بسم الله الرحمن الرحيم

إِنَّ اللَّهَ يَأْمُرُكُمْ أَنْ تُؤَدُّوا الْأَمٰنٰتِ إِلٰى أَهْلِهَا وَإِذَا حَكَمْتُمْ بَيْنَ النَّاسِ
أَنْ تَحْكُمُوا بِالْعَدْلِ إِنَّ اللَّهَ نِعِمَّا يَعِظُكُمْ بِهِ إِنَّ اللَّهَ كَانَ سَمِيعًا بَصِيرًا

سورة النساء ٥٨

Allah doth command you to render back your Trusts to those to whom they are due ; and when ye judge between man and man, That ye judge with justice : Verily how excellent. is the teaching which He giveth you ! For Allah is He Who heareth and seeth all things.

Al - Nisa : 58

O, GOD, OPEN OUR EYES,
TO SEE WHAT IS BEAUTIFUL,
OUR MINDS TO KNOW WHAT IS TRUE
OUR HEARTS TO LOVE WHAT IS GOOD

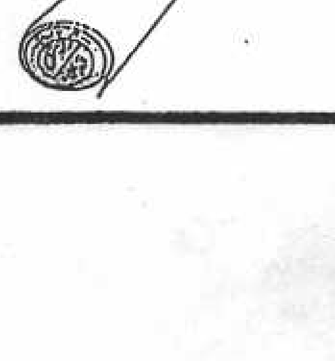
DEDICATED

TO

MY FAMILY

BY THE VIRTUE OF WHOSE PRAYS, I HAVE BEEN ABLE TO REACH AT THIS HIGH POSITION.

AND WHOSE HANDS ARE ALWAYS RAISED FOR PRAY, FOR MY WELL-BEING, EVEN AT THIS MOMENT OF TIME.



EFFECT OF *Trianthema portulacastrum* L. INFESTATION ON DIFFERENT AGRO-PHYSIOLOGICAL TRAITS OF MAIZE

BY

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M.Sc. (Hons.) Agri.

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To

The Controller of Examinations,
University of Agriculture,
FAISALABAD

We, the Supervisory Committee, certify that the contents and form of the thesis submitted by Mahmood A. Randhawa have been found satisfactory and recommend that it be processed for evaluation by the External Examiners for the award of degree.

SUPERVISORY COMMITTEE

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(MAHMOOD A. RANDHAWA)

CONTENTS

ABBREVATIONS

%	=	Per cent
@	=	At the rate of
CGR	=	Crop growth rate
Cm	=	Centimeter
Cob^{-1}	=	Per cob
cv	=	Cultivar
d^{-1}	=	Per day
DM	=	Dry matter
DW	=	Dry weight
FW	=	Fresh weight
g	=	Gram
ha^{-1}	=	Per hectare
HI	=	Harvest index
K	=	Potassium
Kg	=	Kilogram
LA	=	Leaf area
LAD	=	Leaf area duration
LAI	=	Leaf area index
LSD	=	Least significant difference
m^{-1}	=	Per meter
m^{-2}	=	Per square meter
mg	=	Milligram
Mg	=	Million gram
mm	=	Millimeter
MT	=	Metric ton
MWE	=	Maize water extract
N	=	Nitrogen
NAR	=	Net assimilation rate
P	=	Phosphorus

$Plant^{-1}$	=	Per plant
PPM	=	Parts per million
Rs.	=	Rupee
S	=	Sulphur
SWE	=	Sorghum water extract
t	=	Tonne
T. port.	=	Trianthema portulacastrum
TSS	=	Total soluble salts
TWE	=	Trianthema water extract
W	=	Weeding
W.E.	=	Water extract
WAE	=	Weeks after emergence

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INTRODUCTION

CHAPTER I

INTRODUCTION

Maize (*Zea mays L.*) is the third important cereal of Pakistan. It provides valuable raw materials for different industries in addition to its common usage as human food grain, corn oil, bakery products, forage and feed for livestock and poultry. The demand of maize crop has been continuously increasing due to expansion of its uses. But maize productivity has not shown improvement during the last decades in Pakistan. Its average yield is extremely low (1469 kg ha^{-1} (Anonymous, 1996) in Pakistan as compared to countries like USA (7975 kg ha^{-1}), Switzerland (9110 kg/ha), Itlay (9151 kg ha^{-1}), Chile (9445 kg ha^{-1}), New Zealand (9687 kg ha^{-1}), Jordan (10500 kg ha^{-1}), Kuwait (10500 kg ha^{-1}) and UAE (18036 kg ha^{-1}) (Anonymous, 1996).

The inherent yield potential of the domestic maize varieties is not being exploited due to lack of resources as water, fertilizer, etc. and ignorance of farmers in adoption of modern agro-technology. Weed infestation in maize fields is one of the important factors limiting its yield. The adverse effects of weeds on crop are invisible, in addition to competition for nutrients, moisture, light, space, weeds interfere with crop by releasing allelopathic substances causing reduction in crop yields (Rice, 1984).

Trianthema portulacastrum L. (Itsit) is a noxious weed of maize in the Central Punjab. The weed produces numerous seeds in its nodes which are germinable within a few days and it grows very rapidly covering the whole maize field in a couple of days resulting in extremely poor and weak maize crop. *Trianthema portulacastrum* interference reduces maize yield by 32% (Balyan and Bhan, 1989) and yield losses may be even more than this if *Trianthema* is not checked. The magnitude of loss by weed interference depends upon infestation duration, density & growth of weed, fertilizer dose, crop population and allelopathic effects.

The knowledge of growth behaviour and threshold density level of *T. portulacastrum* is of fundamental importance in formulating a proper strategy to control this weed. This strategy could be helpful in minimizing the use of chemical herbicides and reducing the energy costs of control operations and hence to save the environment from pollution. The information regarding threshold level for *T. portulacastrum* in maize crop is hardly available.

Duration of *T. portulacastrum* infestation is another important factor which affects the yield of maize. The time of *T. portulacastrum* removal is as important as the removal itself because the competitiveness of this weed depends upon duration of its interference with the crop. There is an optimum requirement of nutrients for maize during critical period of growth. During the critical period of crop growth, weed-crop competition is the maximum. Control of *T. portulacastrum* during this period is essential to avoid economic losses. Operations performed before and after the critical period are of less economic importance and the investments made do not pay significant returns (Tanveer, 1996).

Weed and crop plants are nourshied by the same nutrients and their requirements for the ecological elements such as moisture, light,space, etc. are also the same. Competition starts as soon as the supply of these elements falls short of their combined demand (Zimdahl, 1980). Information on intra and inter specific competition for nutrients is generally mentioned to be the most important factor of weed-crop competition. Among the essential nutrients, nitrogen appears to be the most critical for weed-crop competition. Being a C_4 plant, the maize crop gives linear response to nitrogen application (Blackman and Templeman, 1938). The law of diminishing return may be used in deciding the most profitable level of nitrogen. Nitrogen plays a dominant role in enhancing crop development processes which results in smothering of weeds and ultimately increasing yield of the main crop. As *T. portulacastrum* is also aggressive to utilize nutrients including nitrogen, establishing the optimum nitrogen requirements of maize and critical period of maize-*T. portulacastrum* competition will help to carry out the economical benefits of weeding.

In view of the above information, present study was designed to achieve the following objectives:

a) to determine the allelopathic effect of maize and *Trianthema portulacastrum* on each other's seed germination and seedling growth,

b) to investigate the effect of duration of *Trianthema portulacastrum* infestation on maize productivity at different nitrogen levels, and

c) to evaluate the interactive effects of *Trianthema portucalastrum* density and intra-row plant spacing of maize on the production potential of maize.

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Considerable work on weed-crop competition has been conducted world over. However, a little work regarding *Trianthema portulacastrum* is available and very little work on the subject is reported in Pakistan. Research work related to the subject is briefly reviewed below.

2.1 ALLELOPATHY IN CROPPING SYSTEMS

The role of allelopathy in agriculture has been realized in the recent past and the scientists have concentrated more to this emerging science during the last few decades (Nelson, 1996). Many plants (crops and weeds) have been identified as allelopathic, however, their effectiveness is influenced by different factors as temperature, water, mineral, soil type, soil microbial activity, age, maturity level of plant, etc. (Woodhead, 1981). The quantity, number and action of allelochemicals, varies in different plants. In smaller amounts, allelochemicals behave differently than in larger quantity. Similarly the allelochemicals are specific and selective in their action (Hussain and Anjum, 1981). In smaller amounts, generally, they promote the germination and growth while in larger quantity they inhibit, however, there are exceptions to this behaviour (Cheema, 1988).

These allelochemicals may be of importance in crop sequencing, in rotation, in minimum-tillage and no-till agriculture where crop residues are left on the soil surface after harvest, or in intensive cropping systems such as intercropping and relay cropping. The use of cover crops and their residues may augment weed control methods to complement conservation tillage in crop production. Proper crop selection and residues management can improve the potential of allelopathy to suppress weeds (Miller, 1996). Interest in intercropping, double cropping, no-till planting and non-rotational cropping increase the need to understand the allelopathy and its role in cropping systems.

2.1.1 ALLELOPATHIC EFFECTS OF CROPS ON WEEDS

Different crops like corn, wheat, sorghum, oat, etc. have been identified as allelopathic against other plants due to presence of allelochemicals i.e. ferulic acid, P-coumaric, syringic, vanillic and P-hydroxybenzoic acids (Guenzi and McCalla, 1966). While evaluating the allelopathic effects of sorghum residues, Putnam and DeFrank (1983) reported that populations of common purslane (*Portulaca oleracea*) and smooth crab grass (*Digitaris ischaemum*) were reduced to 70 and 98 per cent, respectively by residues of sorghum. Putnam *et al.* (1983) examined allelopathic capability of different crops to suppress weeds and they suggested that most effective regime was to grow cover crops of rye, wheat, sorghum or barley to a height of

40-45 cm. Desicate the crops by contact herbicide or freezing and allow the residues to remain on soil surface. They reported that up to 90 per cent of weed control was obtained in the 30-60 days period after desication. They further indicated that weed suppression was attributed to the allelochemicals present in these crops.

Worsham (1984) suggested that weed suppression by allelopathy of crops takes place under mulch conditions and reported that when full season soybeans and sunflowers were planted no till into killed green rye, the lambsquarter growth was reduced by 99 per cent, pigweed growth was reduced 96 per cent and ragweed growth 92 per cent compared with tilled plots with no mulch. Purvis *et al*. (1985) found that residues from mature crops of sorghum, sunflower, oil seed rape, wheat and field pea exhibited selective allelopathic effects on weed germination and growth under field condition. Wheat and pea residues promoted the germination and growth of *Avena fatua* and *Avena sterilis* spp. ludoviciana. Other grass weeds as *Echinochloa crusgalli, Phalaris aquatica, Phalaris paradoxa*, however, were inhibited by the presence of crop residues and extent of inhibition was dependent on residue type. Khalid and Shad (1987) conducted a laboratory experiment to evaluate the allelopatic effects of cultivated sunflower and reported that leaf extracts of this plant exhibited allelopathic effects on different weeds but germination of *Trianthema portulacastrum* was not affected. Similarly Cheema and Randhawa (1994) reported that germination per cent, root and shoot length of *Trianthema portulacastrum* was significantly reduced by the application of 75% and 100% of sorghum water extract under lab. conditions. However, lower concentration (25%) of SWE promoted germination, root and shoot length of *Trianthema portulacastrum*. The review cited above indicates that different field crops are allelopathic which influence germination and growth of weeds.

2.1.2 ALLELOPATHIC EFFECTS OF WEEDS ON CROPS

Like crop plants, weeds also contain different allelochemicals which effect crop plants growing in association. Singh (1968) reported that water extracts of purple nutsedge exhibited allelopathic effects on germination and seedling growth of 10 species of crop plants. Inhibition of seed germination of these crops varied from 0 to about 65 per cent compared to control treatment (no water extract). Seedling growth of 8 plant species was inhibited by nutsedge water extract with the maximum of about 85 per cent. Akhtar *et al.* (1978) in their field and lab. study found that water extracts of *cenchrus* spp. and *chrysopogon* spp. proved to be inhibitory to plant species used in bioassay. They further pointed out that the toxic effects of these weeds increased with increasing concentration and soaking time of weed dry material. Similarly Garbor and Veatch (1981) evaluated the allelopathic effects of quackgrass by using different concentrations of its water extract and reported that 0.1% W/V concentration significantly inhibited seedling and root growth of corn, oat, cucumber and alfalfa.

Hussain and Anjum (1981) conducted laboratory and field study to determine allelopathic effects of dhamangrass (*Cenchrus celiaris* L.) on different crops and observed that the growth of *Zea mays, Lactuca sativa, Capsicum annum, Lycopersicon esculentum* and *Pennisetum americanum* was significantly reduced in root-mixed conditions by *Cenchrus celiaris*. However, the later two species showed slight reduction in the growth of *Cenchrus celiaris*. Water extracts from shoots and roots, root exudates, soil beneath the grass and artificially decomposed litter invariably reduced germination, radicle growth, fresh and dry mass of *Pannisetum americanum, Setaria italica, Lactuca sativa* and *Brassica compestris* in the bioassays. The allelopathic effects, however, depended upon the part assayed, species used and physiological process involved. They suggested that the litter must be removed from the fields during weeding. Srivastava *et al.* (1985) observed that water extracts of *Parthenium hysterophorus* leaves and inflorescence inhibited germination and seedling growth of barley, peas and wheat. They noted that root and stem extracts were less inhibitory. The allelopathic effects were more inhibitory on wheat and peas as compared to barley.

Chughtai *et al.* (1986) evaluated the allelopathic potential of *Fumaria indica* in laboratory conditions. They stated that water extracts from various plant parts significantly inhibited germination and growth of *Triticum aestivum* L. Var. Blue silver. They further indicated that allelopathic effects varied from part to part and also depended upon the amount of the plant material used, the soaking period and the freshness of the material assayed. Dry leaves were found to be highly toxic and allelopathic. Johnson and Coble (1986) evaluated allelopathic effects of borad leaf signalgrass (*Brachiaria platyphylla*), large crabgrass (*Digitaria sanguinalis*) and fall panicum (*Panicum dichotomiflorum*) residues, applied as a mulch or soil incorporated on five plant species. The germination of corn was reduced by soil incorporated fall panicum residue, however, it stimulated the germination of broad leaf signalgrass while germination of other species was not significantly affected. Hussain *et al.* (1987) concluded that water extract of dried plant of *Trianthema portulacastrum* significantly reduced germination and seedling growth of *Zea mays*. Moreover, moisture and chlorophyll contents of shoots of *Zea mays* were retarded by *Trianthema portulacastrum* during its growth. In another study, Hussain and Khan (1988) tested the allelopathic potential of *Cynodon dactylon* L. against different crop species including corn and they revealed that *Cynodon dactylon* L. was strongly allelopathic against corn and other species tested. They further reported that phytotoxic effects were related to the part assayed and test species used. Velu (1989) studied the germination and growth of seeds of sorghum, fingermillet, maize, pearlmillet, redgram, sesame, cotton, groundnuts, mungbeans and blackgram for 7 days in petridishes with root, stem or whole plant extracts of *Trianthema portulacastrum* to assess its allelopathic effects. Results indicated that seed germination was reduced by 28% for sorghum, 36% for finger millet, 14% for both maize and mungbean, 17% for cotton and 5% for blackgram. Seedlings growth and vigour were also reduced. In groundnut, the allelopathic effect was found to enhance germination and seedling growth and vigour.

The review regarding effects of weeds on crops indicates that different weeds are allelopathic which influence the germination and growth of different crops.

2.2 NITROGEN IN RELATION TO GROWTH, YIELD AND QUALITY CHARACTERISTICS OF MAIZE

2.2.1 Growth and yield

Nitrogen is vitally important part of plant nutrition. The growth of plant primarily depends on the nitrogen availability which influence various physiological processes occurring during the life cycle of plant system. While dry matter production and its conversion to economic yield is a cumulative effect of various physiological processes of crop plants. Nitrogen plays a dominent role in growth process as it is integral part of chlorophyll molecules, a constituent of enzyme molecules, protein and nucleic acids (Marschner, 1986). Like other crops, nitrogen is essential for corn growth and development and N deficiency will decrease corn grain yield substantially (Bullock and Bullock, 1994). Wallace (1951) also reported that nitrogen deficiency in crops leads to reduced leaf area. Nitrogen requirement of maize crop is high during growth period than at any other stage during the growth cycle of maize and N deficiency at that stage will cause a reduction in the number of rows of kernels for ear, thereby lowering the final yield (Schreiber *et al.*, 1962). Although final yield of maize depends upon the amount of nitrogen applied but judicious use of nitrogen is important and economic optimum nitrogen rates lie between 178 and 234 kg ha^{-1} on irrigated sandy soil and between 100 and 150 kg ha^{-1}, on finer textured soils (Oberle and Keeney, 1990). Similarly Halemani *et al.* (1976) reported that maize grain yield depends on nitrogen application. They further reported that increasing nitrogen application from (0 to 24 kg ha^{-1}) grain yield of maize was increased (2.66 to 5.24 t ha^{-1}).

Meelu *et al.* (1976) also observed a significant increase in yield of maize due to addition of 50 kg N and 25 kg K_2O_5. Similarly Shukla *et al.* (1978) reported that maize grain yields were higher with 60 kg N/ha in 1974, however, they were the highest with 90 kg N/ha in 1975 under mid hill conditions of Himachal Perdesh. Viswanath (1980) reported that application of 112.5 kg N + 56.3 kg P_2O_5 + 28.1 kg K_2O/ha, significantly enhanced crop yield when applied 30 to 50 days after sowing.

Pinzariu (1981) carried out three year field trial to see the effect of nitrogen levels on the yield of maize crop. The nitrogen was applied at the rate of 60, 120, 180 or 240 kg ha^{-1} alongwith 80 kg P_2O_5 ha^{-1}, 67% of the nitrogen was applied at sowing time and 33% at flowering time. The mean grain yields were 8.73, 11.49, 8.62 and 9.81 t ha^{-1} and the maximum grain yields of 9.85, 13.18, 10.84 and 12.25 t ha^{-1} were obtained with 60, 120, 180 and 240 kg N in hybrid maize crop.

Grewal *et al.* (1982) studied the effect of different NPK combinations on grain yield and stated that grain yield of maize was increased with increasing rates of NPK.
Javid (1982) got the highest grain yield from plots fertilized with 124-62-0 kg NPK ha^{-1}.

Tasseling, silking and maturity were earlier in fertilized plots than control. Application of NP @ 24 to 62 kg ha^{-1} increased plant height, grains per cob and 1000-grain weight significantly over control. Saleem and Aly (1982) observed an increase in all plant attributes viz, number of cobs per plant, 1000-grain weight, etc. with increasing rate of nitrogen.

Short *et al.* (1982) stated that significant yield increase in maize occurred with added N up to the maximum of 200 kg ha^{-1}. Increased N tended to increased cob number per plant (0.91 with 0 kg and 1.05 with 200 kg N ha^{-1}) and grain production per cob. Naeem and Anwar (1986) estimated that a maize crop producing 5 to 6 t ha^{-1} removes approximately 100-150 kg N, 40-60 kg P_2O_5 and 100-150 kg K_2O per hectare from the soil. The NPK requirements of maize crop can not be fulfilled by most of the soils beyond 20-25 per cent and thus additional supply of NPK fertilizer is a must. Haq (1987) conducted experiment on maize under irrigated conditions with application of nitrogen from 0-450 kg ha^{-1} alongwith constant rate both of P and K (75 and 225 kg ha^{-1}). The level of 200 kg N ha^{-1} showed a four fold grain yield increase, above that yield decreased, but there was increase in dry matter production as well as lodging. Khanzada and Ahmed (1988) investigated the yield and yield components of maize under the effect of nitrogen levels viz, 0, 40, 80 and 120 kg ha^{-1}. It was observed that grain yield of maize was increased by increasing nitrogen levels.

Borin and Sartori (1989) conducted field trials with four nitrogen rates from 0-300 kg ha^{-1} and reported the maximum shoot dry matter at 214 kg N ha^{-1}. At high nitrogen rates dry matter yield declined but grain yield continued to increase. Both grain yield and dry matter were the highest at 200 kg N ha^{-1}. Haq *et al.* (1989) conducted two year experiment on maize with different combinations of fertilizer in Pakistan and found the highest grain yields of 2.05 and 2.02 t ha^{-1} in the first and second year, respectively with 100 kg N + 100 kg P_2O_5. Camberato *et al.* (1989) conducted a field trial on four maize hybrids. Nitrogen was applied @ 50-168 kg ha^{-1}. The results revealed that ear, shoot length at silking differed among hybrids but was not affected by nitrogen. At high nitrogen rate, dry matter was increased progressively. Planet *et al.* (1990) studied the effect of 30-240 kg N ha^{-1} on irrigated maize and recorded significantly the highest grain yield (6.7 t ha^{-1}) at 240 kg N ha^{-1}. Nitrogen accumulation by shoots was the maximum at this nitrogen rate (270-300 kg ha^{-1}). Relationship between shoot nitrogen concentration and plant dry matter per unit area was increased.

Prasad *et al.* (1990) concluded that for obtaining the maximum maize yield, the use of increased N at higher plant population is essential. The review cited above shows that maize crop is very responsive to nitrogen application and grain yield is usually enhanced with increased rate of nitrogen.

2.2.2 Grain quality

Improvement in grain quality of maize in response to nitrogen application is recognized and the total protein contents of the maize grain are enhanced with high rates of nitrogen (Mitchell et al., 1952). Davidescu (1965) also found that N applied in addition to PK was effective in increasing protein content. All fertilizer treatments increased starch and oil contents of maize grain.

El-Hattab *et al.* (1980) carried out a 2 year field trial with four major maize cultivars by applying different levels of N-fertilizer (0, 71 and 142 kg ha^{-1}) and reported that NAR and RGR after 30-45 days started to decrease with the increase of age of the plant. It was also noticed that LAI, plant height and total DW per plant increased and LAR and leaf weight ratio decreased with the increase of nitrogen rates. LAR was found to be the maximum at silking stage. Grain yield and all other yield components were also increased with increasing nitrogen. Increasing nitrogen level led to early silking, increased crop yield, total N and P contents and decreased total CH_2O contents. Grain K contents were increased by application of 71 kg N ha^{-1}. Negrila *et al.* (1984) applied 50, 150 or 200 kg N ha^{-1} alone or alongwith 80, 120 or 160 kg P_2O_5 ha^{-1} and found an increase in grain yield and protein content of maize grain with increased rate of N and P_2O_5. The most economic N rate for grain production was 143 kg ha^{-1}. Similarly Thiraporn *et al.* (1992) applied nitrogen @ 0-160 Kg ha^{-1} and reported that grain and biomass yield increased up to 80 kg N. Higher nitrogen did not increase biomass yield but caused slight increase in the grain yield. Harvest Index and protein percentage of grain was increased with higher nitrogen level, same results were observed in case of 1000-grain weight.The above work indicates that nitrogen influence grain quality of maize especially in terms of protein per centage.

2.3 WEEDING IN RELATION TO GROWTH, YIELD AND QUALITY CHARACTERISTICS OF MAIZE

2.3.1 Growth and yield

Weed infestation is a serious problem in the production of crops. Weeds may reduce 20-30% yield per acre, but some time it reaches to 50% (Emond *et al.*, 1976). Weeds compete with the crop throughout the growing season, but competitive effects are different at different stages of growth. In most crop plants, the weed-crop competition is negligible at early growth stages (Bhowmik and Curry, 1983). Likewise the weed growth is normally suppressed by the crop shadding during the later growth stages. So, the weed infestation is more serious in the middle season (Maris, 1985) and therefore the weed control during critical period of infestaton is of paramount importance. It has been proved that the earlier the removal of the weeds better it will be for the crops (Zimdahl (1980). While Burrows and Olson (1955) reported that weed competition in cereals generally reduces crop vigour, tillering, head size and kernel weight.

In another study Glesason (1960) concluded that initial 4 to 5 weeks were essential for weed control in maize because thereafter shadding becomes an effective weed control device. Li (1960) reported that 15-22% maize grain yield reduction was noted after weed competition for 3-5 weeks. Moolani *et al.* (1963) found that the combined total dry matter of weeds and corn was nearly equalent to the total dry matter of corn from the weed free plots.

Bounting and Ludwig (1964) reported the extent of the reduction in grain yield of maize from 33 to 42 per cent due to weed infestation particularly in the early growth stages. Moolani (1965) reported that the losses due to weeds in maize were the highest when weeds were allowed to compete with the crop for 10 weeks after sowing. Nieto (1970) reported that in Mexico, corn with the genetic potential to produce 5000 kg/ha produced only 3500 kg/ha if weeds were not controlled for the first 40 days after crop emergence. Dawson (1971) concluded that variation in the length required for weed free or critical period, occur due to the difference in competitive ability of weeds or geographic regions.

Sandhu and Gill (1973) reported that sedges type of weeds occur and cause losses of maize yield during 2 to 6 weeks after sowing. Thind and Sandhu (1982) reported that a noxious weed namely *Cyperus rotundus* L. occurs in maize crop during 2 to 6 weeks after sowing. During this period it causes the maximum losses to maize crop. Singh (1973) reported that weed free plots for 30 days is a must for optimum maize yields. Gupta and Nirwal (1976) was of the opinion that early season control of grasses with herbicides followed by one row cultivation controlled the weed growing in maize crop throughout the season.

Thomas *et al*. (1978) carried out maize weed (*Cyperus esculentus*) competition experiment for different durations of infestation and reported that competition with *C. esculentus* for the first 6 weeks reduced maize yield by 8.6% only. Stass-Ebregt (1979) claimed that shoot yield of maize was reduced significantly when the weeds were present after the crop had approached the 7th to 8th leaf stage. If the weeds remained present thereafter, no significant interference with crop growth was observed. It was also observed that at 10 to 11 leaf stage, weed growth was severely restricted by crop shading thus making the weed control measures unnecessary at this stage. Zabate *et al.* (1979) concluded that weed competition up to 29 days from sowing or beyond significantly reduced the no of leaves per maize plant and competition for the first 7-18 days reduced maize yield significantly. Krishnamurthy *et al.* (1981) determined the critical period of weed competition and reported that maize crop, need a weed free period of 30-40 days after sowing to obtain higher yields. It was further reported that weed competition reduced DM production per plant. Carssanel *et al.* (1982) studied the effect of weed duration on maize yield. At a density of 7 weeds m^{-2} for 10 weeks. The grain yield of maize was reduced by 18% and reduction in yield was significantly greater when weeds persisted for more than 10 weeks. Grain yields were 3.57 and 2.90 t ha^{-1} at weed persistance of 12 and 14 weeks respectively compared with 5.68 t ha^{-1} in weed free plots. Kumar (1983) assessed the biomass and net productivity of crop plants (maize) and associated weeds at various stages of growth of the crop. 11 species of flowering plants comprised the crop-weed association. Total biomass and net productivity of the weeds were higher than those of the sown crop in early stages of growth up to 35 days. Among the weeds, *Trianthema portulacastrum* had the highest biomass and net productivity, indicating its real competition with the crop. Perry *et al.* (1983) studied the competition between Johnson grass and corn and concluded that there was an inverse relationship between crop yield and *S. halpense* plant DW. Maize yield and stover weight were significantly lower when the crop was allowed to compete with weeds for a longer period of time than the weed-free control. Vernon and Parker (1983) revealed that 30% yield losses in maize are due to weeds. A critical period of competition during which the crop should be kept weed free was demonstrated from 10-30 days after emergence. Defelice *et al.* (1984) found that maize grain yield, number of grains per cob were significantly lower with season long *Abutilon theophrasti* competition compared to weed free plots. By delaying emergence of *A. theophrasti* for 6 weeks, maize yield was similar to that of weed free plots. Both maize seed and weed seed production was significantly reduced by season long competition. Gupta (1984) observed that initial 30-45 days after sowing is the critical period for weed competition in sorghum. Kharwara *et al.* (1984) reported that maize gave grain yield of 1.15 t ha^{-1} without weed control and 3.62 and 3.87 t ha^{-1} with weeding at the 4-5 leaf stage and knee high stages, respectively.

Anonymous (1985) noted that weed removal at different time intervals viz; 2, 4, 6 and 8 weeks after sowing did not show significant difference among treatments. However, four weeks after sowing was the best time to obtain the maximum grain yield of 27.3% higher than unweeded check. Gab-Alla *et al.* (1985) conducted two field experiments to evaluate the effect of frequent hoeing and thinning time on yield and chemical composition of maize. The prevailing weeds were annuals such as *Portulaca oleracea, Corchorus olitorius, Xanthium spinosum, Amaranthus caudatus, Solanum nigrum, Echinochloa colonum* and *Hibiscus trionum*. Results showed that the number of days from planting to 50% tasseling, plant height, stem diameter, leaf area, number of cobs per plant, cob length, cob weight, grain weight per cob, grain yield per feddan increased significantly with increasing number of hoeings. Hoeing caused a significant depression in weed FW, DW and number m^{-2}. Delayed thinning decreased significantly growth characters, yield and yield components of maize plants. (one feddan = 0.42 ha). Singh *et al.* (1985) revealed that weed free conditions up to 60 DAS in maize increased the grain yield by 69%. They also found that the minimum weed DW and no of weeds m^{-2} increased the plant height, number of plants and number of cobs per plot.

Beck (1985) noted 70% increase in maize grain yield by weeding at 2 to 3 leaf stage of crop compared with no control measures. He observed decrease in stalk, cob length and grain number per cob by 50, 20 and 30%, respectively. Verma *et al.* (1985) found that keeping weed free conditions up to 30 DAS significantly increased grain yield of maize. Although reduction in weed DW was significant in plots kept weed free up to 45 DAS but first 30 DAS was found the critical period for weed competition in maize. Makhdoom (1986) recorded that the critical time when competition between weeds and crop plants was the maximum, ranged from crown root initiation to flowering stage of maize crop. Rola (1986) concluded that competition of *Echinochloa crusgalli* and *Amaranthus retroflexus* for 2-6 weeks after emergence reduced maize yield by 7-50% while competition up to harvest resulted in 70% reduction. Both species were the most competitive at 2 to 4 leaf stage. Balyan and Bhan (1987) concluded that atrazine applied @ 0.5 kg/ha pre-emergence to maize gave more effective weed control than weeding 3 and 5 weeks after sowing. Both treatments markedly reduced the DW of *Trianthema portulacastrum* and *Echinochloa colonum* compared with no weed control. Khanzada *et al.*

(1988) reported that the maximum grain yield (5.29 t ha^{-1}) was obtained from the plots weeded after 5 weeks of crop emergence which was not significantly different from those obtained from weeding 4 and 6 weeks after crop emergence. Thomas *et al.* (1988) reported that weed crop competition begins 20 days after maize sown and continues up to maturity but severe competition lies in between 30-60 days after sowing. Zanin *et al.* (1988) revealed that competition of velvet leaf weed (*Abutilon theophrasti*) with maize crop for 54 days reduced maize grain yield by 21% accounted for by a 24% reduction of NAR. It was also observed that when the weed was grown with maize throughout the crop growth period, yields were reduced by about 31% mainly due to marked NAR reduction at the flowering and milky stage. Balyan and Bhan (1989) estimated 87-95% control of *Trianthema portulacastrum* in maize by weeding at 3rd and 5th week of sowing.

Adam Czewski *et al.* (1991) reported that application of suitable herbicide once or twice in combination with various additives when maize was 10-15 cm high, gave good control of a range of weeds and resulted in large yield increases. Ferrero *et al.* (1991) recommended that the weeds must be controlled during 2nd and 3rd week in maize after crop emergence. They also reported that heavy weed infestation reduced maize yield up to 23%. Akhtar *et al.* (1994) conducted an experiment to evaluate the critical period of weed infestation in maize by keeping plots weedy up to Ist week, 6 weeks, 9 weeks and throughout growth period. All treatments invariably influenced leaf area per plant, grain weight per cob, grain rows per cob,, 1000-grain weight and grain yield ha^{-1} significantly over control. The highest grain yield of 50.50 q ha^{-1} was obtained from plot which was kept weed free throughout whereas the lowest grain yield was recorded from plots kept weedy throughout. Hatam and Khattak (1994) reported that when maize crop was kept free of weeds for 14, 21 and 28 days after emergence, weeding during later stage suppressed weed growth. Highest grain yield and grains per cob were recorded in plots where the weeds were controlled for the whole season, for 28 days or 14 days after crop emergence. Highest grain yield and grains per cob were recorded in plots where the weeds were controlled for the whole season, for 28 days or 14 days after crop emergence. The studies mentioned above indicate that weed control in crops is imperative during critical period while critical period varies crop to crop.

2.4 NITROGEN AND WEEDING IN RELATION TO GROWTH, YIELD AND QUALITY CHARACTERISTICS OF MAIZE

2.4.1 Growth and yield

The major cause of losses in crops is weed infestation and these losses are due to weed's competition with the crops for nutrients, water, light, space, etc. Among nutrients, nitrogen favours weed growth more than crop growth (Noda, 1975). Blackman and Templeman (1938) observed that in normal conditions, the competition between crops and weeds is primarily for nitrogen. But several reports address that such competition depend on duration of weed infestation while is often called the critical period which means the maximum period of weeds that can be tolerated by crop without affecting its yield. It also indicates the time during which weed control measures should be carried out to obtain economical benefits of inputs and weeding (Neito *et al.*, 1968). Tollenaar *et al.* (1994) conducted maize-weed competition studies and reported that the effect of weed interference on maize grain yield was higher at low than high nitrogen. Maize crop responded differently to N level and weed interference; reduction in crop dry matter was 17% at high weed pressure, LAI was 15% less in high weed pressure than weed-free while harvest index (HI) was little influenced by N level and weed interference.

2.4.2 Grain quality

Like grain yield of crops, quality of grain may also be influenced due to difference in competition ability in weeds and crops to utilize nitrogen. Friesen *et al.* (1960) found that when weeds compete with grain crops for available nitrogen, reduction occurs not only in grain yield but it is also accompanied by reduction in grain protein contents. It indicates that weeds are more aggressive in utilizing nutrients especially nitrogen.

2.5 PLANT SPACING IN RELATION TO GROWTH, YIELD AND QUALITY CHARACTERISTICS OF MAIZE

2.5.1 Growth and yield

Grain yield of maize increases linearly with population until some competitive effects become apparent. The yield per plant then begins to decrease but yield per hectare continues to increase at a progressively slower rate until the competition is such that grain yield per hectare begins to decline. The increase up to a certain level in yield is probably due to increased number of cobs inspite of the fact that the ear size has decreased (Chaudhry, 1983). Change in plant spacing affects the size, shape, number and leaf angle which determine light interception and ultimately the rate of photosynthesis and productivity of crop plants. Theoretically, any crop plant should grow better and produce more when plant is equidistant. But as plant spacing decreases, the average weight of the ears declines linearly (Dungan *et al.* 1958). Stalk barreness has a considerable influence on yield and is markedly affected by plant spacing. At 6 plants m^{-2}, 33 per cent of the stalks were without ears at the lowest nitrogen level and 16 per cent at the highest nitrogen level (Lang *et al.*, 1956). Similarly Rossman and Cook (1966) reported that the interval between pollen shedding and silking is generally lengthened with decreasing plant spacing and delay in silking may result in reduced grain fill on the ears and even in complete bareness. Haizel and Harper (1973) studied the effect of plant spacing in relation to weed infestation and found that reduced crop plant spacing generally decrease the magnitude of the competitive effects of weeds. Stringfield and Thatcher (1947) concluded that kernel row number per ear in maize hybrids did not change when plant population density of maize was increased (16300 to 46900 plants ha^{-1}) by reducing plant spacing.

Bauman (1960) also reported that row spacing of 0.6 m compared to 0.3 m increased grain yield by increasing the frequency and size of second ears at about 2.4 plants m^{-2}. Prior and Russell (1975) reported an increase in kernel yield of maize with PPD (plant population density) up to 51000 plants ha^{-1}, followed by decreasing yields with further increase of PPD up to 72000 plants ha^{-1}, i.e. a parabolic response. Baenziger and Glover (1980) reported that ear weight and kernel number were increased, but maize yield was decreased by reducing PPD (plant population density). Anonymous (1987) reported that two plants per hill under higher fertility level i.e. 68-68-45 kg NPK per acre gave the highest yield of 2290 kg per acre. Lagoke and Fayemi (1981) carried out trials to study the effect of N, maize population and weed density on the maize production. It was reported that weed competition with maize was influenced by N level and maize plant population. Removal of weeds at 3 and 7 weeks after sowing significantly increased maize grain yield at a population of 80,000 plants ha^{-1}, especially with application of 112 kg N ha^{-1}. To alleviate grain losses due to weed competition with maize at this population, 224 kg N ha^{-1} was required.

Karim *et al.* (1983) fond a curvilinear response in kernel yield and PPD (plant population density) of maize. Lucas and Remison (1984) planted two maize cultivars at 37,000 to 80,000 plants per hectare. They obtained higher dry matter yield at 80,000 plant per hectare and grain yields at 53,000 plants per hectare. Nadar (1984) studied the effect of row spacings and population densities on maize yield under different environmental conditions. The experiment was conducted at two sites and maize cv. Katumani, composite B was sown 30 cm apart with 60, 75 or 90 cm between rows and thinned to 1 to 2 plants/hill. He concluded that the highest grain yield was obtained by sowing 75 cm apart and optimum density under favourable conditions was about 70,000 plants ha^{-1} decreasing to 20,000 plants ha^{-1} under adverse conditions.

Sharma and Adamu (1984) while growing sweet corn under irrigated conditions with 25000, 30000, 35000 and 40000 plants ha^{-1} in 90 cm apart rows concluded that number of leaves and weight of plant were the maximum at the lowest plant population, whereas the maximum number of leaves per plant and plant height were associated with the highest population density. Tsai and Chung (1984) obtained the maximum maize kernel yield (15 Mg ha^{-1}) at 62500 plants ha^{-1}. Also the number of ears per plant decreased linearly as the PPD (plant population density) increased. Hertile and Rikanova (1987) in a field trial in the marginal growing region at Zabcica reported that grain yield of 6 maize hybrids was the highest with late maturity hybrids and hybrid LGII gave the best response to increasing plant density and grain yield of 6.11 t ha^{-1} at spacing of 700 x 150 mm, 5.66 t ha^{-1} at 700 x 200 mm and 5.29 t ha^{-1} at 700 x 300 mm was obtained. The late maturity hybrid CE 330 gave corresponding yield of 6.00, 6.43 and 5.92 t ha^{-1}.

Wang *et al*. (1987) did their research work on maize hybrid Training 351 which was grown at plant spacing of 80 x 10, 80 x 20, 80 x 40 cm giving 125000, 625000 and 31250 plants/ha. They concluded that the plant DW, grain number and ear length increased with decreasing plant density so that yield increased from 117 to 130 g per plant. However, yield per ha decreased from 12.2 to 4.1 t. Yield per ha was closely correlated with silking rate and partition of DM to grain which intended to decrease as plant density decreased indicating that yield was limited by sink capacity and DM utilized at low plant density. The thinning treatments generally gave higher yield than the unthinned stand at the same final density and gave greater partition of assimilate ears. At silking 85-97% of LA but only 40% of DM had developed indicating high rates of assimilation during grain filling. Tetio-Kagho and Gardner (1987) concluded that total and vegetative DM yield in response to increasing PPD (Plant Population Density) of maize was asymptotic, whereas ear and kernel yield responses were parabolic.

Angiras and Singh (1988) conducted split plot design field trials to evaluate the effects of broad leaf weeds on maize grain yield and weed control methods (manual weeding 30 and 60 day after sowing, 60,000-90,000 plants ha^{-1} and fertilizer rate i.e. 50% greater or less than recommended rate. They reported the lowest weed DM from manual weeding at 75,000 plants ha^{-1}. Zaman and Maity (1988) studied the effect of row and plant spacing on maize cv. Vijay during Kharif season. Control spacing were 15 cm between plants and 75 cm apart rows. Test spacing were paired rows with plants 15 cm apart, with gaps of 195, 165, 135 and 105 cm between paired rows. The results showed no significant effect on LAI, CGR, DW, plant height, number of leaves per plant and grain yield of maize.

Amano and Salazar (1989) in a field trial, studied the effect of 0, 60, 90 and 120 kg N ha^{-1} on maize at 40,000, 60,000 and 80,000 plants ha^{-1} and concluded that the highest yield of maize was at 60,000 plants ha^{-1}. It was further concluded that increasing plant population increased total DM yield, LAI and plant height but decreased harvest index and number of cobs per plant. Bangarwa *et al.* (1989) in a trial by applying 60-180 kg N ha^{-1} to maize grown at 40,000, 65,000 and 90,000 plants ha^{-1} concluded that average yields of 3.60-5.22, 4.17-6.49 and 4.23-7.27 t ha^{-1} were obtained, respectively compared with corresponding yields of 2.16, 2.34 and 2.65 t ha^{-1} without nitrogen. Sulewska (1991) conducted a field trial and different varieties of maize were grown at 5, 9 or 13 plants m^{-2} with ratios of 1:1, 1:2 and 1:4 between intra-row and inter-row spacings. Increased plant density decreased the light intensity at the soil surface, prolonged the growing period, especially the reproductive phase, increased the height of the ear on stem, reduced the assimilating area of leaves above the ear, increased LAI and lodging and reduced ear length and diameter. The cultivars differed in their response to plant density. Utilization of solar energy was greater at the 1:1 and 1:2 spacing ratios than at 1:4.

Singh *et al.* (1992) conducted an experiment to evaluate the effect of planting date and plant population on maize cv. Vijay and reported that grain yield decreased from 5.33 to 1.14 t ha^{-1} with delay in sowing from 27 June to 25 July. Plant population (111000, 74000, 83000 or 56000 plants ha^{-1}) had no effect on yield. Anjum *et al.* (1992) reported that closer plant spacing of maize (20 cm) gave more grain yield (59.22 q ha^{-1}) than row spacings of 25 cm (58.11 q ha^{-1}) or 30 cm (53.83 q ha^{-1}). The review cited above indicates that maize plant spacing influence considerably not only growth parameters but yield and its components too.

2.5.2 Grain quality

Grain quality of maize in terms of protein and oil contents is generally reduced as population density increases with narrow plant spacing. However, this is frequently the result of an inadequate level of nitrogen and is only indirectly due to dense plant population (Early and DeTurk, 1948). Further, Hageman and Gitter (1961) explained that dense plant population of maize were fond to cause a decrease in the content of nitrate reductase, an enzyme involved in the nitrogen metabolism of the plant and as a result, less nitrate was converted to protein.

Khan (1992) studied the effect of plant spacing on maize grain oil content and reported that maize planted in double-row strips gave higher grain oil content (4.85%) than that planted in 60 cm spaced single rows (4.58%. This might be due to better grain developed in case of maize planted in well spaced double-row strips. Qureshi (1964) observed a non-significant decrease in protein, P.K. Ca and ash contents of maize as a result of increase in plant population per acre due to reduced plant spacing.

2.6 WEED DENSITY IN RELATION TO GROWTH, YIELD AND QUALITY CHARACTERISTICS OF MAIZE

2.6.1 Growth and yield

The weed plants are usually more aggressive and strong competitors of crop plants for nutrients with the results that benefits of applied inputs are not fully realized. But one has to widen one's concern about effect of weed density on crops and this may help in the economic utilization of the applied inputs (Akhtar, 1990). More number of weeds per unit area not only cause a constant decrease in the height of corn but also lowers grain yield due to severe competition among weeds and corn plant (Moolani *et al.*, 1963). Similarly Sibuga and Bandeen (1984) studied the effect of different weeds on maize crop and observed that the highest weed densities (775 weeds m^{-2}) depressed the grain yield compared with low weed densities (<30 weeds m^{-2}). Similarly Podmayer and Bhowmik (1985) investigated the effects of 4 weed densities i.e. zero, low, medium and high on the maize yield and found that average yield reduction with low, medium and high densities was 66, 47 and 70%, respectively for grain, 29, 41 and 60% for stover and 35, 47 and 69% for number of cobs per plant. Moolani (1965) while studying the competition of pigweed on maize, found that the combined total dry matter of weeds and corn was nearly equalent to the total dry matter of corn from the weed free plots. Kumar and Singh (1983) found 69 weeds belonging to 27 families in 7 irrigated maize fields. Information on occurrence and frequency, distribution, periodicity and density of weeds was collected and the importance value index of *Trianthema portulacastrum* exceeded that of the maize crop.

Sayed and Sandi (1984) performed an experiment on maize by applying 0, 56, 112 and 224 kg N ha^{-1} at 1 day and 6 weeks after sowing and concluded that maize growth was suppressed by weed density of 338980 plant ha^{-1}. Ear number; length, weight and plant height were reduced by competition from 169490 weed ha^{-1}. They further examined that nitrogen application increased ear number, length and weight, grain DW; plant height and weed DW. Young *et al.* (1984) reported that a weed density of 745 plant m^{-2} reduced maize grain yield by 37% compared with uninfested plots and weed competition reduced plant DW, length of cob and cob filling, grain weight per cob and number of grains per cob. Beckett *et al.* (1985) compared the effect on maize yield of 0-6 clumps of *Sorghum bicolor, Setaria faberi, Chenopodium album* and *Xanthium strumarium*/m of crop row on maize yield. It was revealed that 33 clumps or plants of *S. bicolor, S. faberi, C. album* and *X. strumarium*/m of row reduced maize yields by 7,10,13 and 24%, respectively.

Berzsenyi (1985) evaluated 5.9% weed cover as the economic threshold value for post emergence weed control in maize and the regression analysis showed that a 1% increase in weed cover could result in yield reduction of 68 kg ha^{-1}. Zanin *et al.* (1986) studied weed-crop competition in maize with 4 weed populations and reported that weed had a higher crop growth rate than maize, though NAR of weeds was lower than that of maize, irrespect of the composition and density of weed population where as LAI and LAD were closely correlated with DM yield reductions. Anonymous (1987) concluded that grain yield of maize was reduced by *Trianthema portulacastrum* competition probably due to higher density of this weed. Khalid and

Shad (1987) studied different weed densities of Sorghum halepense in competition with maize plants and concluded that by increasing ratio of *Sorghum halepense* to maize i.e. 0:1, 1:1, 2:1 and 3:1 caused a gradual decrease in grain weight, weight of stalk and height of maize plants. They further established that *sorghum halepense* grass was more efficient in nutrient uptake than maize. Beckett *et al.* (1988) reported that maize grain yield was linearly decreased with increase in the clump density. Four weed densities (0.4 to 13.4 plant m^{-2}) declined the maize yield from 18 to 27 per cent.

Zanin and Sattin (1988) carried out four experiments to determine the economic threshold density of velvet leaf weed (*Abutilon theophrasti*) in maize. Artificially created weed infestation range was between zero to 80 plants m^{-2}. The economic threshold, varied between 0.3 and 2.4 plants m^{-2} depending upon the variables considered. Ansar *et al.* (1996) reported that application of 150 kg N ha^{-1} gave higher grain yield (4378 kg ha^{-1}) and weed free plots also produced higher yield (3891 kg ha^{-1}) while higher weed density gave lower yield (3544 kg ha^{-1}). Tollenaar *et al.* (1994) reported that maize grain yield was reduced due to high weed pressure up to 26, 17 and 13% with maize plant density of 4, 7 and 10 plants m^{-2}, respectively. The reduction in dry matter and grain yield was 20 and 18%, respectively, for the high weed pressure treatment. They further suggested that the competitiveness of maize with weeds can be enhanced by increasing plant densities.

Above review suggests that the losses of crop yields including maize due to weed infestation depend upon the weed densities and before deciding the weed control measures, the economic threshold level of weeds must be taken into consideration.

Crops and weeds interfere with each other either by releasing allelochemicals or competing for nutrients. Weed density and the duration of weed competition also influence crops development. Thus present project was designed to investigate the response of maize to *Trianthema* association and to determine the threshold level of *Trianthema* infestation in maize.

MATERIALS & METHODS

CHAPTER 3

MATERIALS AND METHODS

3.1 Experimental Environment

3.1.1 Site

A) LABORATORY EXPERIMENT

This experiment was conducted in weed science laboratory, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan from 3.9.1995 to 13.9.1995 and repeated from 15.9.1995 to 25.9.1995.

B) FIELD EXPERIMENTS

The field experiments were carried out at the agronomic research area, University of Agriculture, Faisalabad, Pakistan, during the year 1994 and repeated in 1995. Experimental area was selected keeping in view the field history to ensure the availability of *Trianthema portulacastrum*.

3.1.2 Soil analysis

Before sowing the crop, soil samples were collected to a depth of 30 cm from the experimental area and analysed for various physico-chemical properties (Table 1) by using the methods described by Homer and Pratt (1961).

3.1.3 Meteorological data

Meteorological data for growth periods of the crop were collected from the Department of Agricultural Meteorology, University of Agriculture, Faisalabad, Pakistan and are presented in Table 2a & 2b. Total rain fall received during growth periods (August - November) of the 1994 and 1995 crops amounted to 126.37 and 103.21 mm, respectively.

Table 1: PHYSICO-CHEMICAL ANALYSIS OF THE EXPERIMENTAL SOIL

Determination	Unit	Year 1994	Year 1995
Physical analysis			
Textural class		Loamy soil	Loamy soil
Chemical analysis			
Soil pH		7.9	8.1
TSS		0.06	0.09
Electrical conductivity	ds/m	1.1	1.3
Organic matter	%	0.72	0.86
Total N	%	0.045	0.060
Available P	ppm	12.25	8.76
Available K	ppm	173	132
Saturation	%	38.33	36.00

Note: Physico-chemical analysis of the experimental soil was done up to the depth of 12"

Table 2a: METEOROLOGICAL DATA FOR GROWTH PERIOD OF THE CROP IN 1994

Weeks	Mean Temperature (°C)	Relative humidity (%)	Rainfall (mm)
1 Aug - 8 Aug	33.03	66.18	00.00
9 Aug - 16 Aug	32.25	67.31	00.00
17 Aug - 24 Aug	32.37	70.62	13.94
25 Aug - 1 Sep	31.00	74.68	23.28
2 Sep - 9 Sep	31.71	73.87	87.89
10 Sep - 17 Sep	30.25	67.00	00.00
18 Sep - 25 Sep	27.58	60.81	00.00
26 Sep - 3 Oct	26.81	58.68	00.00
4 Oct - 11 Oct	27.15	63.68	01.26
12 Oct - 19 Oct	22.68	61.25	00.00
20 Oct - 27 Oct	24.50	67.74	00.00
28 Oct - 4 Nov	20.93	62.18	00.00
5 Nov - 12 Nov	23.71	68.18	00.00
13 Nov - 20 Nov	19.38	69.87	00.00
21 Nov - 28 Nov	17.92	72.87	00.00
29 Nov - 6 Dec	17.27	76.12	00.00
Total			126.37

Source: Department of Agri. Meteorology, University of Agriculture, Faisalabad, Pakistan

Table 2b: METEOROLOGICAL DATA FOR GROWTH PERIOD OF THE CROP IN 1995

Weeks	Mean Temperature (°C)	Relative humidity (%)	Rainfall (mm)
1 Aug - 8 Aug	30.56	70.62	4.02
9 Aug - 16 Aug	30.87	74.37	22.03
17 Aug - 24 Aug	31.56	74.24	77.16
25 Aug - 1 Sep	30.00	69.74	00.00
2 Sep - 9 Sep	29.96	67.12	00.00
10 Sep - 17 Sep	31.31	64.93	00.00
18 Sep - 25 Sep	30.71	62.12	00.00
26 Sep - 3 Oct	29.75	62.93	00.00
4 Oct - 11 Oct	28.25	62.81	00.00
12 Oct - 19 Oct	25.81	65.43	00.00
20 Oct - 27 Oct	22.68	62.56	00.00
28 Oct - 4 Nov	18.06	57.62	00.00
5 Nov - 12 Nov	20.31	66.37	00.00
13 Nov - 20 Nov	19.87	67.31	00.00
21 Nov - 28 Nov	16.75	70.62	00.00
29 Nov - 6 Dec	15.83	73.87	00.00
Total			103.21

Source: Department of Agri. Meteorology, University of Agriculture, Faisalabad, Pakistan

3.2 Experiments

Study comprised one lab. experiment and two field experiments. Detail of each exceperiment is separately given as follows.

3.2.1 EXPERIMENT I

ALLELOPATHIC EFFECTS OF MAIZE AND *Trianthema portulacastrum* ON EACH OTHER'S GERMINABILITY AND SEEDLING GROWTH

3.2.1.1 Treatments (Concentrations of water extract)

A) Maize

C_0 = Control (distilled water)

C_1 = 25% (Extract)

C_2 = 50% "

C_3 = 75% "

C_4 = 100% "

B) ***Trianthema portulacastrum***

C_0	=	Control (distilled water)
C_1	=	25% (Extract)
C_2	=	50% "
C_3	=	75% "
C_4	=	100% "

3.2.1.2 Preparation of maize water extract

Field grown maize plants (uprooted at maturity) were dried at room temperature (30°C ± 4) for a few days and then chopped into 5 cm pieces with hand fodder cutter. Chopped plant material was dried in an oven at 70°C for 48 hours. The dried material was ground in a grinder. The ground herbage was soaked in distilled water for 24 hours at room temperature (30°C ± 4) in the ratio of 1 g herbage: 20 ml water (Hussain and Gadoon, 1981). The water extract was obtained by filtering the mixture (herbage and water) through a whatman # 42 filter paper and used afresh either as such or diluted with distilled water to prepare different concentrations.

3.2.1.3 Preparation of *Trianthema* water extract

The extract of Trianthema was prepared following the procedure as described in section 3.2.1.2

3.2.1.4 Precautionary measures

Before placing the seeds for germination, petri dishes were washed thoroughly with detergent using hot water against pathogens and pollutants. Pure seed of both the species was used.

3.2.1.5 Application of maize water extract to *Trianthema* seed

Maize water extract was diluted with distilled water to prepare solutions of different concentrations (v/v): 0, 25%, 50%, 75% and 100%. Ten seeds of *Trianthema portulacastrum* were placed in each petri dish of a 9 cm diameter replicated four times in completely randomized design. Filter paper (Whatman # 42) was used as a medium of germination. In total 4 ml of solution was applied, half (2 ml) of which was used as moisture for filter paper receiving seeds in the dishes and remaining half was applied to the covering filter paper. The control treatment received 4 ml of distilled water in the same fashion. Both treated and control petri dishes were kept moist by applying distilled water whenever needed. The dishes were kept at room temperature ($30^{\circ}C \pm 4$) for seed germination in the weed science laboratory, Department of Agronomy, University of Agriculture, Faisalabad.

3.2.1.6 Termination of experiment

Germination counts were recorded daily for a period of 10 days and experiment (Trial I and II) was terminated on September, 13 and September, 25 1995, respectively.

3.2.1.7 Observations

Observations recorded during the study are given below:

1. Germination (%)
2. Root length (cm)
3. Shoot length (cm)

3.2.1.8 Procedures

1. Germination (%)

Number of seeds germinated was counted from the date of sowing up to 10 days after sowing and transformed into germination (%) by the formula as follows:

$$\text{Germination (\%)} = \frac{\text{No. of seeds germinated}}{\text{No. of seeds sown}} \times 100$$

2. Root length

Root length of all seedlings was measured with a measuring tape and average root length was determined.

3. **Shoot length**

Shoot length of all seedlings was measured with a measuring tape. Then average shoot length was determined.

3.2.1.9 Application of *Trianthema* water extract to maize seeds

Trianthema water extract was applied to maize following procedure as described in section 3.2.1.4. to 3.2.1.8.

3.2.2 EXPERIMENT 2

EFFECT OF *Trianthema portulacastrum* INFESTATION DURATION ON MAIZE PRODUCTIVITY AT DIFFERENT NITROGEN LEVELS

3.2.2.1 Treatments

A. **Duration of weed infestation**

W_1 = Weed control 2 weeks after crop emergence

W_2 = Weed control 4 weeks after crop emergence

W_3 = Weed control 6 weeks after crop emergence

W_4 = Weed control 8 weeks after crop emergence

B. **Nitrogen levels (Kg N ha^{-1})**

N_0 = 0 (Control)

N_1 = 100

N_2 = 150

N_3 = 200

3.2.2.2 Layout

The experiment was laid out in split plot design with four replications. Nitrogen levels were placed in main plots while duration of weed infestation was allocated to the subplots. Subplot size measured 5.25 x 2.40 m.

3.2.2.3 Sowing

Maize cv. Akbar was sown on a well prepared seed bed in 60 cm spaced rows with a dibble on August 6 and August 7 in 1994 and 1995, respectively.

3.2.2.4 Fertilizer application

Nitrogen as per treatment alongwith a basal dose of phosphorus and potash @ 100 kg P_2O_5 + 100 kg K_2O was applied. N P and K fertilizers were added in the respective plots in the form of urea, single superphosphate and potassium sulphate, respectively. All of phosphorus, potash and half of nitrogen was applied at sowing, while remaining half N was applied as broadcast with first irrigation.

3.2.2.5 Irrigation

First irrigation of 7.5 cm was given to all experimental plots 10 days after sowing. Subsequent irrigations were applied whenever needed.

3.2.2.6 Maintenance of plant spacing

Two seeds per hill were planted at 15 cm distance and at the 4-5 leaf stage, one plant per hill was maintained by thinning to ensure the uniform plant population.

3.2.2.7 Weed removal

After the prescribed competition period, each plot was kept free of weeds by manual hoeings throughout the growth period of the crop.

3.2.2.8 Harvesting

Crop was harvested manually on November 13 and November 14 during 1994 and 1995, respectively.

3.2.2.9 Observations

Observations recorded are given below:

a) Weed Growth

1. Weed dry weight (g) m^{-2}

b) Crop Phenology

1. Plant height (cm)
2. Leaf area Index at the end of tasseling
3. Dry weight per plant (g) at the end of tasseling
4. Crop growth rate (CGR) (g m day) at fortnight interval
5. Net assimilation rate (NAR) (g m day) at fortnight interval
6. Days taken to 50 per cent tasseling
7. Number of cobs per plant
8. Number of grain rows per plant
9. Number of grains per cob
10. Grain weight per cob (g)
11. 1000-grain weight (g)
12. Stover yield (t ha)
13. Grain yield (t ha)
14. Harvest Index (%)
15. Correlation analysis
16. Productivity score
17. Economic analysis
18. Dominance analysis

c) **Grain Analysis**

1. Starch content (%)
2. Oil content (%)
3. Protein content (%)

3.2.2.10 Procedures

A. Count and dry weight of *Trianthema portulacastrum*

At the end of the prescribed weed-crop competition period, *Triathema* was removed and counted from a randomly selected area of one square meter from each plot. Its fresh weight was recorded. Weed was then oven dried at a temperature of 80°C for 72 hours to record the dry weight per square meter.

B. Maize

1. Plant height

Five plants were selected at random from each subplot and their height was measured from ground level to the top of plant. Then average plant height was determined in cm.

2. Leaf area

Leaf area (LA) of five randomly selected plants was determined by portable leaf area meter Model IL-3000. Thereafter, leaf area per plant was calculated.

3. Leaf area Index

Leaf area index (LAI) was calculated by the formula of Beadle (1987) as follows:

$$LAI = \frac{\text{Leaf area plant}^{-1}}{\text{Land area plant}^{-1}}$$

4. Dry weight per plant

Dry weight (DW) per plant was recorded at the end of tasseling. Five plants were taken at random from each subplot and chopped into small pieces (5 cm) with the help of a manual fodder cutter. Chopped plant material was mixed thoroughly and 500 g samples were taken in muslin cloth bags and oven dried at 80°C to a constant dry weight and weighed. Then dry weight per plant was calculated.

5. **Crop growth rate**

Crop growth rate (CGR) was also calculated at fortnight interval by the formula of Beadle (1987) as follows:

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \text{ (g m}^{-2}\text{ land area day}^{-1}\text{)}$$

Where

W_1 = DW m^{-2} at first harvest

W_2 = DW m^{-2} at second harvest

T_1 = Time corresponding to first harvest

T_2 = Time corresponding to second harvest

6. **Net assimilation rate**

Net assimilation rate (NAR) was determined at fortnight interval by the formula of Beadle (1987) as follows:

$$NAR = \frac{\text{Total DW at harvest}}{LAD} \text{ (g m}^{-2}\text{ land area day}^{-1}\text{)}$$

$$LAD = \frac{[(LAI_1 + LAI_2) \times (t_2 - t_1)]}{2}$$

Where

LAD = Total leaf area duration

LAI_1 = LAI at first harvest

LAI_2 = LAI at second harvest

t_1 = Time corresponding to first harvest

t_2 = Time corresponding to second harvest

DW = Dry weight

7. Days taken to 50 per cent tasseling

Number of days taken to tasseling was counted from date of sowing to the time when 50 per cent plants had tasseled.

8. Number of cobs per plant

Ten plants from each subplot were selected at random and the total number of cobs were counted and average number of cobs per plant were calculated.

9. Number of grain rows per cob

Ten randomly selected cobs from each subplot were taken and grain rows were counted and averaged to get number of grain rows per cob.

10. Number of grains per cob

Number of grains per cob was averaged from the total number of grains of ten randomly selected cobs from each subplot.

11. Grain weight per cob

Grains from ten randomly selected cobs were taken from each subplot and weighed, then average grain weight per cob (g) was calculated.

12. 1000-grain weight

Three samples of 1000 grains each were taken at random from seed lot of each subplot and weighed. Then average 1000-grain weight was determined.

13. Stover yield

Crop from each subplot was harvested manually at maturity. Cobs were removed from all plants. Thereafter, stalks were air dried. Stover yield of each subplot was recorded and transformed to t ha^{-1}.

14. Grain yield

Seed yield was recorded on subplot basis and then transformed to t ha^{-1}.

15. Harvest Index

Harvest index (HI) was calculated by using the following formula:

$$H.I. = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Biological yield comprised both seed and stover yields.

16. Productivity score

Productivity score was calculated by using the following formula of Stoskopf (1981).

Productivity score = Biological yield + grain yield + harvest index

17. Economic analysis

Economic analysis was carried out on the basis of variable costs and prevailing market prices of weeding, nitrogenous fertilizer and maize crop in experiment

No. 2. Dominance analysis was carried out as suggested by Perrin *et al.* (1976).

18. Grain starch content

Grain samples were taken randomly from each subplot. Grain starch content was determined by using the method described by Juliano (1971).

19. Grain oil content

Grain samples were taken randomly from each subplot. Grain oil content was determined by Soxhlet method described by Low (1990).

20. Grain protein content

Nitrogen percentage of maize grain samples collected from each subplot was determined by the microkjeldhal method (Anonymous, 1980). Then crude protein content of grains was determined by using the following formula:

Crude protein content = Nitrogen content x 6.25

21. Statistical analysis

All experimental data were analysed by using "MSTATC" statistical package on a computer (Anonymous, 1986) and differences among the treatment means were compared by the least significant difference (LSD) test at 0.05 P (Steel and Torrie, 1984).

3.2.3 EXPERIMENT 3

EFFECT OF *Trianthema portulacastrum* DENSITY ON PRODUCTIVITY OF MAIZE GROWN AT DIFFERENT PLANT SPACINGS

3.2.3.1 Treatments

A. *Trianthema* density

D_0 = Control (Weed free)

D_1 = 5 plants m^{-2}

D_2 = 10 Plants m^{-2}

D_3 = 15 plants m^{-2}

D_4 = 20 plants m^{-2}

A. Maize plant spacing

S_1 = 15 x 60 cm

S_2 = 25 x 60 cm

S_3 = 35 x 60 cm

3.2.3.2 Layout

Experiment was laid out in split plot design with four replications and a subplot size of 5.25 x 2.40 m. Maize plant spacing was maintained in main plots and *Trianthema* density in subplots.

3.2.3.3 Sowing

Maize cv. Akbar was sown on a well-prepared seed bed in 60 cm spaced rows with 15, 25 and 35 cm plant to plant distance. Sowing was done with a dibble on August 6 and August 7 in 1994 and 1995, respectively.

3.2.3.4 Fertilizer application

A basal dose of 150 kg N ha^{-1}, 100 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} was applied. N.P. and K fertilizer were added in the form of urea, single super phosphate and potassium sulphate, respectively.

All the phosphorus and potash and half nitrogen were applied at sowing, while remaining half of N was broadcasted in maize with first irrigation.

3.2.3.5 Maintenance of *Trianthema* density

Sufficient plants of *Trianthema* species were available at the time of crop emergence. The weed densities of 50000 (5 m^{-2}), 100000 (10 m^{-2}), 150000 (15 m^{-2}) and 200000 (20 m^{-2}) plants ha^{-1} were maintained till the crop harvest. Weeds in excess of the desired level and other weed species were removed just after their germination and were kept removed till the crop harvest.

3.2.3.6 Maintenance of maize plant spacing

Maize plant spacings of 60 x 15 cm, 60 x 25 cm and 60 x 35 cm were maintained.

3.2.3.7 Other crop husbandry practices

The crop was irrigated and harvested in the same way as in experiment 2.

3.2.3.8 Observations and procedures

Observations recorded and procedures for recording individual observations on maize crop as well as statistical analysis of the data were the same as in experiment 2.

RESULTS & DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

4.1 ALLELOPATHIC EFFECTS OF MAIZE AND *Trianthema portulacastrum* ON EACH OTHER'S GERMINABILITY AND SEEDLING GROWTH

4.1.1 Introduction

Germination is a basic parameter which determines the final plant stand and reflects the response of species to their immediate environment. Different plants have been reported to contain allelochemicals which can influence germination of other plants. Guenzi and McCalla (1966) identified five phenolic acids as ferulic, p-coumeric, syringic, vanilic and p-hydroxybenzoic acid in corn, wheat, sorghum and oat residues.

Similarly many weed species possess allelochemicals. Hussain *et al.* (1987) have reported that *Trianthema portulacastrum* contains caffeic, chlorogenic, p-hydroxybenzoic, p-coumeric and ferulic acids. These allelochemicals may inhibit or promote germination of other plants. Inhibition or promotion of germination influences plant densities, their distribution and growth. Keeping this in view, preliminary trials were carried out under laboratory conditions during 1995 with the objective to asses the allelopathic effects of maize and *Trianthema portulacastrum* on each other's germinability.

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4.1.2 Materials and Methods

The experimental details are described in section 3.2.1

4.1.3 Results and Discussion

4.1.3.1 Influence of maize water extract on seed germination of *Trianthema portulacastrum*

Maize water extract influenced the germination of *Trianthema portulacastrum* significantly (Figs. 1,2). Lower concentration (25%) promoted the germination by 14.28% over control in both the trials, while higher concentration (100%) showed some inhibitary effect in trial II but the effect was statistically non-significant in trial I. The treatments as 50% and 75% MWE showed some promotive effect on germination of *Trianthema* in trial II but their effect in trial I was statistically equal to control. The results of these trials indicated the presence of allelopathic activity in maize water extract. This is in line with the work of Guenzi and McCalla (1966) who reported the presence of five phenolic acids in corn residues.

4.1.3.2 Root length of *Trianthema portulacastrum*

Maize water extract affected the root growth of *T. portulacastrum* significantly in both the trials (Table 3). Higher concentrations of MWE (75 and 100%) promoted root length of *Trianthema*, while lower concentration, i.e. 25% of MWE showed non-significant effect. The promotion of *Trianthema* root growth with MWE might be due to the presence of

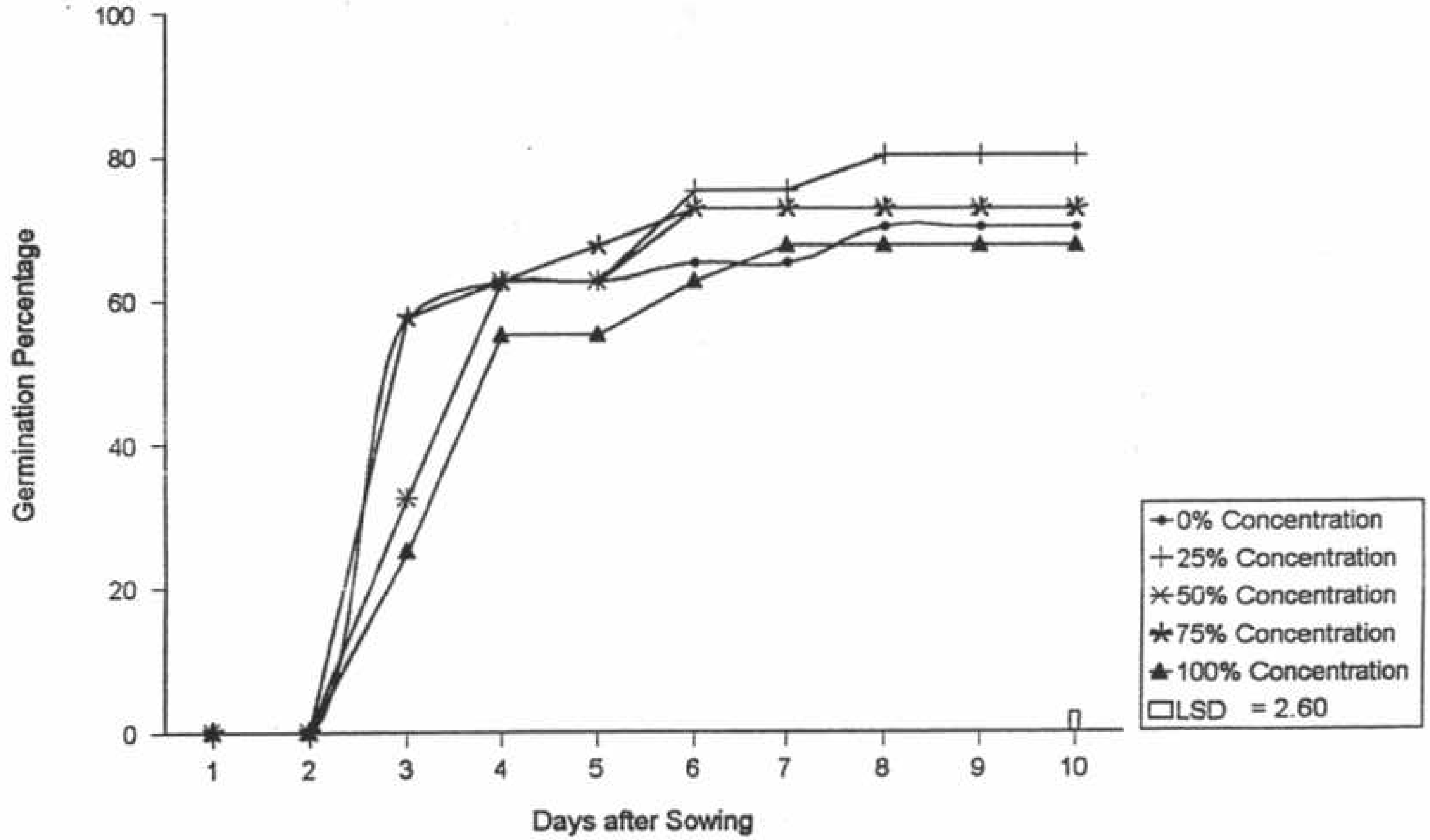

Fig. # 1: EFFECT OF MAIZE WATER EXTRACT ON SEED GERMINATION OF *Trianthema portulacastrum* (03.09.1995)

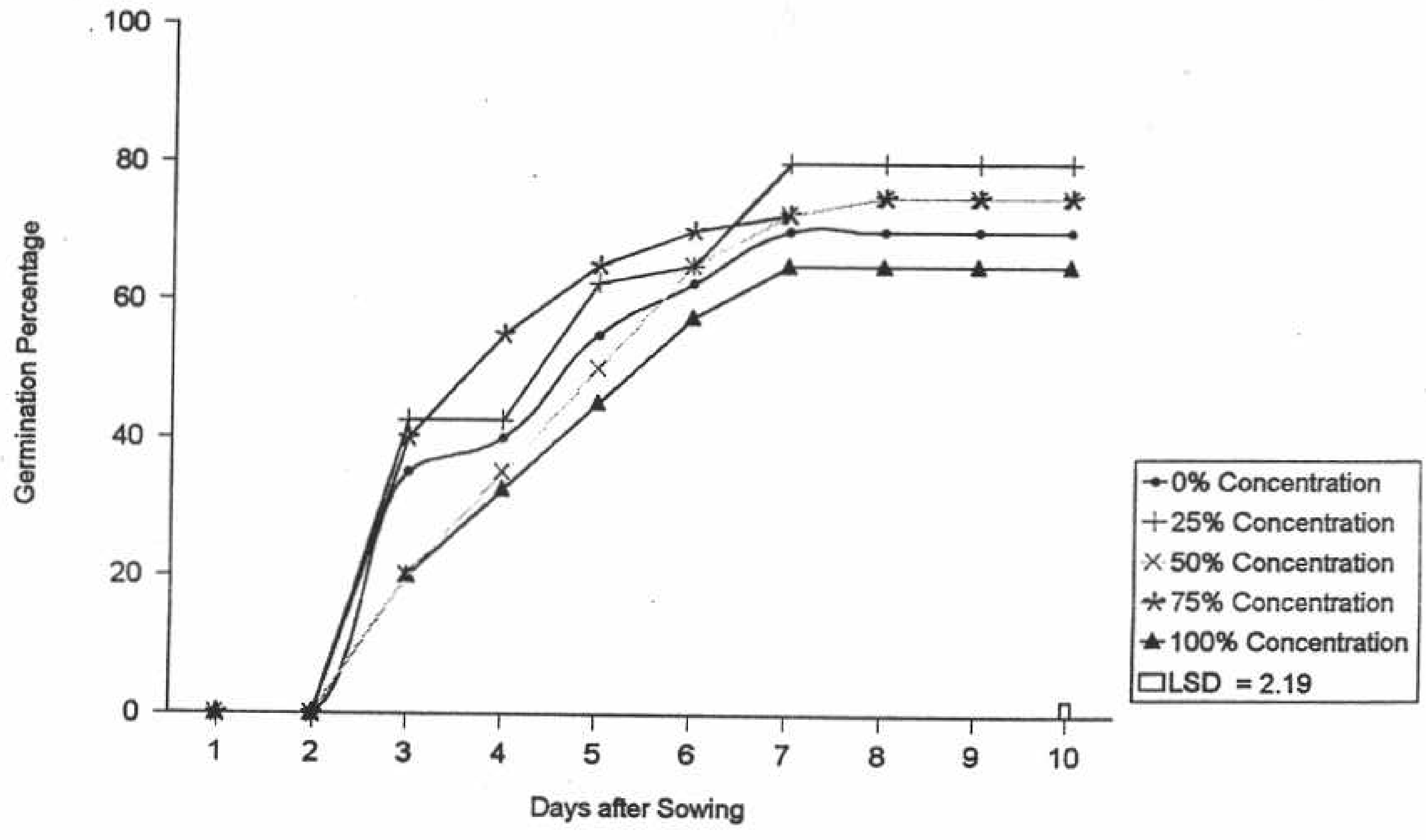

Fig. # 2: EFFECT OF MAIZE WATER EXTRACT ON SEED GERMINATION OF *Trianthema portulacastrum* (15.09.1995) allelochemicals in maize extract. Probably due to this effect, *Trianthema* flourishes in maize crop and this effect was enhanced with increased concentration. Application of 100% MWE increased root length up to 56.36% and 50.22% compared to control in Trial I and Trial II, respectively. Purvis and Jessop (1985) also reported that allelochemicals of wheat crop stimulated germination and growth of *Avena sterilis*.

4.1.3.3 Shoot length of *Trianthema portulacastrum*

Shoot length of *T. portulacastrum* in both the trials (Table 4) was also increased significantly with higher concentrations (75 & 100 %) of MWE except over control. Application of 100% MWE resulted in the maximum shoot length followed by 75% and 50% MWE treatments which were statistically equal to each other, while the minimum shoot length was recorded in control treatment that was statistically equal to 25% MWE. These results clearly show that maize water extract promoted the shoot length of *Trianthema* indicating the presence of allelochemicals in maize herbage. Promotion of shoot growth in *Trianthema portulacastrum* with maize water extract was possibly due to the presence of smaller quantities of allelochemicals in maize herbage. In an other study lower concentration (25%) of sorghum water extract also promoted shoot growth of *Trianthema* but higher concentration of sorghum water extract suppressed *Trianthema* (Cheema and Randhawa, 1994) which supports the concept that maize herbage contains relatively less allelochemicals than that of sorghum; that is why even the higher concentration of MWE (50, 75 and 100%) promoted *Trianthema* root and shoot length.

Table 3: EFFECT OF DIFFERENT CONCENTRATIONS OF MAIZE WATER EXTRACT ON ROOT LENGTH (cm) OF *Trianthema portulacastrum*

Treatment	Trial I	Trial II	Mean
C_0 (Control)	2.20 cd	2.21 bc	2.21
C_1 (25% MWE)	2.15 d	2.14 c	2.15
C_2 (50% MWE)	2.44 c	2.43 b	2.44
C_3 (75% MWE)	3.02 b	3.14 a	3.08
C_4 (100% MWE)	3.44 a	3.32 a	3.38
LSD =	0.257	0.270	

Means not sharing a letter in common differ significantly.
LSD= Least significant difference at 5 %.
MWE= Maize water extract.

Table 4: EFFECT OF DIFFERENT CONCENTRATIONS OF MAIZE WATER EXTRACT ON SHOOT LENGTH (cm) OF *Trianthema portulacastrum*

Treatment	Trial I	Trial II	Mean
C_0 (Control)	1.33 c	1.34 c	1.34
C_1 (25% MWE)	1.42 c	1.36 c	1.39
C_2 (50% MWE)	2.09 b	2.10 b	2.10
C_3 (75% MWE)	2.24 b	2.25 b	2.25
C_4 (100% MWE)	2.90 a	2.87 a	2.89
LSD=	0.190	0.197	

Means not sharing a letter in common differ significantly.
LSD= Least significant difference at 5 %.
MWE= Maize water extract.

4.1.3.4 Influence of *Trianthema* water extract on seed germination of maize

Effect of *Trianthema* water extract (TWE) on seed germination of maize in both the trials was statistically equal to control (Figs. 3,4). However, significant differences (17.50%) in germination between higher concentration (100%) treatment and lower concentration, i.e. 25% TWE were recorded. Such differences in maize germination were possibly due to the presence of allelochemicals in *Trianthema* water extract. Germination was completed on 8th day of planting in control, 50% TWE and 75% TWE, while it was completed on 9th and 7th day in 25% and 100% TWE, respectively. Suppression of maize seed germination with higher concentration of TWE has also been reported by Hussain *et al.* (1987).

4.1.3.5 Root length of maize

Significant reduction in root length of maize in response to application of TWE was recorded in both the trials (Table 5). There was a significant decrease in root length with corresponding increase in concentration of TWE as compared to control in trial I. Similar trend was noted in trial II. However, higher concentration (100%) resulted in the minimum root length (2.26 cm). The inhibitory effect of TWE decreased as the concentration was diluted. The inhibitory effects of TWE on maize root growth were possibly due to the occurrence of allelochemicals in *Trianthema*. Suppression of maize root growth in response to TWE application has also been reported by Hussain *et al.* (1987). Rice (1984) also documented inhibitory effects of water extracts of many weeds against the crops.

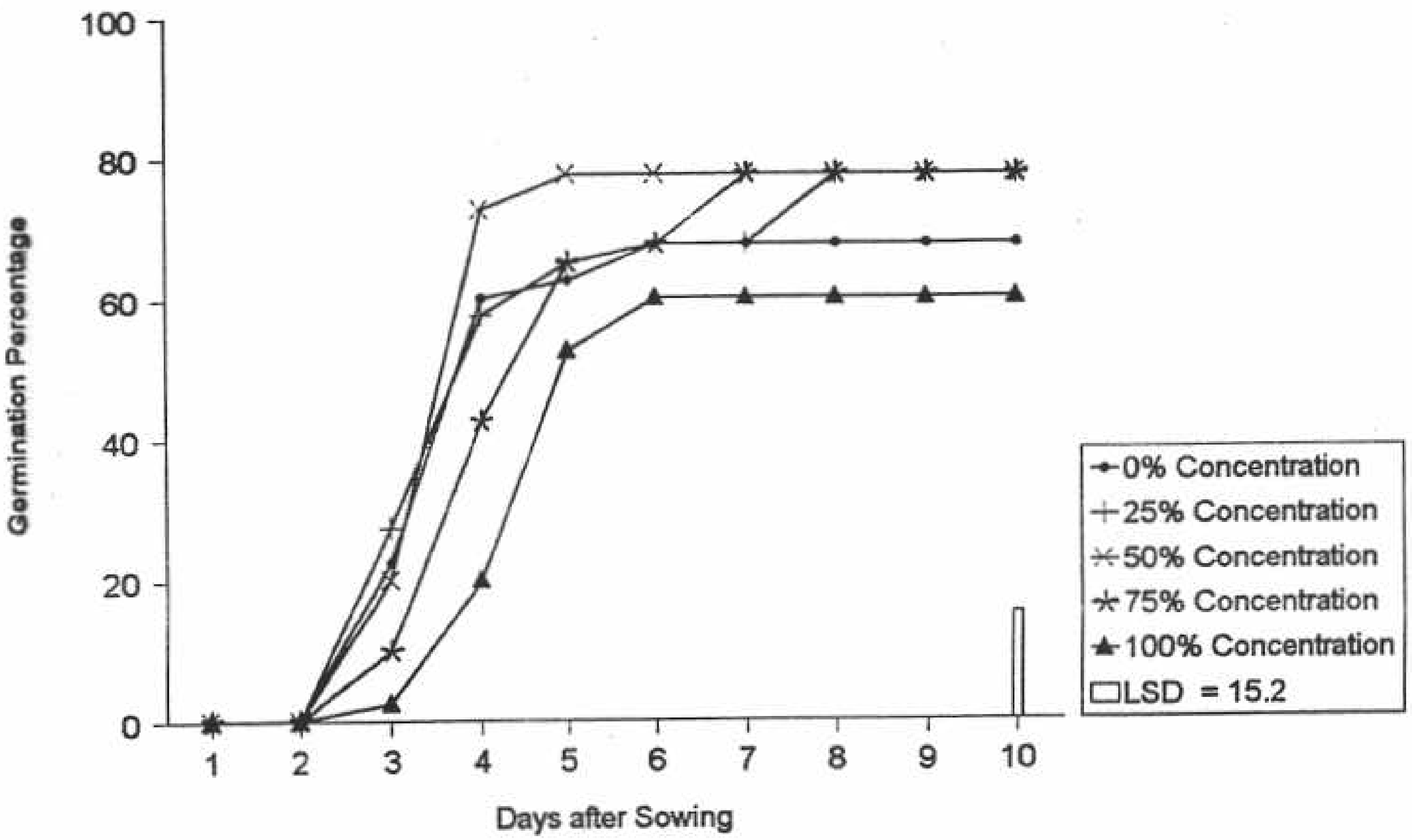

Fig. # 3: EFFECT OF *Trianthema portulacastrum* WATER EXTRACT ON SEED GERMINATION OF MAIZE (03.09.1995)

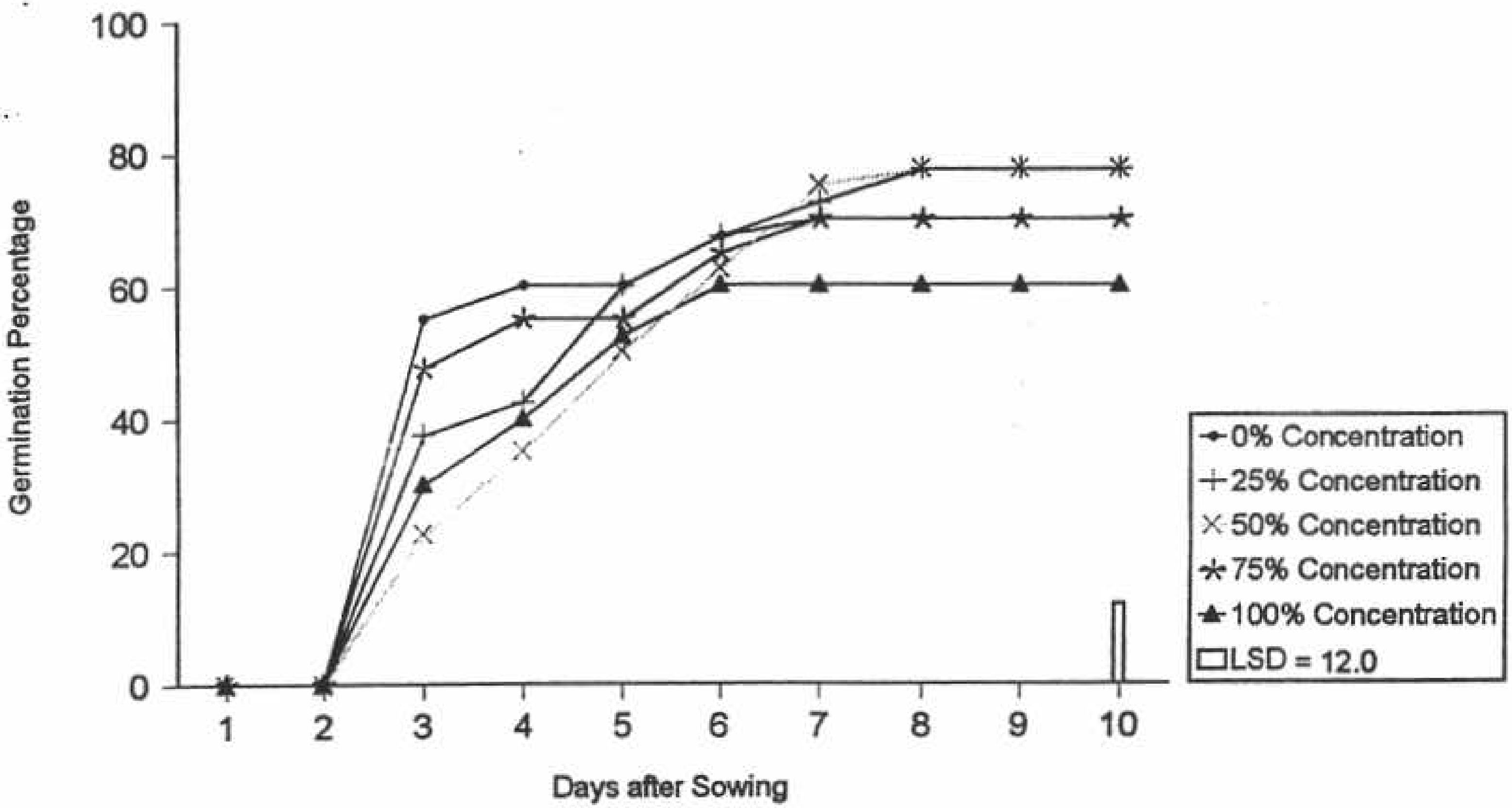

Fig. # 4: EFFECT OF *Trianthema portulacastrum* WATER EXTRACT ON SEED GERMINATION OF MAIZE (15.09.1995)

4.1.3.6 Shoot length of maize

Data regarding the allelopathic effects of *Trianthema portulacastrum* on maize shoot are presented in table 6. TWE treatments (50, 75 and 100%) decreased shoot length of maize significantly. However, the lowest concentration (25%) did not differ significantly from control. The minimum shoot length of 1.82 cm was noted with 100% TWE. Similar trend was observed in both the trials. Maize shoot retardation by TWE might be due to the allelochemicals present in TWE. Hussain *et al.* (1987) have also reported allelochemicals such as caffeic, chlorogenic, p-hydroxybenzoic, p-coumeric and ferulic acids in *Trianthema portulacastrum*.

From the results of these preliminary trials it appeared that maize and *Trianthema* both possess allelopathic activity. The maize allelochemicals generally promoted the germination, root and shoot growth of *Trianthema*, while *Trianthema* extract concentrations generally suppressed seedling growth of maize. These results suggest that the common occurrence of *Trianthema portulacastrum* in maize fields may be due to its allelopathic effects on seed germination and seedling growth of the associated maize.

Table 5: EFFECT OF DIFFERENT CONCENTRATIONS OF *Trianthema portulacastrum* WATER EXTRACT ON ROOT LENGTH (cm) OF MAIZE

Treatment	Trial I	Trial II	Mean
C_0 (Control)	3.83 a	3.81 a	3.82
C_1 (25% TWE)	3.68 a	3.61 b	3.64
C_2 (50% TWE)	3.40 b	3.47 b	3.43
C_3 (75% TWE)	3.07 c	3.14 c	3.12
C_4 (100%TWE)	2.26 d	2.25 d	2.26
LSD=	0.160	0.190	

Table 6: EFFECT OF DIFFERENT CONCENTRATIONS OF *Trianthema portulacastrum* WATER EXTRACT ON SHOOT LENGTH (cm) OF MAIZE

Treatment	Trial I	Trial II	Mean
C_0 (Control)	2.98 a	2.99 a	2.99
C_1 (25% TWE)	2.86 a	2.89 ab	2.87
C_2 (50% TWE)	2.36 b	2.60 b	2.48
C_3 (75% TWE)	2.03 c	2.04 c	2.04
C_4 (100%TWE)	1.82 d	1.81 c	1.82
LSD=	0.184	0.380	

Means not sharing a letter in common differ significantly.
LSD= Least significant difference at 5 %.
TWE= *Trianthema* water extract.