Agric. Sci., 100: 509-511.

Rathi, G.S., R.S. Sharma and B. Sachidanand. 1993. Effect of irrigation and phosphorus levels on protein content and uptake of nutrients in field pea (*Pisum sativum* L.). J.S. Crops. Madhya Pradesh, Ind., 3(2): 80-83.

Raymond, A.T.G. 1980. In: Technical guidelines for Vegetable Seed Technology, F.A.O. Rome.

Raymond, M.A. and C.S. Jeffrey. 1987. Irrigation management effects on spring pea seed yield and quality. Hort Sci., 22(6): 1262-1263.

Raymond, M.A., Stark, J.C. and G.A. Murray. 1988. Final irrigation timing for spring pea seed production. J. Amer. Soc. Hort. Sci., 133: 827-830.

Reickosky, D.C. L.G. Heatherly. 1990. Soybean. In irrigation of agricultural crops. Eds., Steward, B.A. and D.R. Nielson., Agron. Monogr. 30.ASA, CSSA and SSSA, Maidison, WI. pp. 639-674.

Ries, S.K. 1971. The relationship of size and protein content of bean seed with growth and yield. J. Am. Soc. Hort. Sci., 96: 557-560.

Ries, S.K. and E.H. Everson. 1973. Protein content and seed size relationships with seedling vigour of wheat cultivars. Agronomy J., 65: 884-886.

Roberts, E.H. and P.H. Abdallah. 1968. The influence of temperature, moisture and oxygen on period of seed viability in barley, broad brans and peas. Annals Bot., 32: 97-117.

Roberts, E.H. and P.H. Abdallah. 1968. The influence of temperature, moisture and oxygen on period of seed viability in barley, broad brans and peas. Annals Bot., 32: 97-117.

Salter, P.J. 1962. Some responses of peas to irrigation at different growth stages. J. Hort. Sci., 37: 141-149.

Salter, P.J. 1963. The effect of wet and dry soil condition different stages on the components of yield of a pea crop. J. Hort. Sci., 38: 321-334.

Salter, P.J. and J.B. Williams. 1967. The effect of irrigation on pea crops grown different plant densities. J. Hort. Sci., 42: 59-66.

Sanhewe, A.J. and R.H. Ellis. 1996. Seed development and maturation in *Phaseolus vulgaria*. Ability to germinate and to tolerate desiccation. J. Expt. Bot., 47: 949-958.

Schlesinger, J.S. 1970. Fertilizing wheat for protein. Cereal Sci., 15: 370-374.

Schuster, M.A. 2003. Causes of desertification. Annals of Arid Zone, 42: 417-430.

Shahien, A.H. 1996. Effect of irrigation frequency and fertilization on pea growth, yield, yield components and total uptake of some macro nutrients. Agri. Res. Cent. Giza, Egypt, Ann., Agri. Sci., 34(2): 669-689.

Shaukat, A. 1994. Effect of nitrogen and phosphorus fertilizers on root growth and nodulation in black locust (*Robinia pseudoacia* L.) seedlings. Pak. J. Forestry, 44(2): 65-72.

Shaw, R.H and W.E. Loomis. 1950. Bases for the prediction of corn yields. Plant Physiol., 25: 225-244.

Shukla, Y.R., U.K. Kohil and S.K. Sharma. 1993. Influence of phosphorus fertilization on yield, quality and traits in early cultivar of garden pea. Hort. J., 6(2): 129-131.

Simon, E. and R.M. Raja Harun. 1972. Leakage during seed imbibitions. J. Expt. Bot., 23: 1076-1085.

Simon, E.W. 1974. Phospholipids and plant membrane permeability. New Physiologist, 73: 377-420.

Singh, R.M., S.B. Singh and A.S. Warsi. 1992. Nutrient management in field pea (*Pisum sativum* L.). Indian J. Agron., 37(3): 474-476.

Singh, S. P., 1995: Selection for water-stress tolerance in interracial populations of common bean. Crop Sci., 35: 118-124.

Sinha, B.N., B.S. Mehta and J. Mandal. 2000. Quality and seed yield of garden pea (*Pisum sativum* L.) cultivar as influenced by date of planting and phosphorus levels. Ind. J. Agri. Sci., 70(4): 248-249.

Smiciklas, K.D., R.E. Mullen, R.E. Carlson and A.D. Knapp. 1989. Drought induced stress effects on soybean seed calcium and seed quality. Crop Science, 29: 1519-1523.

Smittle, D. and G. Bradley. 1966. The effect of irrigation planting and harvest dates on yield and quality of peas. Proc. Amer. Soc. Hort. Sci., 88: 441-446.

Soulnke, B.R. A.R. Singh and S.T. Borikar. 1994. Studies on seed development and maturation in relation to seed quality in sunflower. J. Maharashtra Agric. Universities 19(2): 301.

Steel, R.G.D and J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics. A Biometrical Approach. 3rd ed. McGraw Hill Book Co., New York, USA.

Stoker, R. 1977. Irrigation of garden peas on a good cropping soil. N.Z. J. Expt. Agr. 5: 233-236.

Stoker, R. 1979. Peas for threshing: cultivars, requirements and husbandry. Agr. Link FPP 350, New Zealand Ministry of Agriculture and Fisheries. pp: 3

Stoker, R., 1974: Effect on dwarf beans of water stress at deferent phases of growth. NZ J. Exp. Agric., 2: 13-15.

Streeter, J.G. 1978. Effect of nitrogen starvation of soybean plants at various stage of growth on seed yield and nitrogen concentration of plant at maturity. Agron. J., 70: 74-76.

Sun, W.Q. and A.C. Leopold.1995**.** The Maillard reaction and oxidative stress during ageing of soybean seeds. Physiologia Plantarum. 94: 94–105.

Sun, W.Q. and A.C.Leopold.1997. Cytoplasmic vitrification and survival of anhydrobiotic organisms. Comparative Biochemistry and Physiology 117A: 327–333.

Svoboda, A. 1976. Conjugation of yeast protoplasts. Folia Microbiol. (Prague) 21:193-194.

Tao, K.J. 1978. Factors causing variation in the conductivity test for soybean seeds. J. Seed Tech., 3: 10-18.

Tawaha, A.M. and M.A. Turk. 2004. Field pea seeding management for semi-arid Mediterranean conditions. J. Agron. and Crop Sci., 190(2): 86.

Tekrony, D.M. and D.B. Egli. 1977. Relationship between laboratory indices of soybean seed vigour and field emergence. Crop Sci., 17: 573-577.

TeKrony, D.M. and D.B. Egli. 1997. Accumulation of seed vigour during development and maturation. In: Basic and Applied Aspects of seed biology (Eds. Ellis, R.H. Black, M. Murdock, A.J. and Hong T.D.). pp: 369-384.

TeKrony, D.M. and D.B. Egli. 1997. Relationship between laboratory indices of soybean seed vigour and field emergence. Crop Sci., 17: 573-577.

TeKrony, D.M., D.B. Egli and A.D. Ohillips. 1980. Effect of field weathering on the viabiolity and vigour of soybean seed. Agron. J., 72: 749-753.

Thorne, G.N., S.M. Thomas and I. Pearman. 1979. Effects of nitrogen nutrition on physiological factors that control yield of carbohydrate in grain. In: Crop Physiology and General Breeding. (Proceedings of a Eucarpia Workshop, Wageningen). (Eds. Spiertz J.H. and Kramer, T.H.). pp: 80-90.

Trachuk, R. 1966. Amino acid composition of wheat flours. Cereal Chemistry 43: 207-223.

Tripathi, B. M., S. S. Singh and S. P. Singh. 1991. Effect of nitrogen, Phosphorus and weed control on growth and yield of vegetable Pea. Ind. Veg. Sci., 18(1): 11-15.

Urbano, G., P. Aranda and E. Gomez-Villalva. 2003. Nutritional evaluation of pea (*Pisum sativum* L.) protein diets after mild hydrothermal treatment and with and without added phytase. J. Agri. Food Chem., 51: 2415–2420.

Vieira, R.D. and F.C. Krzyzanowski. 1999. Teste de condutividade eletrica. *In*: Krzyzanowski, F.C., R.D. Vieira and J.B. Franca Neto (eds.), Vigor De Sementes: Conceitos e Testes, pp: 1–26.

Vieira, R.D., B.M. Tekorony and D.B. Egli. 1992. Effect of drought and defoliation stress in the field on soybeen seed germination and vigour. Crop Science, 32: 471-475.

Vieira, R.D., D.M. Tekrony and D.B. Egli. 1991. Effects of drought stress on soybean germination and vigour. J. Seed Technol., 15: 12-21.

Vieira, R.D., D.M. Tekrony, D.B. Egli, and M. Rucker. 2001. Electrical conductivity of soybean seeds after storage in several environments. Seed Science and Technology, 29: 599-608.

Vimala, B. and S. Natarajan. 1999. Studies on effect of N, P and biofertilziers on growth, flowering and yield of pea (*Pisum sativum*). Hort. Res. Inst. Combatore. India, 47(1): 61-64.

Water, L. and B.L. Blanchette. 1983. Prediction of sweet corn field emergence by conductivity and cold tests. J. Am. Soc. Hort. Sci., 108(5): 778-781.

Wendell, Q.S. and L.A. Carl. 1994. Glassy state and seed storage stability: A viability equation analysis. Annals of Bot., 74: 601-604.

White, J.C.H., G.W. Sheath and G. Meiger. 1982. Yield of garden peas-field responses to variation in sowing rate and irrigation. N.Z. J. Expt. Agr. 10: 155-160.

Wiggans S.C., D.S. Metcalfe and H.E. Thompson. 1956. The use of desiccant sprays in harvesting birdsfoot trefoil for seed. Agron. J., 48: 281-284.

Winch, J.E., and H.A. MacDonaled. 1961. Flower, pod and seed development relative to the timing of seed harvest of Viking birdsfoot trefoil, *Lotus corniculatus*. Can. J. Plant Sci. 41: 281-284.

Winch, J.E., S.E. Robinson, and C.R. Ellis. 1985. Birdsfoot trefoil seed production. Min. Agric. and Food. pp. 85-111.

Woodstock, L.W. 1973. Physiological and biochemical tests for seed vigour. Seed Sci. & Tech., 1: 127-157.

Yadav, R.P. and D.V.S. Chauhan. 1997. Effect of irrigation, phosphorus and row spacing on nutrient uptake and protein production by pea. Indian J. Agri. Res., 31(2): 105-109.

Yaklich, R.W. 1984. Moisture stress and soybean seed quality. J. Seed Technol., 9: 60-67.

Yaklich, R.W. and P.B. Cregan. 1981. Moisture migration in to soybean pods. Crop Sci., 21: 197-194.

Yaklich, R.W., M. Kulik and J.D. Anderson. 1979. Evaluation of vigour tests in soybean seeds: relationship of ATP, conductivity and radioactive tracer multiple criteria laboratory tests to field performance. Crop Sci., 19: 806-810.

Zain, Z.M., J.N. Gallagher, J.G.H. White and J.B. Reid. 1983. The effect of irrigation on radiation absorption, water use and yield of conventional and semi-leafless peas. Proc. Ann. Conf. Agron. Soc. N.Z. 13: 95-102.

Zanakis, G.N., R.H. Ellis and R.J. Summerfield. 1994. A comparison of changes in vigour among three genotypes of soybean (*Glycine max L.*) during seed development and maturation in three temperature regimes. Exp. Agr., 30: 157-170.

APPENDIX

Experiment No.1:

Effect of varying irrigation frequencies on growth, seed yield, vigour and quality of pea crop.

App. 1:- Analysis of variance Table for Main Stem Length (cm)

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	27.563	27.563	7.0966	0.0109
Rep (Y)	6	19.875	3.313	0.8529	
Factor A	1	2185.563	2185.563	562.7195	0.0000
YA	1	7.563	7.563	1.9471	0.1702
Factor B	3	1030.688	343.563	88.4575	0.0000
YB	3	30.688	10.229	2.6337	0.0623
AB	3	14.688	4.896	1.2605	0.3002
YAB	3	10.688	3.563	0.9172	
Error	42	163.125	3.884		
Total	63	3490.438			

App. 2:- Analysis of Variance Table for Leaves Per Plant

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	301.891	301.891	59.6240	0.0000
Rep (Y)	6	21.594	3.599	0.7108	
Factor A	1	467.641	467.641	92.3599	0.0000
YA	1	301.891	301.891	59.6240	0.0000
Factor B	3	409.047	136.349	26.9292	0.0000
YB	3	45.797	15.266	3.0150	0.0404
AB	3	56.047	18.682	3.6898	0.0191
YAB	3	52.797	17.599	3.4758	0.0242
Error	42	212.656	5.063		
Total	63	1869.359			

App. 3:- Analysis of Variance Table for Leaf area (cm^2)

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	97.516	97.516	3.9164	0.0544
Rep (Y)	6	261.969	43.661	1.7535	0.1324
Factor A	1	15.016	15.016	0.6030	
YA	1	3.516	3.516	0.1412	
Factor B	3	31491.547	10497.182	421.5811	0.0000
YB	3	66.172	22.057	0.8859	
AB	3	11635.172	3878.391	155.7615	0.0000
YAB	3	4.672	1.557	0.0625	
Error	42	1045.781	24.900		
Total	63	44621.781			

App. 4:- Analysis of Variance Table for Number of Pods Per Plant

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	50.766	50.766	36.1958	0.0000
Rep (Y)	6	19.344	3.224	2.2987	0.0522
Factor A	1	21.391	21.391	15.2515	0.0003
YA	1	21.391	21.391	15.2515	0.0003
Factor B	3	143.422	47.807	34.0865	0.0000
YB	3	9.922	3.307	2.3581	0.0853
AB	3	5.297	1.766	1.2589	0.3008
YAB	3	1.297	0.432	0.3082	
Error	42	58.906	1.403		
Total	63	331.734			

App. 5:- Analysis of Variance Table for Number of Seed Per Pod

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	2.673	2.673	28.7777	0.0000
Rep (Y)	6	0.130	0.022	0.2334	
Factor A	1	50.126	50.126	539.6187	0.0000
YA	1	0.032	0.032	0.3488	
Factor B	3	6.832	2.277	24.5166	0.0000
YB	3	2.193	0.731	7.8692	0.0003
AB	3	3.171	1.057	11.3780	0.0000
YAB	3	0.650	0.217	2.3326	0.0878
Error	42	3.901	0.093		
Total	63	69.710			

App. 6:- Analysis of Variance Table for 1000-Seed Weight (g)

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	4.516	4.516	0.0300	
Rep (Y)	6	468.594	78.099	0.5185	
Factor A	1	594.141	594.141	3.9442	0.0536
YA	1	0.766	0.766	0.0051	
Factor B	3	5326.547	1775.516	11.7869	0.0000
YB	3	3.047	1.016	0.0067	
AB	3	126.922	42.307	0.2809	
YAB	3	2.047	0.682	0.0045	
Error	42	6326.656	150.635		
Total	63	12853.234			

App. 7:- Analysis of Variance Table for Seed Fresh Weight Per Plant (g)

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	8.843	8.843	1.9535	0.1696
Rep (Y)	6	37.171	6.195	1.3685	0.2496
Factor A	1	2415.845	2415.845	533.6630	0.0000
YA	1	3.549	3.549	0.7839	
Factor B	3	1772.114	590.371	130.4137	0.0000
YB	3	20.133	6.711	1.4824	0.2331
AB	3	178.343	59.448	13.1320	0.0000
YAB	3	21.948	7.316	1.6161	0.2000
Error	42	109.130	4.527		
Total	63	4647.076			

App. 8:- Analysis of Variance Table for Seed Dry Weight Per Plant (g)

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	16.985	16.985	5.4886	0.0240
Rep (Y)	6	8.079	1.347	0.4351	
Factor A	1	105.807	105.807	34.1916	0.0000
YA	1	0.803	0.803	0.2596	
Factor B	3	139.023	46.341	14.9752	0.0000
YB	3	0.255	0.085	0.0274	
AB	3	44.417	14.806	4.7845	0.0059
YAB	3	10.524	3.508	1.1336	0.3465
Error	42	129.970	3.095		
Total	63	455.864			

App. 9:- Analysis of Variance Table for Seed Yield Per Hectare (Tones)

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	0.471	0.471	5.8144	0.0203
Rep (Y)	6	1.183	0.197	2.4335	0.0414
Factor A	1	1.389	1.389	17.1547	0.0002
YA	1	0.083	0.083	1.0294	0.3161
Factor B	3	5.720	1.907	23.5418	0.0000
YB	3	0.153	0.051	0.6311	
AB	3	0.325	0.108	1.3358	0.2756
YAB	3	0.047	0.016	0.1929	
Error	42	3.402	0.081		
Total	63	12.773			

App. 10:- Analysis of Variance Table for Electrical Conductivity

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	2.066	2.066	1.6558	0.2052
Rep (Y)	6	6.773	1.129	0.9046	
Factor A	1	295.410	295.410	236.7156	0.0000
YA	1	0.035	0.035	0.0282	
Factor B	3	69.637	23.212	18.6002	0.0000
YB	3	0.137	0.046	0.0365	
AB	3	19.543	6.514	5.2200	0.0037
YAB	3	0.043	0.014	0.0115	
Error	42	52.414	1.248		
Total	63	446.059			

App. 11:- Analysis of Variance Table for Germination %

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	83.266	83.266	33.4556	0.0000
Rep (Y)	6	22.219	3.703	1.4879	0.2058
Factor A	1	37.516	37.516	15.0735	0.0004
YA	1	9.766	9.766	3.9238	0.0542
Factor B	3	174.547	58.182	23.3773	0.0000
YB	3	4.672	1.557	0.6257	
AB	3	46.672	15.557	6.2508	0.0013
YAB	3	62.672	20.891	8.3937	0.0002
Error	42	104.531	2.489		
Total	63	545.859			

App. 12:- Analysis of Variance Table for Emergence %

Source	D.F	S.S	M.S	F. Value	Prob.
Year	1	0.016	0.016	0.0049	
Rep (Y)	6	38.844	6.474	2.0306	0.0827
Factor A	1	284.766	284.766	89.3174	0.0000
YA	1	37.516	37.516	11.7669	0.0014
Factor B	3	1655.297	551.766	173.0625	0.0000
YB	3	152.547	50.849	15.9489	0.0000
AB	3	50.797	16.932	5.3109	0.0034
YAB	3	26.047	8.682	2.7232	0.0562
Error	42	133.906	3.188		
Total	63	2379.734			

Experiment No. 2:
Influence of Different Phosphorus Levels on Pea Seed Yield Quality of Pea Crop.

App. 13:- Analysis of Variance Table for Main Stem Length (cm)

Source	**D.F**	**S.S**	**M.S**	**F.Value**	**Prob.**
Block	3	10.77	3.59	987.30	0.0000
V	1	1683.02	1683.02	92.34	0.0000
Trt.	6	944.50	157.42	4.14	0.0026
V*Trt.	6	42.36	7.06		
Error	39	66.48	1.70		
Total	55	2747.13			

App. 14:- Analysis of Variance Table for Number of Leaves Per Plant

Source	**D.F**	**S.S**	**M.S**	**F. Value**	**Prob.**
Block	3	28.24	9.414	71.62	0.0000
V	1	881.42	881.420	26.00	0.0000
Trt.	6	1919.87	319.979	1.84	0.1173
V*Trt.	6	135.54	22.591		
Error	39	480.00	12.308		
Total	55	3445.08			

App. 15:- Analysis of Variance Table for Leaf Area (cm^2)

Source	**D.F**	**S.S**	**M.S**	**F. Value**	**Prob.**
Block	3	1083.2	361.07	0.00	0.9754
V	1	0.2	0.16	26.55	0.0000
Trt.	6	26616.7	4436.11	8.39	0.0000
V*Trt.	6	8415.5	1402.58		
Error	39	6517.1	167.10		
Total	55	42632.6			

App. 16:- Analysis of Variance Table for Number of Pods Per plant

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	2.739	0.9131		
V	1	0.290	0.2900	0.18	0.6780
Trt.	6	308.581	51.4302	31.04	0.0000
V*Trt.	6	13.776	2.2961	1.39	0.2447
Error	39	64.614	1.6568		
Total	55	390.001			

App. 17:- Analysis of Variance Table for Length of pod (cm)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.4723	0.15744		
V	1	0.5246	0.52458	2.86	0.0987
Trt.	6	10.5285	1.75476	9.57	0.0000
V*Trt.	6	2.4910	0.41516	2.27	0.0570
Error	39	7.1480	0.18328		
Total	55	21.1644			

App. 18:- Analysis of Variance Table for Number of Seeds Per pod

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	1.4071	0.46905		
V	1	4.1149	4.11486	34.35	0.0000
Trt.	6	9.0583	1.50972	12.60	0.0000
V*Trt.	6	5.9372	0.98953	8.26	0.0000
Error	39	4.6723	0.11980		
Total	55	25.1898			

App. 19:- Analysis of Variance Table for 1000 Seed Weight (g)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	14.62	4.875		
V	1	451.45	451.446	69.69	0.0000
Trt.	6	2468.36	411.393	63.51	0.0000
V*Trt.	6	179.93	29.988	4.63	0.0012
Error	39	252.63	6.478		
Total	55	3366.98			

App. 20:- **Analysis of Variance Table for Seed yield Per Hectare (Tones)**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.4976	0.16588		
V	1	0.2392	0.23921	2.26	0.1412
Trt.	6	8.9655	1.49425	14.09	0.0000
V*Trt.	6	0.6367	0.10607	1.00	0.4389
Error	39	4.1368			
Total	55	14.4758			

Chemical Composition of the Plant Parts (Leaves, Stems and Pods)
(i) Chemical Composition of the Pea Leaves

App. 21:- **Analysis of Variance Table for Ash**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00666	0.00222		
V	1	0.02362	0.02362	36.17	0.0000
Trt.	6	1.47010	0.24502	375.28	0.0000
V*Trt.	6	0.77485	0.12914	197.80	0.0000
Error	39	0.02546			
Total	55	2.30068			

App. 22:- **Analysis of Variance Table for Nitrogen**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00016	0.00005		
V	1	0.00778	0.00778	38.44	0.0000
Trt.	6	0.02574	0.00429	21.20	0.0000
V*Trt.	6	0.01497	0.00250	12.33	0.0000
Error	39	0.00789	0.00020		
Total	55	0.05654			

App. 23:- **Analysis of Variance Table for Protein**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00324	0.00108		
V	1	0.10983	0.10983	166.57	0.0000
Trt.	6	0.34032	0.05672	86.03	0.0000
V*Trt.	6	0.16972	0.02829	42.90	0.0000
Error	39	0.02571	0.00066		
Total	55	0.64882			

Seed Nutrient Concentration (N, P, K, and crude protein contents)

App. 24:- Analysis of Variance Table for Nitrogen

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.04279	0.01426		
V	1	0.05406	0.05406	5.74	0.0215
Trt.	6	2.55984	0.42664	45.31	0.0000
V*Trt.	6	0.35939	0.05990	6.36	0.0001
Error	39	0.36726	0.00942		
Total	55	3.38334			

App. 25:- Analysis of Variance Table for Phosphorus

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00449	0.00150		
V	1	0.00018	0.00018	0.85	0.3626
Trt.	6	0.13034	0.02172	103.22	0.0000
V*Trt.	6	0.00192	0.00032	1.52	0.1967
Error	39	0.00821	0.00021		
Total	55	0.14514			

App. 26:- Analysis of Variance Table for Potash

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00069	0.00023		
V	1	0.12446	0.12446	241.40	0.0000
Trt.	6	1.13640	0.18940	367.36	0.0000
V*Trt.	6	0.14297	0.02383	46.22	0.0000
Error	39	0.02011	0.0052		
Total	55	1.42462			

App. 27:- Analysis of Variance Table for Protein

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.071	0.0238		
V	1	0.041	0.0407	0.89	0.3502
Trt.	6	273.187	45.5312	999.70	0.0000
V*Trt.	6	1.639	0.2731	6.00	0.0002
Error	39	1.776	0.0455		
Total	55	276.714			

App. 28:- Analysis of Variance Table for Electrical Conductivity

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	9.228	3.0759		
V	1	91.290	91.2902	55.02	0.0000
Trt.	6	129.491	21.5818	13.01	0.0000
V*Trt.	6	31.241	5.2068	3.14	0.0132
Error	39	64.710	1.6592		
Total	55	325.960			

App. 29:- Analysis of Variance Table for Emergence %

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	8.14	2.714		
V	1	10.29	10.286	1.16	0.2888
Trt.	6	1763.43	293.905	33.05	0.0000
V*Trt.	6	138.71	23.119	2.60	0.0324
Error	39	346.86	8.894		
Total	55	2267.43			

App. 30:- Analysis of Variance Table for Germination %

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	47.482	15.8274		
V	1	11.161	11.1607	1.53	0.2233
Trt.	6	248.750	41.4583	5369	0.0003
V*Trt.	6	35.464	5.9107	0.81	0.5679
Error	39	284.268	7.2889		
Total	55	627.125			

Experiment No. 3:
Influence of different potash levels on pea seed yield and quality of pea crop

App. 31:- Analysis of Variance Table for Main Stem length (cm)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	17.30	5.77		
Trt.	7	792.98	113.28	22.71	0.0000
V.	1	1732.64	1732.64	347.37	0.0000
Trt. V*	7	37.23	5.32	1.07	0.4004
Error	45	224.45	4.99		
Total	63	2804.61			

App. 32:- Analysis of Variance Table for Number of leaves Per Plant

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	17.90	5.97		
Trt.	7	1825.50	260.79	19.76	0.0000
V.	1	1297.89	1297.89	98.35	0.0000
Trt. V*	7	182.85	26.12	1.98	0.0791
Error	45	593.84	13.20		
Total	63	3917.98			

App. 33:- Analysis of Variance Table for Leaf Area (cm^2)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	1580.9	536.97		
Trt.	7	46578.4	6654.05	28.19	0.0000
V.	1	695.6	695.64	2.95	0.0929
Trt. V*	7	11746.0	1678.00	7.11	0.0000
Error	45	10620.3	236.01		
Total	63	71221.2			

App. 34:- Analysis of Variance Table for Number of Pods Per Plant

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	1.590	0.5299		
Trt.	7	170.114	24.3020	28.08	0.0000
V.	1	14.343	14.3433	16.57	0.0002
Trt. V*	7	16.501	2.3573	2.72	0.0192
Error	45	38.946	0.8655		
Total	63	241.494			

App. 35:- Analysis of Variance Table for Length of Pod (cm)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.4378	0.14594		
Trt.	7	10.5258	1.50369	10.04	0.0000
V.	1	0.9001	0.90013	6.01	0.0182
Trt. V*	7	2.0498	0.29282	1.96	0.0828
Error	45	6.7390	0.14976		
Total	63	20.6525			

App. 36:- Analysis of Variance Table for Number of Seeds Per Pod

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.2759	0.09196		
Trt.	7	8.2453	1.17790	6.02	0.0001
V.	1	2.9113	2.91129	14.87	0.0004
Trt. V*	7	4.1120	0.58742	3.00	0.0113
Error	45	8.8078	0.19573		
Total	63	24.3522			

App. 37:- Analysis of Variance Table for 1000 Seed Weight (g)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	39.31	13.104		
Trt.	7	2339.44	334.205	36.75	0.0000
V.	1	612.56	612.562	67.37	0.0000
Trt. V*	7	116.94	16.705	1.84	0.1033
Error	45	409.19	9.093		
Total	63	3517.44			

App. 38:- Analysis of Variance Table for Seed Yield Per Hectare

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.1916	0.06386		
Trt.	7	7.0106	1.00152	13.58	0.0000
V.	1	0.0010	0.00098	0.01	0.9089
Trt. V*	7	0.5643	0.08061	1.09	0.3837
Error	45	3.3181	0.07374		
Total	63	11.0856			

Chemical Composition of the plant parts (Leaves, Stems and Pods)
(i) Chemical Composition of Pea Leaves

App. 39:- Analysis of Variance Table for Ash

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.19277	0.06426		
Trt.	7	3.89160	0.55594	46.11	0.0000
V.	1	0.01410	0.01410	1.17	0.2852
Trt. V*	7	0.04969	0.00710	0.59	0.7615
Error	45	0.54251	0.01206		
Total	63	4.69066			

App. 40:- Analysis of Variance Table for Nitrogen

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00080	0.00027		
Trt.	7	0.03582	0.00512	6.33	0.0000
V.	1	0.00833	0.00833	10.30	0.0025
Trt. V*	7	0.01259	0.00180	2.22	0.0497
Error	45	0.03637	0.00081		
Total	63	0.09391			

App. 41:- Analysis of Variance Table for Protein

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.06747	0.02249		
Trt.	7	0.33619	0.04803	4.85	0.0004
V.	1	0.10644	0.10644	10.75	0.002
Trt. V*	7	0.17107	0.02444	2.47	0.0311
Error	45	0.44536	0.00990		
Total	63	1.12652			

(ii) Chemical Composition of Pea Stems

App. 42:- Analysis of Variance Table for Ash

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00252	0.00084		
Trt.	7	2.23232	0.31890	320.86	0.0000
V.	1	0.82356	0.82356	828.62	0.0000
Trt. V*	7	0.57444	0.08206	82.57	0.0000
Error	45	0.04472	0.00099		
Total	63	3.67758			

App. 43:- Analysis of Variance Table for Nitrogen

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00151	0.00050		
Trt.	7	0.00707	0.00101	3.64	0.0034
V.	1	0.00063	0.00063	2.25	0.1405
Trt. V*	7	0.00115	0.00016	0.59	0.7591
Error	45	0.01249	0.00028		
Total	63	0.02284			

App. 44:- Analysis of Variance Table for Protein

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00953	0.00318		
Trt.	7	0.21189	0.03027	34.38	0.0000
V.	1	0.00040	0.00040	0.45	0.5037
Trt. V*	7	0.12520	0.01789	20.32	0.0000
Error	45	0.03962	0.00088		
Total	63	0.38664			

(i) Chemical Composition of Pod+ Seed

App. 45:- Analysis of variance Table for Ash

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00172	0.00057		
Trt.	7	0.35417	0.05060	47.25	0.0000
V.	1	0.00181	0.00181	1.69	0.2006
Trt. V*	7	0.05397	0.00771	7.20	0.0000
Error	45	0.04818	00107		
Total	63	0.45984			

App. 46:- Analysis of Variance Table for Nitrogen

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00241	0.00080		
Trt.	7	0.04844	0.00692	22.66	0.0000
V.	1	0.05063	0.05063	165.76	0.0000
Trt. V*	7	0.01988	0.00284	9.30	0.0000
Error	45	0.01374	0.00031		
Total	63	0.13509			

App. 47:- Analysis of Variance Table for Protein

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00558	0.00186		
Trt.	7	2.31129	0.33018	340.64	0.0000
V.	1	1.54381	1.54381	1592.69	0.0000
Trt. V*	7	0.81709	0.11673	120.42	0.0000
Error	45	0.04362	0.00097		
Total	63	4.72139			

Seed Nutrient Concentration (N, P, K and crude protein contents)

App. 48:- Analysis of Variance Table for Nitrogen

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00534	0.00178		
Trt.	7	1.44219	0.20603	225.12	0.0000
V.	1	0.13598	0.13598	148.58	0.0000
Trt. V*	7	0.09759	0.01394	15.23	0.0000
Error	45	0.04118	0.00092		
Total	63	1.72227			

App. 49:- Analysis of Variance Table for Phosphorus

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00092	0.00031		
Trt.	7	0.10873	0.01553	30.64	0.0000
V.	1	0.00483	0.00483	9.53	0.0035
Trt. V*	7	0.00254	0.00036	0.72	0.6586
Error	45	0.02281	0.00051		
Total	63	0.13984			

App. 50:- Analysis of Variance Table for Potash

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00087	0.00029		
Trt.	7	1.08088	0.15441	610.86	0.0000
V.	1	0.00010	0.00010	0.40	0.5325
Trt. V*	7	0.22627	0.03232	127.88	0.0000
Error	45	0.01138	0.00025		
Total	63	1.31950			

App. 51:- Analysis of Variance Table for Protein

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.001	0.0002		
Trt.	7	266.871	38.1244	30327.7	0.0000
V.	1	0.026	0.0256	20.36	0.0000
Trt. V*	7	7.172	1.0246	815.08	0.0000
Error	45	0.057	0.0013		
Total	63	274.126			

App. 52:- Analysis of Variance Table for Electrical Conductivity

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	7.824	2.6081		
Trt.	7	187.465	26.7807	14.04	0.0000
V.	1	63.004	63.0039	33.02	0.0000
Trt. V*	7	30.277	4.3253	2.27	0.0458
Error	45	85.863	1.9081		
Total	63	374.434			

App. 53:- Analysis of Variance Table for Emergence %

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	13.92	4.641		
Trt.	7	1724.11	246.301	27.90	0.0000
V.	1	15.02	15.016	1.70	0.1988
Trt. V*	7	146.36	20.908	2.37	0.0378
Error	45	397.33	8.830		
Total	63	2296.73			

App. 54:- Analysis of Variance Table for Germination %

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	32.422	10.8073		
Trt.	7	227.734	32.5335	5.13	0.0002
V.	1	34.516	34.5156	5.63	0.0220
Trt. V*	7	53.359	7.6228	1.24	0.2997
Error	45	275.828	6.1295		
Total	63	623.859			

Experiment No.4:

Qualitative and quantitative response of pea to judicious applications of irrigation with P and K.

App. 55:- Analysis of Variance Table for Main Stem Length (cm)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	16.75	5.583		
V	1	924.50	924.500	85.24	0.0000
Trt.	3	685.75	228.583	21.08	0.0000
V*Trt.	3	89.25	29.750	2.74	0.0687
Error	21	227.75	10.845		
Total	31	1944.00			

App. 56:- Analysis of Variance Table for Number of Leaves Per Plant

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	2.500	0.8333		
V	1	4.500	4.5000	0.55	0.4680
Trt.	3	114.250	38.0833	4.62	0.0124
V*Trt.	3	7.750	2.5833	0.31	0.8154
Error	21	173.000	8.2381		
Total	31	302.000			

App. 57:- Analysis of Variance Table for Leaf Area (cm^2)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	19.625	6.5417		
V	1	10.125	10.1250	2.05	0.1672
Trt.	3	49.125	16.3750	3.31	0.0399
V*Trt.	3	1.125	0.3750	0.08	0.9724
Error	21	103.875	4.9464		
Total	31	183.875			

**App. 58:-	Analysis of Variance Table for Number of Pods Per Plant**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	5.344	1.7813		
V	1	0.781	0.7812	0.18	0.6770
Trt.	3	128.844	42.9479	9.81	0.0003
V*Trt.	3	2.344	0.7813	0.18	0.9098
Error	21	91.906	4.3765		
Total	31	229.219			

**App. 59:-	Analysis of Variance Table for Length of Pod (cm)**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.3596	0.11987		
V	1	0.0893	0.08925	0.38	0.5444
Trt.	3	9.6604	3.22014	13.70	0.0000
V*Trt.	3	2.0079	0.66930	2.85	0.0621
Error	21	4.9375	0.23512		
Total	31	17.0546			

**App. 60:-	Analysis of Variance Table for Number of Seeds Per Pod**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.7182	0.23941		
V	1	9.8014	9.80138	32.31	0.0000
Trt.	3	12.7403	4.24675	14.00	0.0000
V*Trt.	3	2.8093	0.93642	3.09	0.0493
Error	21	6.3709	0.30338		
Total	31	32.4400			

**App. 61:-	Analysis of Variance Table for 1000 Seed Weight (g)**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	59.37	19.792		
V	1	800.00	800.00	36.35	0.0000
Trt.	3	102.62	34.208	1.55	0.2301
V*Trt.	3	8.75	2.917	0.13	0.9396
Error	21	462.12	22.006		
Total	31	1432.87			

App. 62:- Analysis of Variance Table for Seed Yield Per Hectare (Tones)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.53923	0.17974		
V	1	0.06125	0.06125	0.70	0.4130
Trt.	3	1.65238	0.55079	6.27	0.0033
V*Trt.	3	0.06908	0.02303	0.26	0.8518
Error	21	1.84368	0.08779		
Total	31	4.16560			

(i) Chemical Composition of Pea Leaves

App. 63:- Analysis of Variance Table for Ash

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00001	4.16706		
V	1	0.04500	0.04500	81.91	0.0000
Trt.	3	5.67071	1.89024	3440.52	0.0000
V*Trt.	3	0.12313	0.04104	74.70	0.0000
Error	21	0.01154	5.49404		
Total	31	5.85039			

App. 64:- Analysis of Variance Table for Nitrogen

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00086	0.00029		
V	1	0.00038	0.00038	1.29	0.2692
Trt.	3	0.02856	0.00952	32.42	0.0000
V*Trt.	3	0.00081	0.00027	0.92	0.4488
Error	21	0.00617	0.00029		
Total	31	0.03677			

App. 65:- Analysis of Variance Table for Protein

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00103	0.00034		
V	1	0.13650	0.13650	214.07	0.0000
Trt.	3	0.30281	0.10094	158.29	0.0000
V*Trt.	3	0.11733	0.03911	61.34	0.0000
Error	21	0.01339	0.00064		
Total	31	0.57107			

(i) Chemical Composition of Pea Stems

App. 66:- Analysis of Variance Table for Ash

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00228	0.00076		
V	1	0.52020	0.52020	307.51	0.0000
Trt.	3	2.29892	0.76631	452.99	0.0000
V*Trt.	3	0.23707	0.07902	46.71	0.0000
Error	21	0.03553	0.00169		
Total	31	3.09400			

App. 67:- Analysis of Variance Table for Nitrogen

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00036	0.00012		
V	1	0.00211	0.00211	9.67	0.0053
Trt.	3	0.00886	0.00295	13.52	0.0000
V*Trt.	3	0.00406	0.00135	6.20	0.0035
Error	21	0.00459	0.00022		
Total	31	0.01999			

App. 68:- Analysis of Variance Table for Protein

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00083	0.00028		
V	1	0.01125	0.01125	36.49	0.0000
Trt.	3	0.35062	0.11687	379.05	0.0000
V*Trt.	3	0.03182	0.01061	34.41	0.0000
Error	21	0.00647	0.00031		
Total	31	0.40100			

(ii) Chemical Composition of Pea Pods + Stems

App. 69:- Analysis of Variance Table for Ash

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00158	0.00053		
V	1	0.00125	0.00125	2.44	0.1335
Trt.	3	0.37703	0.12568	2444.94	0.0000
V*Trt.	3	0.00332	0.00111	2.16	0.1230
Error	21	0.01078	0.00051		
Total	31	0.39395			

**App. 70:-	Analysis of Variance Table for Nitrogen**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00026	0.00009		
V	1	0.03380	0.03380	98.75	0.0000
Trt.	3	0.03211	0.01070	31.27	0.0000
V*Trt.	3	0.00902	0.00301	8.79	0.0006
Error	21	0.00719	0.00034		
Total	31	0.08239			

**App. 71:-	Analysis of Variance Table for Protein**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00078	0.00026		
V	1	0.01280	0.01280	31.53	0.0000
Trt.	3	2.55775	0.85258	2100.21	0.0000
V*Trt.	3	0.19070	0.06357	156.59	0.0000
Error	21	0.00853	0.00041		
Total	31	2.77055			

(iii) Seed Nutrient Concentration

**App. 72:-	Analysis of Variance Table for Nitrogen**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.01128	0.00376		
V	1	0.00070	0.00070	0.23	0.6342
Trt.	3	0.90266	0.30089	99.76	0.0000
V*Trt.	3	0.41316	0.13772	45.66	0.0000
Error	21	0.06334	0.00302		
Total	31	1.39115			

**App. 73:-	Analysis of Variance Table for Phosphorus**

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00036	0.00012		
V	1	0.00165	0.00165	10.31	0.0042
Trt.	3	0.08006	0.02669	166.51	0.0000
V*Trt.	3	0.00073	0.00024	1.53	0.2367
Error	21	0.00337	0.00016		
Total	31	0.08617			

App. 74:- Analysis of Variance Table for Potash

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	0.00152	0.00051		
V	1	0.19531	0.19531	282.38	0.0000
Trt.	3	0.69408	0.23136	334.49	0.0000
V*Trt.	3	0.07976	0.02659	38.44	0.0000
Error	21	0.01453	0.00069		
Total	31	0.98520			

App.75:- Analysis of Variance Table for Protein

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	4.980	1.6598		
V	1	1.022	1.0224	0.61	0.4428
Trt.	3	188.322	62.7742	37.57	0.0000
V*Trt.	3	0.619	0.2064	0.12	0.9452
Error	21	35.087	1.6708		
Total	31	230.031			

App. 76:- Analysis of Variance Table for Electrical Conductivity

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	1.750	0.583		
V	1	153.125	153.125	111.85	0.0000
Trt.	3	40.750	13.583	9.92	0.0003
V*Trt.	3	11.625	3.875	2.83	0.0631
Error	21	28.750	1.369		
Total	31	236.000			

App. 77:- Analysis of Variance Table for Emergence %

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	17.50	5.833		
V	1	180.50	180.500	66.50	0.0000
Trt.	3	984.25	328.083	120.87	0.0000
V*Trt.	3	24.25	8.083	2.98	0.0547
Error	21	57.00	2.714		
Total	31	1236.50			

App. 78:- Analysis of Variance Table for Germination %

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	2.594	0.8646		
V	1	3.781	3.7813	2.20	0.1532
Trt.	3	57.344	19.1146	11.10	0.0001
V*Trt.	3	0.344	0.1146	0.07	0.9770
Error	21	36.156	1.7217		
Total	31	100.219			

Experiment No. 5. Effects of Different Seed moisture Contents at Harvest on Pea Seed Quality.

App. 79:- Analysis of Variance Table for Seed Fresh Weight (g)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	19.59	6.53		
V	1	3080.71	3080.71	654.64	0.0000
Trt.	6	808.42	134.74	28.63	0.0000
V*Trt.	6	7.24	1.21	0.26	0.9537
Error	39	183.53	4.71		
Total	55	4099.48			

App. 80:- Analysis of Variance Table for Seed Dry Weight (g)

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	1.505	0.5017		
V	1	23.451	23.4512	9.90	0.0032
Trt.	6	160.309	26.7181	11.28	0.0000
V*Trt.	6	14.601	2.4335	1.03	0.4222
Error	39	92.371	2.3685		
Total	55	292.237			

App. 81:- Analysis of Variance Table for 1000 Seed weight

Source	D.F	S.S	M.S	F. Value	Prob.
Block	3	8.929	2.9762		
V	1	34.571	84.5714	7.17	0.0108
Trt.	6	168.464	28.0774	5.82	0.0002
V*Trt.	6	2.179	0.3631	0.08	0.9982
Error	39	188.071	4.8223		
Total	55	402.214			

App. 82:- Analysis of Variance Table for Germination %

Source	**D.F**	**S.S**	**M.S**	**F. Value**	**Prob.**
Block	3	32.429	10.8095		
V	1	37.786	37.7857	5.94	0.0195
Trt.	6	154.607	25.7679	4.05	0.0030
V*Trt.	6	49.964	8.3274	1.31	0.2761
Error	39	248.071	6.3608		
Total	55	522.857			

App. 83:- Analysis of Variance Table for Emergence %

Source	**D.F**	**S.S**	**M.S**	**F. Value**	**Prob.**
Block	3	16.429	5.4762		
V	1	41.143	41.1429	6.23	0.0169
Trt.	6	317.857	52.9762	8.02	0.0000
V*Trt.	6	15.857	2.6429	0.40	0.8744
Error	39	257.571	6.6044		
Total	55	648.857			

App. 84:- Analysis of Variance Table for Electrical Conductivity

Source	**D.F**	**S.S**	**M.S**	**F. Value**	**Prob.**
Block	3	6.763	2.2545		
V	1	78.969	78.9688	40.56	0.0000
Trt.	6	192.991	32.1652	16.52	0.0000
V*Trt.	6	9.563	1.5938	0.82	0.5622
Error	39	75.924	1.9468		
Total	55	364.210			

Experiment No-6:

Effects of packing material and storage conditions on pea seed quality

App. 85:- Analysis of Variance Table for Germination %

Source	D.F	S.S	M.S	F. Value	Prob.
Replication	3	19.792	6.597	2.6902	0.0529
Factor A	2	110.771	55.385	22.5851	0.0000
Factor B	1	12.042	12.042	4.9104	0.0300
AB	2	1.896	0.948	0.3865	
Factor C	3	140.708	46.903	19.1261	0.0000
AC	6	5.479	0.913	0.3724	
BC	3	1.542	0.514	0.2096	
ABC	6	3.521	0.587	0.2393	
Error	69	169.208	2.452		
Total	95	464.958			

App. 86:- Analysis of Variance Table for Electrical Conductivity

Source	D. F	S.S	M.S	F .Value	Prob.
Replication	3	39.698	13.233	5.3379	0.0023
Factor A	2	263.521	131.760	53.1503	0.0000
Factor B	1	173.344	173.344	69.9244	0.0000
AB	2	0.438	0.219	0.0882	
Factor C	3	7041.698	2347.233	946.8406	0.0000
AC	6	14.396	2.399	0.9678	
BC	3	41.865	13.955	5.6292	0.0016
ABC	6	2.479	0.413	0.1667	
Error	69	171.052	2.479		
Total	95	7748.490			

App. 87:- Analysis of Variance Table for Emergence %

Source	D. F	S.S	M.S	F .Value	Prob.
Replication	3	10.865	3.622	2.0252	0.1184
Factor A	2	107.583	53.792	30.0816	0.0000
Factor B	1	21.094	21.094	11.7961	0.0010
AB	2	2.250	1.125	0.6291	
Factor C	3	1173.865	391.288	218.8175	0.0000
AC	6	95.667	15.944	8.9165	0.0000
BC	3	12.365	4.122	2.3049	0.0844
ABC	6	20.167	3.361	1.8796	0.0967
Error	69	123.385	1.788		
Total	95	1567.240			

Seed Nutrient Concentration

App. 88:- Analysis of Variance Table for Nitrogen

Source	D.F	S.S	M.S	F. Value	Prob.
Replication	3	0.004	0.001	0.0212	
Factor A	2	0.080	0.040	0.6516	
Factor B	1	0.017	0.017	0.2793	
AB	2	0.015	0.008	0.1263	
Factor C	3	3.266	1.089	17.8166	0.0000
AC	6	0.051	0.008	0.1381	
BC	3	0.174	0.058	0.9491	
ABC	6	0.007	0.001	0.0194	
Error	69	4.217	0.061		
Total	95	7.217			

App. 89:- Analysis of Variance Table for Phosphorus

Source	D.F	S. S	M.S	F. Value	Prob.
Replication	3	0.000	0.000	0.07030	
Factor A	2	0.003	0.001	3.5637	0.0337
Factor B	1	0.000	0.000	0.4220	
AB	2	0.000	0.000	0.5627	
Factor C	3	0.196	0.065	183.4843	0.0000
AC	6	0.000	0.000	0.1876	
BC	3	0.002	0.001	1.7975	0.1558
ABC	6	0.000	0.000	0.0625	
Error	69	0.025	0.000		
Total	95	0.226			

App. 90:- Analysis of Variance Table for Potash

Source	D.F	S.S	M.S	F. Value	Prob.
Replication	3	0.001	0.000	0.0442	
Factor A	2	0.041	0.021	5.0261	0.0092
Factor B	1	0.304	0.304	74.4120	0.0000
AB	2	0.003	0.001	0.3307	
Factor C	3	1.920	0.640	156.8115	0.0000
AC	6	0.046	0.008	1.8632	0.0997
BC	3	0.122	0.041	9.9774	0.0000
ABC	6	0.006	0.001	0.2273	
Error	69	0.282	0.004		
Total	95	2.723			

App. 91:-   Analysis of Variance Table for Protein

Source	D. F	S.S	M.S	F. Value	Prob.
Replication	3	1.458	0.486	0.1960	
Factor A	2	17.706	8.853	3.5706	0.0334
Factor B	1	0.527	0.527	0.2124	
AB	2	3.932	1.966	0.7929	
Factor C	3	535.414	178.471	71.9804	0.0000
AC	6	3.932	0.655	0.2643	
BC	3	4.983	1.661	0.6699	
ABC	6	4.787	0.798	0.3218	
Error	69	171.082	2.479		
Total	95	743.082			