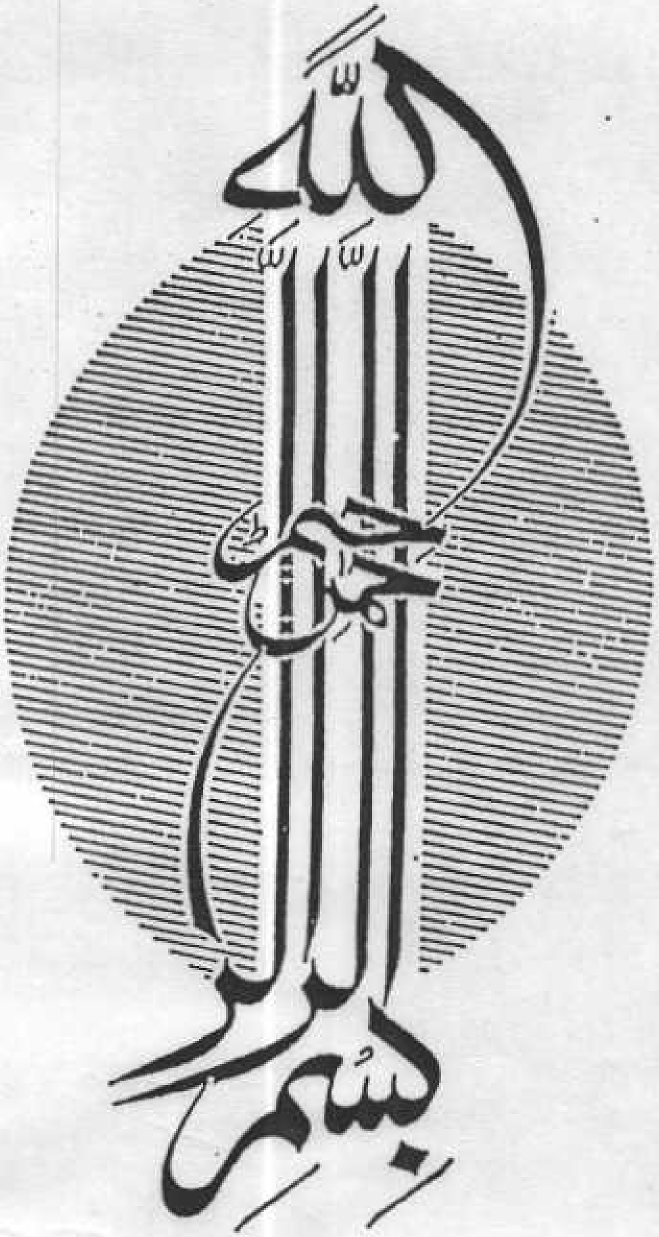

IN THE NAME OF ALLAH
THE COMPASSIONATE, THE MERCIFUL

INFLUENCE OF TILLAGE AND FERTILIZER LEVELS ON WHEAT AND WEED RESPONSE TO THE ALLELOPATHIC EFFECTS OF CROP RESIDUES (ROOTS)

BY

MUHAMMAD ARSHAD

M.Sc.(Hons.) Agri.
UAF (1968)

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

In

AGRONOMY

FACULTY OF AGRICULTURE
UNIVERSITY OF AGRICULTURE
FAISALABAD
1995

To

The Controller of Examinations,
University of Agriculture,
Faisalabad.

We, the members of the supervisory committee find the thesis submitted by Mr. Muhammad Arshad Satisfactory and recommend that it be processed for evaluation by the External Examiners for the award of degree.

Chairman: **DR. SAEED AHMAD**

Member: **DR. ABID HUSSAIN**

Member: **DR. NAZIR AHMAD**

CONTENTS

S.no	TITLE	Page
	Acknowledgements	vi
	Abbreviations	vii
Chapter 1:	Introduction	1
Chapter 2:	Review of literature	
2.1	Introduction	5
2.2	Chemical nature of allelochemicals	7
2.3	Mode of action of allelochemicals	
2.4	Allelochemicals in crop-crop interaction	
2.5	Role of allelopathy in crop weed interaction	
2.6	Tillage and allelopathic effects	30
2.7	Allelopathy and nutrition	33
Chapter 3:	Materials and methods	
3.1	Introduction	38
3.2	Laboratory experiments	39
3.2.1	Effect of different concentrations of water extracts of crop roots (sorghum, maize and pearl millet) on the germination of wheat and some weed seeds.	39
3.2.2	Effect of ethanolic extracts of different crop roots of sorghum, maize & pearl millet on the germination and seedling growth of wheat seed.	39
3.2.3	Estimation of some phenolic acids from sorghum, maize and pearl millet roots by paper chromatographic techniques.	39
3.3	Field experiment	40
	Cropping systems	
	Tillage systems	
	Fertilizer levels	

3.3.1 Seedbed preparation 42

3.3.2 Weed count, fresh and dry weights 42

3.3.3 Wheat growth and yield 43

3.3.4 Soil analysis 43

3.3.5 Meteorological data 43

3.3.6 Statistical analysis 43

Chapter 4: Experimental Results

4.1 Effect of different concentration of water extract (WE) of sorghum, maize and pearl millet on the germination of wheat seed and seeds of Coronopus didymus, Phalaris minor, and Avena fatua. 47

4.1.1 Introduction 47

4.1.2 Materials and Methods 48

4.1.3 Experimental results 49

4.1.3.1 Effect of different concentrations of water extract of sorghum roots on the germination of wheat & wheat weeds. 49

4.1.3.1.1 Wheat (Triticum aestivum) 49

4.1.3.1.2 Wild oats (Avena fatua) 49

4.1.3.1.3 Canary grass (Phalaris minor) 52

4.1.3.1.4 Swine cress (Coronopus didymus) 52

4.1.3.2 Effect of different concentrations of water extract (WE) of maize roots on the germination of wheat and wheat weeds. 55

4.1.3.2.1 Wheat (Triticum aestivum) 55

4.1.3.2.2 Wild oats (Avena fatua) 55

4.1.3.2.3 Canary grass (Phalaris minor) 58

4.1.3.2.4 Swine cress (Coronopus didymus) 58

4.1.3.3 Effect of different concentrations of water extract (WE) of pearl millet roots on the germination of wheat and wheat weeds. 58

4.1.3.3.1 Wheat (Triticum aestivum) 58

4.1.3.3.2 Wild oats (Avena fatua) 62

4.1.3.3.3 Canary grass (Phalaris minor) 62

4.1.3.3.4 Swine cress (Coronopus didymus) 65

4.1.3.4 Discussion 65

4.2. Effect of Ethanol extract of sorghum, maize and pearl millet roots on the germination and seedling growth of wheat. 69

4.2.1 Introduction 69

4.2.2 Materials and methods 69

4.2.3 Experimental results 70

4.2.3.1 Germination 70

4.2.3.2 Root dry weight 71

4.2.3.3 Shoot dry weight 71

4.2.4 Discussion 75

4.3 Identification and estimation of some Phenolic acids in sorghum, maize and pearl millet roots. 77

4.3.1 Introduction 77

4.3.2 Materials and methods 77

4.3.3 Experimental results 80

4.3.4 Discussion 80

4.4 Tillage and fertilizer influence on wheat and weed response to the allelopathic effects of different crops (Field experiment) 83

4.4.1 Introduction 83

4.4.2 Materials and methods 83

4.4.3 Experimental results 86

4.4.3.1 Above ground biomass of sorghum, maize and pearl millet. 86

4.4.3.2 Germination of wheat 86

4.4.3.3 Weed count (m^{2}) 89

4.4.3.3.1 Interaction effects on total weed count 92

4.4.3.3.2 Interaction effects on C.didymus weed count 94

4.4.3.3.3 Interaction effects on M.parviflora weed count 96

4.4.3.3.4 Interaction effects on C.album weed count 98

4.4.3.4 Weed Biomass (g m^{2}) 100

4.4.3.4.1 Interaction effects on total weed biomass 102

4.4.3.4.2 Interaction effects on C.didymus biomass 105

4.4.3.4.3 Interaction effects on M.parviflora biomass 108

4.4.3.4.4 Interaction effects on C.album biomass 111

4.4.3.5 Weed dry weight (g m^{2}) 114

4.4.3.5.1 Interaction effects on total weed dry weight 114

4.4.3.5.2 Interaction effects on C.didymus dry weight 118

4.4.3.5.3 Interaction effects on M.parviflora dry weight 120

4.4.3.5.4 Interaction effects on C.album dry weight 122

4.4.3.6 Leaf area index (Lai) 125

4.4.3.6.1 Interaction effects on lai (1) 125

4.4.3.6.2 Interaction effects on lai (2) 128

4.4.3.6.3 Interaction effects on lai (3) 130

4.4.3.7 Plant height, fertile tillers and spike length 132

4.4.3.7.1 Interaction effects on plant height (cm) 132

4.4.3.7.2 Interaction effects on spike length (cm) 135

4.4.3.7.3 Interaction effects on fertile tillers 135

4.4.3.8 Number of spikelets per spike, grains per spike and 1000 grains weight (g) 138

4.4.3.8.1 Interaction effects on spikelets per spike 139

4.4.3.8.2 Interaction effects on grains per spike 139

4.4.3.7.3 Interaction effects on 1000 grain weight (g) 142

4.4.3.9 Biological yield (t ha^{-1}), grain yield (t ha^{-1}), harvest index (%) and productivity score 142

4.4.3.9.1 Interaction effects on biological yield 145

4.4.3.9.2 Interaction effects on grain yield 148

4.4.3.9.3 Interaction effects on harvest index 150

4.4.3.9.4 Interaction effects on productivity score 152

4.4.3.10 Discussion 155

4.4.3.10.1 Biomass of sorghum, maize and pearl millet 155

4.4.3.10.2 Germination of wheat (plants m^{-2}) 155

4.4.3.10.3 Weed count 157

4.4.3.10.4 Weed fresh weight (g m^{-2}) 159

4.4.3.10.5 Weed dry weight (g m^{-2}) 160

4.4.3.10.6 Leaf area index 163

4.4.3.10.7 Plant height 167

4.4.3.10.8 Fertile tillers 167

4.4.3.10.9 Number of spikelets per spike 168

4.4.3.10.10 Number of grains per spike 168

4.4.3.10.11 1000-Grain weight (g) 170

4.4.3.10.12 Biological yield (t ha^{-1}) 170

4.4.3.10.13 Grain yield (t ha^{-1}) 175

4.4.3.10.14 Harvest index (%) 180

4.4.3.10.15 Productivity score 183

5. Summary 187

6. Conclusions 193

Literature cited 195

ACKNOWLEDGEMENTS

All Glory be to Thee, O, Allah, The Beneficial, The Merciful, Whose blessings and exaltations flourished my thoughts and thrived my ambitions to have the cherished fruit of my modest efforts in the form of this write up. All praises be to the Holly prophet Muhammad (Peace be upon Him), the city of knowledge.

I would like to extend deep gratitude to my supervisor, Dr. Saeed ahmad, Ph.D (Wales), Professor, Department of Agronomy, University of Agriculture, Faisalabad for his kind supervision, sincere help, sympathetic attitude and unabated guidance during the conduct and preparation of this manuscript. I would also like to express my sincere gratitude to the following:

Dr. Abid Hussain, Ph.D (Newzeland), Associate Professor, Department of Agronomy, for technical guidance and cooperative attitude. Dr. Nazir Ahmad, Ph.D (Wales), Professor and Chairman, Department of Crop Physiology for cooperation, guidance and technical help. Dr. Z.A. Cheema, Ph.D.(UAF) for reviewing the manuscript with patience and providing sincere and scholastical guidance. Dr. Jamil A. Quareshi, Head Department of Biological Chemistry Division, NIAB, for providing technical guidance and the laboratory facilities during chemical analysis and quantitative estimation of allalochemics.

Dr. M. Shafi Nazir, Ph.D. (USSR), Professor, Department of Agronomy for sincere help and guidance. Dr.M. Munir Nayyar, Ph.D. (Turkey), Director, Agronomic Research Institue, Faisalabad for his cooperation, patience and encouragement during the completion of this work. My teachers/ colleagues and friends who always provided help and moral support during the conduct and completion of this work and Agriculture Economic Section, Ayub Agricultural Research Institute, Faisalabad, particularly Mr. Muhammad Younus, M.Sc. (UAF), for providing computer facilities and sincere and devoted efforts of Mr. Munir Ahmad, M.A. (Pb) in preparation of graphs/charts and editing the manuscript.

Last but not the least, my parents and family members who always prayed for my success.

MUHAMMAD ARSHAD

ABBREVIATIONS

C. al	: Chenopodium album
C.D.	: Coronopus didymus
C.S.	: Cropping system
C.V.	: Cultivated Variety
g.	: gram
$g\ m^{-2}$	: gram per square meter
ha	: hectare
ha^{-1}	: per hectare
kg.	: Kilogram
$kg\ ha^{-1}$	: kilogram per hectare
m	: meter
m2	: square meter
mg	: milligram
ml	: milliliter
mm	: millimeter
M.P	: Melilotus parviflora
ns	: non significant
spp	: species
$t\ ha^{-1}$	: tonnes per hectare
v/v	: volume by volume
w/v	: weight by volume
wt	: weight
w/w	: weight by weight
%	: percent
*	: significant at .05
**	: significant at .01
>	: greater than
<	: lesser than

INTRODUCTION

CHAPTER-1

INTRODUCTION

Plants live in association and often interfere with each other for various reasons. Two different types of interference mechanisms have been recognized. They compete physically for the resources, thus the immediate environment might become depleted. Such resource depleted environment put the plants into a state of struggle (Hussain, 1983) which is popularly known as " competition ".

On the other hand certain plants have the tendency to exhibit mutual inhibition type of biochemical competition. Such endeavour for the existence is termed as "allelopathy" and has been defined by Muller (1965) as the "adverse effects of one plant upon another growing in close vicinity by the release of certain metabolic waste toxic products in the environment". These substances have selective effects which are either stimulatery or inhibitory to the growth of companion/subsequent crops or weeds depending upon their concentrations (Purvis et al. 1985). These substances have been called allelochemicals (Rice, 1984) and can be leached from leaves by rain water, secreted by roots and be formed from the decaying plant residues (Colton and Einhellig, 1980). Mostly, these are phenolics, flavonoids, alkaloids and terpenes (Ting, 1982).

Allelopathic effects are the result of biochemical interactions among all types of plants including microorganisms. Allelopathy is related to and depends upon various factors such as temperature, light, soil, precipitation and nutrient status of the habitat. The inhibitory mechanism is also regulated through rate and route of releasing phytotoxins (Hussain, 1983). The physical properties of the soil are affected by various tillage practices (Sprague & Triplet, 1986). In turn, such effects have marked influence on the pattern and density of weed flora. Weeds are serious pest tolling heavily on crop yields and yield losses can go upto 25% (Shad, 1987). Weeds can be controlled by cultural practices and more effectively by weedicides. Herbicide usage requires some sort of technical know how and may increase environmental pollution problems. Herbicides are unsafe (Kassasian 1971) and might affect nutritive value of certain crops (Saghir & Bhatti, 1970).

Sowing crops in rotations and leaving land fallow are other effective means of controlling weeds and maintaining soil productivity. These practices have their own specific rotational effects, some exhaust the soil and decrease yield of the subsequent crops while others restore the fertility.

Sorghum, maize and pearl millet have been considered as exhaustive crops and are still grown on wider area under irrigated and rainfed conditions. These crops cannot be eliminated from the existing cropping systems due to their economic importance, as these are source of green fodder for livestock and supplementing cereal supply needed for domestic consumption and livestock feed.