ANNUAL REPORT (2017-18)

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CONTENTS

I. INTRODUCTION

Pakistani soils are generally deficient in nitrogen and phosphorus whereas the deficiency of potash and micronutrients especially zinc and boron has now established in many areas. The application of these nutrients and adoption of new technologies are essential for successful farming without damaging the environment and to combat with the hiking prices of fertilizer. Like fertilizer, plant protection measures are also important for increasing crop production. The use of pesticides has tremendously increased during the last decades therefore the availability of adulteration free pesticides is essential to reduce the quantity of pesticide use in the country and to save the cost on its import. To address these problems effectively, the Institute of Soil Chemistry and Environmental Sciences was established in 2009 by brining Soil Chemistry Section (established in 1907), Pesticide Quality Control Labs Faisalabad, Kala Shah Kaku, Multan and Bahawalpur (established in 1971, 1985, 1985 and 2005 respectively) and Pesticide Residue Research Lab Kala Shah Kaku (established in 2005) under one umbrella.

I. OBJECTIVES

The core objectives of the institute are as under:

- Use of chemical fertilizers and their effects on soil properties
- Use of macro and micronutrients for crops, vegetables and fruits
- Integrated use of chemical fertilizers and organic manures
- Studies on environmental pollution by agricultural inputs
- Safe use of domestic and industrial wastes for agriculture
- Organic farming and its prospective
- Pesticide quality control
- Pesticide residue research

II. STAFF POSITION

Sr. #	Designation	Posts	In position	Vacant
Soil Chemistry Section Faisalabad				
1	Agricultural Chemist(Soils)	1	1	-
2	Associate Agricultural Chemist	1	-	1
3	Assistant Agricultural Chemist	1	1	-
4	Assistant Research Officer	10	10	-
Total:		13	12	01

III. BUDGET

A. Allocations for the year 2017-18 (Rs million)

Component	18-Agri.	36-Agri.	38-Agri.	42-Agri.	Total
Soil Chemistry Section, ISCES, AARI, Faisalabad.	39.802	1.602	-	-	41.404
Total:	**39.802**	**1.602**	**-**	**-**	**41.404**

B. Expenditure for the year 2017-18 (Rs million)

Component	18-Agri.	36-Agri.	38-Agri.	42-Agri.	Total
Soil Chemistry Section, ISCES, AARI, Faisalabad.	38.720	1.434	-	-	40.154
Total:	**38.720**	**1.434**	**-**	**-**	**40.154**

V. RESEARCH WORK

SOIL CHEMISTRY

ENVIRONMENTAL POLLUTION

1. OPTIMIZATION OF pH, TEMPERATURE, REACTION TIME AND NH_4MgPO_4 RATIOS FOR STRUVITE FORMATION FROM The WASTE WATER (Lab Study)

Nitrogen and Phosphorus are mainly derived in the water environment from the industrial discharge and municipal wastewaters. Recovery of phosphorus from waste streams as struvite and recycling those nutrients into agriculture as fertilizer appears promising, particularly in agricultural manure and municipal waste water treatment plants. Struvite is a Fertilizer-grade ($NH_4MgPO_4{\cdot}6H_2O$) P product. The natural resource of P (rock Phosphate) can be conserved by this approach of nutrients recycling and the problem of P-availability can be overcome because of its slow release mechanism. So, this study was planned to evaluate the formation of struvite from

Table 1.1; Analysis of wastewater and its molar ratio calculation

Parameters	Unit	Waste water	Sources and quantity used for Molar Ratio per 2 L Waste water (g)			%age of P in Struvite
			NH_4Cl	$MgCl_2.6H_2O$	KH_2PO_4	
pH	-	7.61	0.16	1.57	5.98	-
EC	dSm^{-1}	5				-
PO_4	(mg/kg)	15.29				**24.64%**
Mg		90.5				**9.80%**
N		2000				**5.50%**
Pb		0.16				-
Cd		0.058				-
Ni		0.7				-
Cr		4				-
As		0.4				-

waste water. Analysis of waste water (Table 1.1) showed that its pH was 7.61 and EC was $5dSm^{-1}$. While PO_4 concentration was 15.29 mg/kg. The result also revealed that Mg and N concentration was 90.5 and 2000 mg/kg respectively. Four studied were conducted. In first study, pH was varying while reaction time, temperature and molar ratios were kept constant. The result (Table 1.2) reveled that at pH 9, reaction time 6o min., temperature 50 ^oC and molar ratio of NH_4:PO_4:Mg at 1:01:01**,** 0.142 g Struvite was formed. Data also revealed that High temperature was not too much affecting the formation of struvite. While the molar ratio of NH_4MgPO_4 was affecting the formation of struvite in study III. Reaction time in study II showed its effect on struvite formation as we increase reaction time, more the struvite formation. The results showed the maximum struvite (0.188 g/2 L) was formed on best level of pH 9.00, Reaction time 60 min, Temperature 50°C and molar ratio of NH_4:PO_4:Mg :: 1.2:1:1.

Table 1.2; Results of best conditions (pH, Reaction time, Temperature and Molar Ratio NH_4:PO_4:Mg for formation of Struvite in 4 studies

Treatment	pH	Reaction time (min)	Temperature (°C)	Molar Ratio NH_4:PO_4:Mg	Struvite (g)
STUDY-I					
T_1	7	60	50	1:01:01	0.004
T_2	8	60	50	1:01:01	0.095
T_3	9	60	50	1:01:01	0.142
STUDY-II					
T_1	9	30	50	1:01:01	0.102
T_2	9	60	50	1:01:01	0.171
T_3	9	90	50	1:01:01	0.127
STUDY-III					
T_1	9	60	25	1:01:01	0.154
T_2	9	60	50	1:01:01	0.163
T_3	9	60	75	1:01:01	0.172
STUDY-IV					
T_1	9	60	50	1:01:01	0.165
T_2	9	60	50	1.2:1:1	0.184
T_3	9	60	50	1.5:1:1	0.188

2. MICRONUTRIENTS AND HEAVY METALS STATUS IN VEGETABLES GROWN IN TUNNELS

Vegetables are the rich source of nutrients, carbohydrates, vitamins and proteins that are good for human health. As population of Pakistan has increased, the demand of basic dietary vegetables has also increased manifold. On the other hand for getting high yield of vegetables to meet the population food requirements, farmers compromise over the quality of produce. Due to the use of huge quantities of agricultural inputs (fertilizers, fungicides and pesticides) to increase the production of vegetables grown in tunnels, a substantial quantity of heavy metals accumulate in vegetables as well as in soil due. Micronutrients are required for the normal metabolic functioning of human being. No information regarding micronutrients and heavy metals status in vegetables grown in tunnels is available therefore, this survey study was planned to assess the micronutrients and heavy status in tunnel grown vegetables in Faisalabad district. Different vegetable samples were collected from different locations in Faisalabad district (Mamukanjan, chak jhumera, and AARI area). The data (Table 2.1) reveled that substantial amounts of heavy metals (Cd and Pb) contents were present in all vegetable samples. 100% samples of spinach, cabbage, Hybrid Brinjal, bell pepper, 95% cucumber, 86% tomato, 50% of cauliflower and 33% of Fenugreek samples were above safe limits for Cadmium. While 100 % samples of cauliflower, 67% Spinach, 75% cucumber and 67 fenugreek samples were above safe limit for Lead. Micronutrients contents in all vegetables were low but the overall trend indicated that Cadmium (Cd) and Lead (Pb) concentration was too much high in all vegetables samples.

Table 2.1; Cadmium and lead status of different vegetables grown in tunnels in district Faisalabad

Vegetables	Cadmium (Cd)			Lead (Pb)		
	Range	Mean	% sample above safe limit	Range	Mean	% sample above safe limit
Spinach	0.60-1.74	1.35±0.65	100	1.94-9.65	5.53±3.88	67
Cabbage	0.68-1.64	1.27±0.52	100	1.17-6.17	3.09±2.70	33
Cucumber	0.29-1.26	0.79± 0.21	95	2.9- 23.5	7.45±4.28	75
Cauliflower	0.49- 0.78	0.145± 0.9	50	8.1- 8.49	8.3± 0.28	100
Tomato	0.29- 1.38	0.65± 0.36	86	0.545- 9.26	5.6± 3.02	29
Bell Pepper	0.42- 1.05	0.68± 0.16	100	4.63- 8.49	3.52± 3.38	40
Green Chili	0.25- 1.32	0.62± 0.39	83	3.46- 7.72	2.83± 3.69	17
Fenugreek	0.45- 0.5	0.02± 0.5	33	2.7- 5.78	4.5± 1.6	67
Coriander	0.47- 0.76	0.30± 0.66	67	0.23- 5	1.8± 2.8	33
Brinjal	0.54- 0.6	0.57± 0.04	100	3.09- 7.72	5.4± 3.3	50
Safe Limit	**0.30**			**05.0**		

Table 2.2; Micronutrients (Zinc and Copper) status of different vegetables grown in tunnels in district Faisalabad

Vegetables	Zinc	Copper	Iron	Manganese
	Mean± SD			
Spinach	26.2± 20.8	11.4± 3.15	9.78± 1.86	89.4± 11.6
Cabbage	16.3± 3.9	9.28± 0.21	0.32± 0.51	17.1± 2.90
Cucumber	48.5± 42.9	8.42± 8.28	2.25± 2.00	16.9± 7.77
Cauliflower	33.3± 7.2	13.0± 2.46	2.15± 3.04	28.7± 17.1
Tomato	28.3± 2.5	11.3± 2.94	2.05± 1.19	18.6± 4.55
Bell Pepper	30.5± 32.9	13.1± 7.16	1.96± 2.57	22.6-10.1
Green Chilies	22.4± 9.7	10.9± 4.31	0.67± 0.83	14.2± 4.74
Fenugreek	34.4± 3.2	16.3± 9.00	8.4± 1.49	33.3± 11.1
Coriander	22.4± 4.5	8.91± 2.14	12.8± 2.33	57.3± 4.77
Hybrid Brinjal	27.7± 3.4	10.0± 0.93	0.48± 0.30	16.9± 5.87

Micronutrients contents (Table 2.2) in all vegetables were low but the overall trend indicated that Cadmium (Cd) and Lead (Pb) concentration was too much high in all vegetables samples.

3. HEAVY METAL STATUS OF VEGETABLES AND FODDER IRRIGATED WITH WASTE WATER FROM NINE DIVISIONAL DISTRICTS OF PUNJAB

Sewage and industrial waste water is commonly used for growing vegetables and fodder near big cities. These types of water may contain heavy metals like Pb, Cd and Ni and may contaminate vegetables and fodder. Therefore, this study was planned to monitor the accumulation of these pollutants in vegetables and fodder samples irrigated with wastewater in different districts of Punjab.

A. Heavy metal contamination in vegetables and fodder;

The data showed in Table 3.1 indicated that in 86% of vegetable and fodder samples irrigated with wastewater were contaminated with chromium, 67% by lead, 52% by cadmium and 10% by nickel. The order of contamination in vegetable and fodder samples was ***Cr >Pb> Cd > Ni***

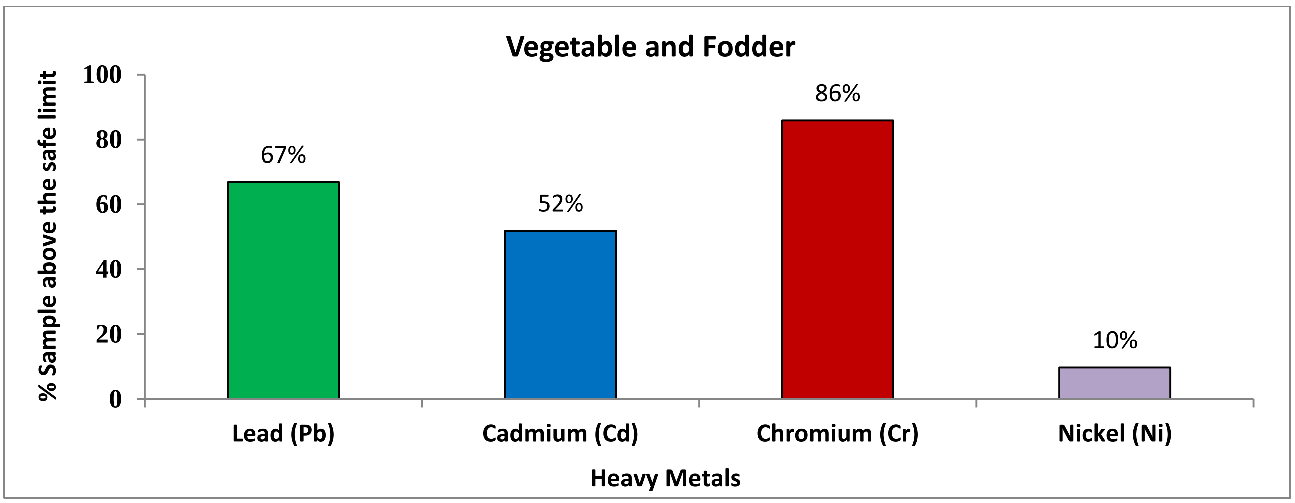

Figure 3; Heavy metal contamination (%) in vegetable and fodder samples of Punjab

B. Heavy metal contamination in Waste water samples;

The data showed (Table 3.1) that there was a substantial amount of heavy metals in waste water. 72.6 % waste water samples were contaminated with Cr while 0.44 % samples were contaminated with Pb.

Table 3.1; Heavy metal contamination (%) in wastewater samples of different districts of Punjab

Heavy Metals	Analyzed samples	Above safe Limit (%)
Chromium (Cr)	441	72.6

Lead (Pb)	452	0.44
Cadmium (Cd)	410	38.5
Nickel (Ni)	480	37.9

C. Heavy metal contamination in Soil samples;

The data showed (Table 3.2) that there was a substantial amount of heavy metals in all soil samples irrigated with waste water. 14.2% soil samples were contaminated with Cd, 8.9% with Pb and 7.9% with Ni. While all soil samples were safe for Cr contamination.

Table 3.2; Heavy metal contamination in soil samples of different districts of Punjab

Heavy Metals	Analyzed samples	Above safe Limit (%)
Chromium (Cr)	506	0
Lead (Pb)	472	8.9
Cadmium (Cd)	462	14.2
Nickel (Ni)	441	7.9

4. MONITORING OF HEAVY METALS IN MAIN SEWAGWE WATER DRAIN OF FAISALABAD

Water pollution is a rapidly growing concern throughout the world due to discharge of untreated industrial effluents into surface water. In Pakistan, there is no separate sewage system for industrial effluent disposal. All the industrial wastewater is being disposed in urban sewage system without adequate treatment. Farmers use this wastewater to irrigate their vegetables crops, either directly by surface irrigation or pumping out wastewater from main drains with the help of engine. The use of effluents containing wastewater to irrigate vegetables and fodder has raised concern of accumulation of excessive quantities of heavy metals which are toxic to the health of consumers. So, this study was conducted to monitor the heavy metal contamination in main sewage drains. Wastewater samples were collected from three main sewage drains (Samana drain, Madhoana drain, Malkhanwala drain) passing near textile and tannery industries of metropolitan city of Faisalabad, Punjab, Pakistan and analyzed for heavy. The result showed that mean Pb contents 0.16 mg kg^{-1} in Malkhanwala drain, 0.53 mg kg^{-1} in Madhoana drain and 0.75 mg kg^{-1} in Samana drain. While mean chromium (Cr) contents were 3.97 mg kg^{-1} Malkhanwala in drain, 4.69 mg kg^{-1} in Madhoana drain and 0.98 mg kg^{-1} in Samana drain.

Table 4; Heavy metal content in main sewage drain of Faisalabad

Drains	Descriptive statistics	Lead	Cadmium	Chromium	Nickel
		(mg L^{-1})			
Malkhanwala	Range	0.0-0.54	0.04-0.08	2.15-7.58	0.53-1.17

	Mean ± SD	0.16 ± 0.13	0.06 ± 0.01	3.97 ± 1.40	0.70 ± 0.16
Madhoana	Range	0.19-2.16	0.03-0.08	0.51-23.12	0.0-1.14
	Mean ± SD	0.53 ± 0.32	0.04 ± 0.01	4.69 ± 3.89	0.41± 0.24
Samana	Range	0.50-0.96	0.0-0.05	0.0-2.51	0.29-1.03
	Mean ± SD	0.75 ± 0.12	0.02 ± 0.01	0.98 ± 0.72	0.50 ± 0.29
Safe limit		5.0	0.3	1.3	10

5. MAPPING THE PHYISCO-CHEMICAL CHARACTERISTICS OF WASTEWATER IRRIGATED SOILS FROM MAIN DISTRICTS OF PUNJAB USING *ARC GIS*

Application of wastewater is an important supplementary way of irrigation for many crops especially vegetables to relieve water shortage issue. This untreated wastewater contains many essential nutrients as well as toxic elements those affect the soil quality and physiochemical characteristics of soils. To monitor this critical situation, a survey study of 8 districts of Punjab (Gujranwala, Faisalabad, Lahore, Sargodha, Bahawalpur, Rawalpindi, Sahiwal and Multan) was conducted during the period from October, 2017 to September 2018. For this purpose, about fifty samples of soil were collected randomly from each district to determine the concentration of toxic metals and other soil characteristics. GPS was used to record their respective coordinates and *Arc GIS* were used to analyze the data for spatial variability.

Table 5.1; Physicochemical properties of waste water irrigated surface soils

Districts	pHs	ECe	O.M (%)	Total N (%)	P (mg/kg)	Ext. K (mg/kg)
	Mean± S.D					
Gujranwala	7.0 ± 0.23	2.42 ± 1.40	1.49±0.41	0.074±0.02	36±5.69	414±86.8
Faisalabad	7.64 ± 0.23	8.16 ± 3.45	1.26±0.34	0.063±0.02	31±9.79	295±98.6
Lahore	7.35 ± 0.35	4.45 ± 2.24	1.54±0.52	0.051±0.02	29±8.03	300±63.5
Sargodha	7.38 ± 0.25	5.51 ± 2.35	1.07±0.32	0.054±0.02	35±6.49	341±83.2
Bahawalpur	7.22 ± 0.18	7.00 ± 3.23	1.02±0.31	0.051±0.02	35±6.26	382±62.7
Rawalpindi	7.38 ± 0.23	1.55 ± 0.70	1.15±0.39	0.057±0.02	29±5.16	354±60.8
Sahiwal	7.43 ± 0.28	5.81 ± 3.04	1.15±.0.50	0.057±0.03	32±5.92	376±74.6
Multan	7.44 ± 0.18	5.51±2.47	0.93±0.16	0.047±0.01	32±6.47	301±74.3

Results (Table 5.1) showed that Gujeranwala soil has maximum Organic matter (1.49%), Total nitrogen (0.074%), Phosphorus (36mg/kg) and Potassium (414 mg/kg) than soils of other districts. It was also found that continuous irrigation with waste water has build up the heavy metals concentration in Gujeranawala soils than other districts above permissible level.

Table 5.2; Heavy metal concentration in soil irrigated with waste water

Districts	Lead	Cadmium	Nickel	Chromium
	Mean (mg/kg)			
Gujranwala	24.73	0.65	6.57	0.1
Faisalabad	3.78	0.06	0.48	0.03
Lahore	3.96	0.1	0.44	0.05

Sargodha	6.98	0.05	0.84	0.05
Bahawalpur	3.4	0.04	0.4	0.02
Rawalpindi	2.46	0.03	0.4	0.05
Sahiwal	3.73	0.05	0.74	0.03
Multan	4.28	0.03	0.25	0.02
Permissible limits	13	0.3	2.6	3.8

6. IDENTIFICATION OF WASTE WATER IRRIGATED AREAS AND TO PROPOSE THE ALTERNATE CROPS OTHER THAN VEGETABLE CROPS FOR GROWING UNDER WASTE WATER

Wastewater application for agricultural production causes heavy metal contamination in soil and plant which in turn affects human and animal health, so this study was planned to identify the alternate crops and to test the floricultural crops, ornamental plants and other forest plants as an alternate of vegetables. For this purpose survey of wastewater irrigated areas of Faisalabad was carried out and soil, wastewater and vegetable samples were collected and analyzed for heavy metals (chromium, lead, cadmium, nickel, zinc and manganese).

Results (Table 6.1) showed that substantial amount heavy metal content (mg/kg) in wastewater, soil and vegetable in district Faisalabad were present. Chromium (Cr) content in wastewater ranged from 0.05-5.08, in soil 0.0-12.47 and in vegetables 0.61-38.36 mg/kg. Lead (Pb) content in wastewater ranged from 0.42-3.70, in soil 1.40-12.58and in vegetables 0.0-23.74 mg/kg. Heavy metal cadmium (Cd) concentration was ranged from 0.0-0.09, 0.61-55.0 and 0.0-9.11 mg/kg in wastewater, soil and vegetable samples of district Faisalabad respectively. However, nickel concentration was ranged from 0.0-0.22, 0.44-2.14, 0.0-12.47 mg/kg in wastewater, soil and vegetable samples.

Zinc (Zn) content in wastewater ranged from 0.0-0.18, in soil 2.30-54.02 and in vegetables 0.0-128.5 mg/kg. In case of manganese (Mn), concentration was ranged from 0.0-10.95, 14.38-45.82 and 0.0-364.7 mg/kg in wastewater, soil and vegetable samples of district Faisalabad respectively. Analysis results (Figure 6.1) also showed that 98% vegetable samples irrigated with wastewater in district Faisalabad were contaminated with Cr, 55% with Pb, 52% with Cd, 9% with Zn and 4% with Ni and Mn when compared with permissible limit. Results (Table 6.2) showed that heavy metal content varied in ornamental, flowering and trees plant of district Faisalabad. Chromium (Cr) content were ranged from 0.0-103, Pb 0.0-33, Cd 0.0-7.7, Ni 0.0-15, Zn 7.8-154 and Mn 0.0-153 mg/kg in ornamental, flowering and trees plant of district Faisalabad. Analysis results also showed that 91% ornamental, flowering and trees plant samples in district Faisalabad were contaminated with Cr, 87% with Pb, 68% with Cd, 18% with Ni and 4% with Mn (Figure 6.2) when compared with permissible limit.

Table 6.1; Heavy metal content (mg/kg) in wastewater, soil and vegetable in district Faisalabad

Heavy metals	Lead	Cadmium	Nickel	Chromium	Zinc	Manganese
	Mean ± SD (mg/kg)					
Wastewater	3.10 ± 0.90	0.04 ± 0.03	0.02 ± 0.07	1.35 ± 1.50	0.04 ± 0.06	5.10 ± 4.49
Permissible limit	**5**	**0.01**	**0.2**	**0.1**	**2**	**0.2**
Soil	5.65 ± 2.19	22.02 ± 19.7	0.98 ± 0.36	3.91 ± 3.43	14.8 ± 10.9	27.1 ± 7.90

Permissible limit	**13**	**0.3**	**2.6**	**3.8**	**-**	**-**
Vegetable	7.08 ± 5.37	0.62 ± 1.56	2.51 ± 2.55	8.34 ± 7.79	58.7 ± 25.5	75.2 ± 62.0
Ornamental, Plants	13.8 ± 7.2	1.7 ± 1.5	5.9 ±4.1	11.6 ± 14.9	54.2 ± 25.0	59.0 ± 30.4
Permissible limit	**5**	**0.3**	**10**	**1.3**	**100**	**200**

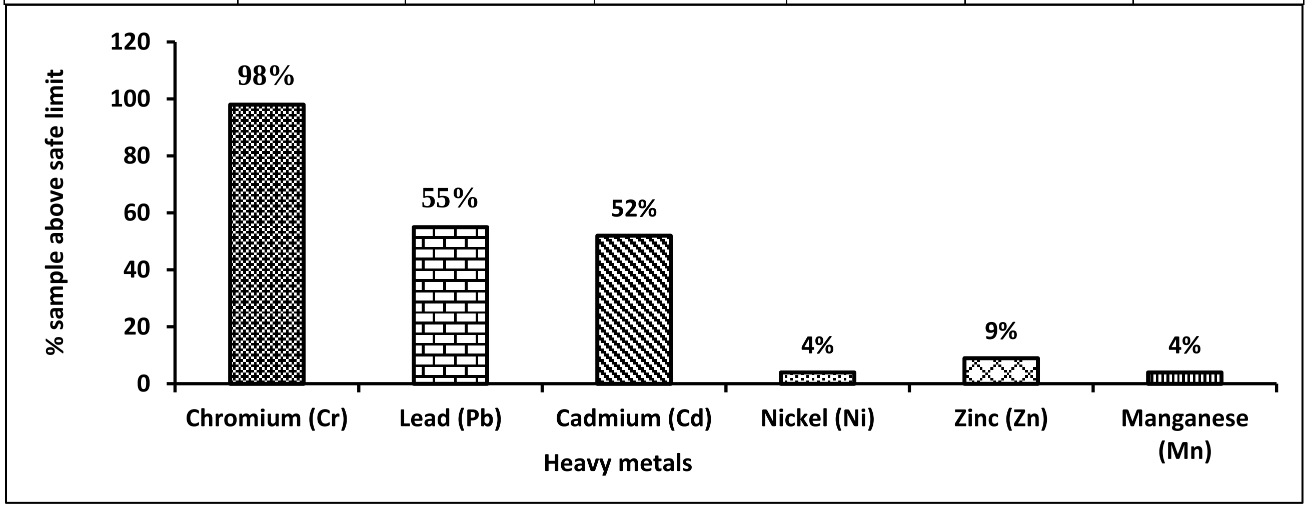

Figure 6.1; Percentage of vegetable samples found contaminated with wastewater irrigation in peri-urban areas of district Faisalabad

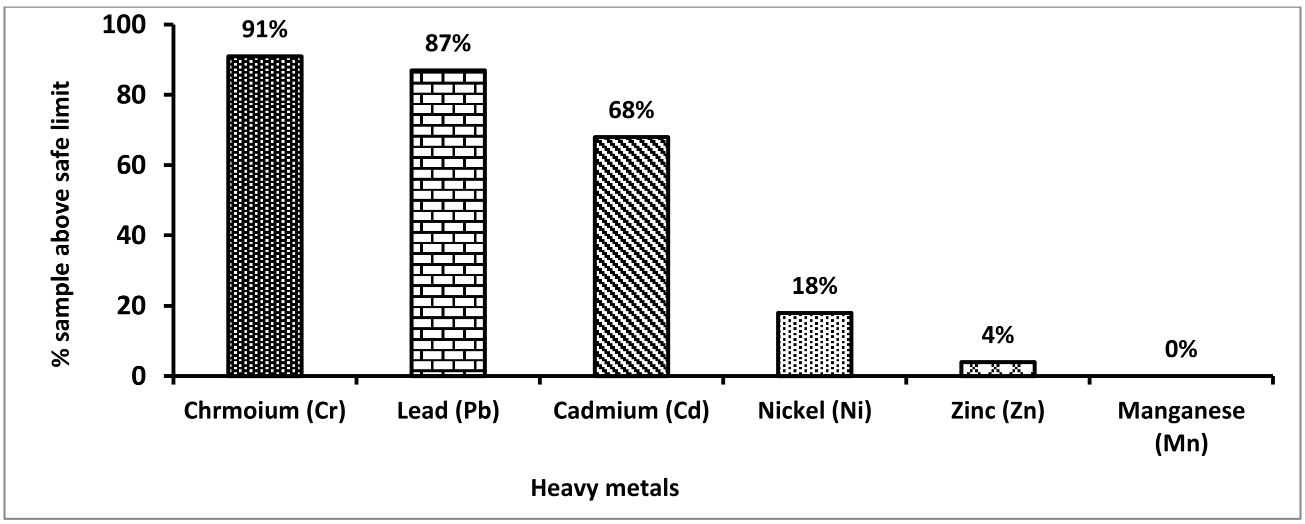

Figure 6.2; Level of contamination in Ornamental, flowering and tree plants of Faisalabad

7. ASSESSMENT OF HEAVY METALS IN GROUND WATER OF FAISALABAD

Water is the elixir of life and one of the most critical, scarce, precious and non-replenishable natural resource which cannot be created. Over exploitation of groundwater, natural and anthropogenic contamination now is becoming major problems for humans. Water quality of major cities in Pakistan is deteriorating because of unchecked disposal of industrial wastewater and unscrupulous use of fertilizers, pesticides and insecticides. This study was planned to check the quality of groundwater of district Faisalabad by quantifying its heavy metals content (Pb, Cd, Ni, Cr) pH and EC. Groundwater (100) samples were collected from different location (Nazimabad, Gurunanak pura, Gobind pura, Afghan abad, Jinnah Colony, Ghulam Muhammadabad and AARI colony) of district Faisalabad. The results (Table 7.1) reveled that highest pH (7.89) was found in the water collected from Afghan Abad, while lowest pH (7.00) was found in Gurunanak Pura water. With comparison of sample pH values with standard value of WHO (6.0-8.5), found that all samples are in standard range and the water is fit regarding pH. High value of EC was 5.39 in samples which were collected from Gobind Pura while samples collected from Nazimabad showed lowest EC (0.47).

Table 7.1; EC and pH range in groundwater from district Faisalabad

Locations	pH		EC (dSm^{-1})	
	Range	Mean	Range	Mean
Nazimabad	7.13-7.64	7.3	0.47-5.00	2.9
Gurunanak Pura	7.00-7.40	7.2	0.84-3.07	2.3
Gobind pura	7.01-7.52	7.2	0.74-5.39	2.3
Afghan Abad	7.01-7.89	7.2	0.57-4.84	2.0
Jinnah Colony	7.10-7.56	7.2	0.58-4.99	2.1
Ghulam Muhammad Abad	7.17-7.63	7.3	0.59-4.87	3.2
AARI Colony	7.28-7.70	7.4	0.52-1.92	1.1
WTO Standards	**6.0-8.5**		-	

Electrical conductivity in groundwater samples varied from 0.47 to 5.39 dS/m those are in WTO standard range and the water is fit regarding EC. The Range and mean values for the heavy metal contents (Pb, Cd, Ni, Cr) in different areas of district Faisalabad showed that 56% for lead, 30% for Chromium, 13% for Cadmium and 39% for Nickel samples are exceeds from the permissible limit according to WHO Standards. are for Cr (µg/L), Pb (µg/L), Cd (µg/L) and Ni (µg/L) in water (WWF, 2007 and WHO, 2007).

Table 7.2; Heavy metals (Cr, Pb, Cd, Ni) Range & Mean in 100 samples of groundwater from district Faisalabad

Locations	Cr (µg/L)		Pb (µg/L)		Cd (µg/L)		Ni (µg/L)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Nazimabad	12.2-50.8	<u>34.1</u>	15.4-84.9	45.5	0.0-11.2	<u>4.9</u>	4.9-87	<u>50.7</u>
Gurunanak Pura	14.3-30.6	23.8	15.4-54	27.9	1.2-10.2	3.7	0.0-83.8	15.6
Gobind Pura	10.2-50.4	25.4	0-61.7	25.4	0.0-10.3	3.0	0.0-37.1	9.9

Afghan Abad	2.0-52.1	31.3	7.7-69.5	42.8	0.0-10.5	2.8	0.0-228.8	16.8
Jinnah Colony	0.1-51.0	20.6	30.9-69.5	49.8	0.0-2.4	0.6	4.8-32.2	18.4
Ghulam Muhammad Abad	2.0-53.1	26.8	23.2-100.2	61.8	0.0-2.6	0.9	0.0-37.1	18.4
AARI Colony	8.1-59.1	21.1	15.5-61.7	42.7	0.0-10.0	1.8	0.0-33.8	9.6
Permissible limit WWF, WHO, 2007	50		50		10		25	

NUTRIENTS USE EFFECIENCY

8. ASSESSMENT OF NUTRIENTS REMOVAL BY DIFFERENT WEEDS UNDER DIFFERENT NUTRITION SCENARIOS

The use of chemical fertilizer is indispensable for maximum crop production as population increased manifold to meet the food requirement. Plants which are out of its proper place known as weed. Weeds not only deteriorate the quality of the produce but also compete desired plants for space, light, water and applied nutrients. Weeds also reduce the yield of crop up to 30%. No information regarding the nutrients uptake by weeds is available. So keeping in view the above mentioned facts, study was planned to assess the growth of weeds and nutrients removal under different nutrients scenario. Maize and wheat crop were selected as test crop. Maize (Zea Maize L.) and Wheat (*Triticum aestivum* L.) are the main cereal crop and the staple food of people of Pakistan. These are grown on wide variety of soil and climatic conditions. Wheat is grown on an area of 7.98 mha with total annual production of 18.47 million tons and national average yield of 2314 Kg ha^{-1}. Wheat contributes 13.1% to the value added in Agriculture and 2.8 % to GDP in Pakistan. Maize is the fourth largest grown crop after wheat, cotton and rice. The area under maize here is over one million hectares and production 3.5 million metric tons. Punjab contributes 39 per cent of the total area under maize

Treatments

T1: Control
T2: RD of N
T3: RD of NP
T4: RD of NPK
T5: FARM MANURE (FM)
T6: ½ N FROM FM+ ½ N FROM CHEMICAL FERILIZER + RD OF PK

Prior to sowing, the composite soil samples from 0-15 depth were collected and analyzed. Basic soil analysis showed that the field was free from salinity and sodicity hazards with low organic matter status, moderate in available P and adequate in available K in Table 1.

Maize being the highest yielding cereal crop in the world is a significant importance for countries like Pakistan, where rapidly increasing population has already out stripped the available food supplies. Maize ranks third most grown crop in the world with an area of more than 118 million hectares with an annual production of about 600 million metric tons. In Pakistan, maize is the fourth largest grown crop after wheat, cotton and rice. The area under maize here is over one million hectares and production 3.5 million metric tons. Punjab contributes 39 per cent of the total area under maize and 30 per cent of total production; KPK contributes 56 per cent of the total area and 63 per cent of the production while five per cent of the total area and three per cent of the total production is contributed by Sindh and Baluchistan.

Table 8.1; Basic Soil Analysis

Soil depth (cm)	pH_s	EC_e ($dS\ m^{-1}$)	Av. P (mg/kg)	Av. K (mg/kg)	O.M (%)	Texture
0-15	7.9	1.33	7.4	176	0.66	Sandy clay loam

Wheat

Wheat variety (Faisalabad-2008) was sown on 20-11-2017 and harvested on 25-04-2018. The experiment was conducted in RCBD design with 3 replications at Soil Chemistry Section ISCES Faisalabad. The composite soil samples were collected before sowing of the crop and analyzed for basic soil characteristics. Recommended dose of NPK @ 120-90-60 kg/ha was applied. All Fertilizers applied as per treatment plan. Phosphorous & Potassium was` applied before Sowing while nitrogen was broadcasted in two split doses.

The result (Table 8.2) showed that maximum yield was observed in T4 (3.01 t/ha) whereas minimum was obtained in T1 (2.41 t/ha). Whereas maximum nitrogen 1.46 % was removed by ITSIT in treatment T3 after that 1.26% by BHAKRA in T3, GRASS 1.30% In T2, LEHLI 1.23% in T5, and TANDLA 1.1% in T6. While in case of removal of phosphorous and potassium, similar trend was observed.

Table 8.2; Wheat yield under different nutrients scenario

Treatments	Wheat yield (t/ha)
T1: Control	2.41 AB
T2: RD of N	2.17 B
T3: RD of NP	2.19
T4: RD of NPK	3.01 A
T5: FARM MANURE (FM)	2.45 AB
T6: ½ N FROM FM+ ½ N FROM CHEMICAL FERILIZER + RD OF PK	2.84 A
LSD	0.52

Table8.3; Nitrogen removal by different weeds

TREATMENTS	Grass	Bhakra	It sit	Tandla	Lehli
T1: Control	0.8 ab	0.83 ab	0.86 ab	0.76 ab	1.08 a
T2: RD of N	1.3 a	1.16a	1.13a	0.96a	0.83 ab
T3: RD of NP	1.1 a	1.26 a	1.46 a	1.0a	0.8ab
T4: RD of NPK	1.0 a	1.1a	1.16 a	0.73 ab	0.9ab
T5: FARM MANURE (FM)	0.9 ab	0.91ab	1.1 a	1.03 a	1.23a
T6: ½ N FROM FM+ ½ N FROM	1.2 a	1.3a	0.83 ab	1.1a	1.2a

CHEMICAL FERILIZER + RD OF PK					
LSD	0.03	0.033	0.04	0.016	0.03

Table 8.4; Phosphorous removal by different weeds

TREATMENTS	**Grass**	**Bhakra**	**It sit**	**Tandla**	**Lehli**
T1: Control	0.14 ab	0.17ab	0.12 b	0.14ab	0.17b
T2: RD of N	0.34a	0.17ab	0.14b	0.20ab	0.25ab
T3: RD of NP	0.32a	0.12ab	0.17ab	0.29a	0.26ab
T4: RD of NPK	0.15ab	0.24a	0.25a	0.18ab	0.23ab
T5: FARM MANURE (FM)	0.14ab	0.23a	0.25a	0.26a	0.32a
T6: ½ N FROM FM+ ½ N FROM CHEMICAL FERILIZER + RD OF PK	0.29a	0.24a	0.18ab	0.26a	0.15b
LSD	0.05	0.042	0.032	0.036	0.02

Table8.5; potassium removal by different weeds

TREATMENTS	**Grass**	**Bhakra**	**It sit**	**Tandla**	**Lehli**
T1: Control	0.11b	0.16c	0.14 b	0.21 b	0.21 b
T2: RD of N	0.17b	0.20bc	0.33 a	0.24 b	0.23 ab
T3: RD of NP	0.27ab	0.27b	0.33 a	0.32 ab	0.30 a
T4: RD of NPK	0.31a	0.37ab	0.35 a	0.45 a	0.27 ab
T5: FARM MANURE (FM)	0.34a	0.41a	0.32 a	0.35 ab	0.35 a
T6: ½ N FROM FM+ ½ N FROM CHEMICAL FERILIZER + RD OF PK	0.31ab	0.33ab	0.27 ab	0.43 a	0.32 a
LSD	0.02	0.031	0.024	0.015	0.03

Maize

Maize (Zea Maize L.) was sown on 8th August, 2017 and harvested on 15 November 2017. All the fertilizers were applied according to the plan. Phosphorous & Potassium was` applied before Sowing while nitrogen was broadcasted in two split doses. The result related to the maize grain yield showed that maximum maize grain yield of 7.2 t/ha was observed in treatment 3 and 4 while lowest of 3.4 t/ha in no fertilized treatment.

The experiment was conducted in RCBD design with 3 replications at Soil Chemistry Section ISCES Faisalabad. The composite soil samples were collected before sowing of the crop and analyzed for basic soil characteristics. Recommended dose of NPK @ 275-125-75 kg/ha was applied.

Table8.6; Basic Soil Analysis

Soil depth	**pH_s**	**EC_e**	**O.M**	**Av. P**	**Av. K**
(cm)		**(dSm^{-1})**	**(%)**	**(mg/kg)**	

0-15	8.2	1.57	0.61	8.2	195
15-30	8	1.59	0.59	7.9	180

The analysis of the field showed that the soil was free from salinity and sodicity, low in organic matter and phosphorus while potash was medium.

The data regarding grain yield (Table 2) showed that Maximum grain yield of 7.2 t/ha was obtained in treatment 3 and 4 while lowest of 3.4 t/ha in no fertilizer treatment. In case of weed biomass, maximum (1.33 t/ha) is recorded in treatment 6 whereas minimum (0.92 t/ ha) in (control) treatment where no fertilizer is applied.

Table8.7; Maize grain yield and different weeds biomass (t/ha)

Treatments	Grain yield	Weed Biomass
	(t/ha)	
T1: Control	3.4	0.92
T2: RD of N	6.4	0.79
T3: RD of NP	7.2	1.05
T4: RD of NPK	7.2	1.2
T5: FARM MANURE (FM)	5.8	1.08
T6: ½ N FROM FM+ ½ N FROM CHEMICAL FERILIZER + RD OF PK	7.0	1.33
LSD	NS	NS

9. YIELD AND POTASSIUM UPTAKE OF MAIZE USING DIFFERENT SOURCES OF NITROGEN

With the introduction of high yielding varieties in our cropping system, the removal of nutrients from the soils has increased many folds where as high nitrogen losses by ammonia volatilization are predictable when urea is used as the source of N which is mainly due to high pH of alkaline calcareous soils of Pakistan. In current scenario ammonia and Oxides of nitrogen are potential source of climate change. Ammonium ions being monovalent reduce the potassium ions uptake in plants. To avoid nitrogen losses in the form of ammonia and to increase nitrogen use efficiency, a field study was initiated using calcium ammonium nitrate (CAN) and urea as sources of nitrogen along with half and full dozes of potassium in wheat. Nitrogen was splited according to the treatments plan while phosphorus @ 125 kg/ha was applied in all plots except control. The experiment was conducted in RCBD design with 3 replications at Soil Chemistry Section ISCES Faisalabad.

Treatments

T1: Control (no fertilizer)

T2: RD of N (1st ½ as urea + 2nd ½ as urea) + K @ 0 kg/ha

T3: RD of N (1st ½ as urea + 2nd ½ as urea) + K @ 50% of recommended

T4: RD of N (1st ½ as CAN + 2nd ½ as CAN) + K @ 50% of recommended

T5: RD of N (1st ½ as urea + 2nd ½ as CAN) + K @ 50% of recommended
T6: RD of N (1st ½ as urea + 2nd ½ as urea) + K @ 100% of recommended
T7: RD of N (1st ½ as CAN + 2nd ½ as CAN) + K @ 100% of recommended
T8: RD of N (1st ½ as urea + 2nd ½ as CAN) + K @ 100% of recommended

Maize

The composite soil samples were collected before sowing of the crop and analyzed for pre-sowing soil analysis. Maize crop was sown on 03-08-2018 and was harvested on 15-11-2018.

Table 9.1; Basic Soil Analysis

Soil depth	pH_s	EC_e	O.M	Av. P	Av. K	Texture
(cm)		(dSm^{-1})	(%)	(mg/kg)		
0-15	7.82	1.35	0.68	7.90	170	Sandy Clay loam
15-30	7.96	1.43	0.51	4.89	142	

Pre-sowing analysis (Table 9.1) showed that the soil was free from salinity and sodicity, low in organic matter and phosphorus while potash was medium. The result (Table 9.2) showed that Maximum grain yield (6.80 t/ha) was obtained in T8 where fist ½ nitrogen applied in the form Urea and 2nd dose as CAN along with full rate of potassium was applied while, minimum grain yield (3.63 t ha^{-1}) in T1 (control). However the yield of the rest of treatments was statistically at par with those treatments where urea as source of nitrogen along with full doze of potassium was applied.

Table 9.2; Effect of different sources of nitrogen and varying rates of potassium on maize grain yield (t/ha) and on Nitrogen and Potassium uptake (kg/ha)

Treatments	Grain yield	N uptake	K uptake
	(t/ha)	(Kg/ha)	
T1: Control (no fertilizer)	3.6 c	79	49
T2: RD of N (1st ½ as urea + 2nd ½ as urea) + K @ 0 kg/ha	5.5 b	122	71
T3: RD of N (1st ½ as urea + 2nd ½ as urea) + K @ 38 kg/ha	6.1 ab	130	76
T4: RD of N (1st ½ as CAN + 2nd ½ as CAN) + K @ 38 kg/ha	6.3 ab	133	81
T5: RD of N (1st ½ as urea + 2nd ½ as CAN) + K @ 38 kg/ha	6.4 ab	129	68
T6: RD of N (1st ½ as urea + 2nd ½ as urea) + K @ 75 kg/ha	6.5 a	131	70
T7: RD of N (1st ½ as CAN + 2nd ½ as CAN) + K @ 75 kg/ha	6.6 a	137	75
T8: RD of N (1st ½ as urea + 2nd ½ as CAN) + @ 75 kg/ha	6.8 a	145	81
LSD	0.97		

Nitrogen and potassium uptake data reveled that, highest nitrogen and Potassium uptake (145 kg/ha, 81 kg/ha) was observed in T8 where 1st half as urea and 2nd half CAN as source of nitrogen along with full doze of potassium was used.

Wheat

Wheat crop was sown on 17-11-2017 and was harvested on 2-04-2018. Fertilizers were applied as per treatment plan.

Table 9.3; Basic Soil Analysis

Soil depth (cm)	*pH_s*	*EC_e (dSm^{-1})*	*O.M (%)*	*Av. P (mg/kg)*	*Av. K (mg/kg)*	*Texture*
0-15	*7.95*	*1.35*	*0.63*	*7.3*	*192*	*Sandy Clay loam*
15-30	*7.9*	*1.43*	*0.5*	*5.9*	*139*	

The composite soil samples were collected before sowing of the crop and analyzed for pre-sowing soil analysis. Pre-Sowing soil analysis(Table 9.3 showed that the soil was free from salinity and sodicity, low in organic matter and phosphorus while potash was medium.

Table 9.4; Effect of different sources of nitrogen and varying rates of potassium on wheat grain and straw yield (t/ha), NPK contents (%) and nitrogen and potassium uptake (kg/ha)

Treatments	**grain yield**	**Straw yield**	**N**	**P**	**K**	**N**	**K**
	(t/ha)		**(%)**			**(Kg/ha)**	
T1: Control (no fertilizer)	2.0 d	4.20 d	1.9	0.17	0.45 b	48	74
T2: RD of N (1st ½ as urea + 2nd ½ as urea) + K @ 0 kg/ha	3.20 d	6.23 bc	2.19	0.19	0.52 ab	120	138
T3: RD of N (1st ½ as urea + 2nd ½ as urea) + K @ 38 kg/ha	3.60 bc	6.80 abc	2.24	0.18	0.53 ab	129	154
T4: RD of N (1st ½ as CAN + 2nd ½ as CAN) + K @ 38 kg/ha	4.0 ab	6.96 abc	2.22	0.22	0.55 a	128	183
T5: RD of N (1st ½ as urea + 2nd ½ as CAN) + K @ 38 kg/ha	3.51 bc	6.20 c	2.28	0.19	0.57 a	125	149
T6: RD of N (1st ½ as urea + 2nd ½ as urea) + K @ 75 kg/ha	3.7 abc	6.73 abc	2.21	0.21	0.55a	135	153
T7: RD of N (1st ½ as CAN + 2nd ½ as CAN) + K @ 75 kg/ha	4.1a	7.40 a	2.17	0.19	0.54a	130	169
T8: RD of N (1st ½ as urea + 2nd ½ as CAN) + @ 75 kg/ha	3.8 ab	7.20 ab	2.26	0.2	0.56a	136	168
LSD	0.48	0.98	0.19	NS	0.21	NS	

The data regarding grain yield (Table 9.4) showed that maximum grain and straw yield (4.1 t/ha, 7.40 t/ha) was observed in T7 where fist ½ and 2nd dose of nitrogen was applied in the form of CAN while minimum grain and straw yield (2.0 t/ha, 4.20 t/ha) was observed in control. The data regarding grain NPK contents (Table 9.4) showed that maximum nitrogen and potassium contents (2.28 and 0.57 %) were found in T5 where half dose of nitrogen from urea and 2nd half from CAN along with half dose of potassium was applied, however these concentration were non-significant with all other treatments except control. Phosphorus concentration on the other hand was non-significant in all treatments. While nitrogen and potassium uptake data reveled that, highest nitrogen uptake (136 kg/ha) was noted in T8 where 1st ½ dose as urea and 2nd CAN as source of nitrogen along with full doze of potassium was used. In case of Potassium uptake, the highest uptake (169 kg/ha) was found in T7 where half nitrogen from urea and half from CAN along with full doze of potassium was used.

10. SURVEY OF SOIL SULPHUR (S) CONTENTS IN OILSEED GROWING AREAS

Severe deficiency of S has been reported in some oil seed crops. It may be due to low S in soil or no application of S containing fertilizer. So this study was planned to assess the S contents of soils. Soil samples were collected from Yousaf wala Maize Research area from 27 sites at 2 depths (0-15 cm and 15-30 cm). Crop rotation practiced in Yousafwala is given in table 10.1. Result showed crop rotation had impact on S status and potato-maize rotation utilize more sulphur than other rotations however, soils of all crop rotations were found sufficient in Sulphur (17.4-52.2 mg/kg).

Table 10.1; Status of Soil Sulphur at Yousaf wala Maize Research area

Crop Cycle	Sulphur Contents		Sufficient level
	Range	Average	
	(mg/kg)		
Maize-Maize	19.4-45.0	24.5	05-20
Maize-Wheat	25.6-41.4	29.8	
Potato-Maize	17.4-45.0	20.5	
Sorghum-Maize	27.6-52.2	33.9	

In Okara, miaze–wheat rotation is practiced. Soil samples were collected from 2 depth (0-15 cm and 15-30 cm).The result (Table 10.2) showed that Soil has sufficient sulphur contents (20-168 mg/kg).

Table 10.1: Status of Soil Sulphur of Okara

Depth	Range	Average	SD	Sufficient Level
cm	(mg/kg)			
0-15	20-168	64	42	05-20
15- 30	25-139	75	36	

11. TO STUDY THE NUTRIENT USE EFFICIENCY UNDER BURNT AND RETAINED CROP RESIDUE IN RICE/WHEAT CROPPING SYSTEM

Burning of wheat and rice straw is a common practice in rice tract. So this study was planned to evaluate the efficiency of NPK under burnt and retained crop residue situation. This study was conducted at Soil Chemistry Section, Institute of Soil Chemistry and Environmental Sciences, Ayub Agricultural Research Institute Faisalabad. The four different treatments were tested by using Split Plot design with three replications.

The four different treatments (sub plot) were:

T1: Control

T2: 50% of recommended dose of NPK

T3: 75% of recommended dose of NPK

T4: 100% of recommended dose of NPK

The three main plots were:

1: Traditional plot

2: Burnt plot

3: Rotavated plot

Recommended dose of NPK (for Rice) = 150-90-60 kg ha^{-1}

Recommended dose of NPK (for wheat) = 120-90-60 kg ha^{-1}

Rice Crop:

The rice crop was transplanted on 14-07-2017. The composite soil samples (0-15 and 15-30 cm depth) were taken before the start of the experiment and analyzed (Table 11.1).

Table 11.1; Basic Soil analysis

Depth	pH	ECe	Organic matter	Av. P	Av. K	Texture
(cm)		(dS/m)	(%)	(mg/kg)		
0-15	8.18	1.11	0.76	7.69	201	Sandy clay loam
15-30	8.1	1.01	0.62	7.62	170	

The soil analysis showed that the field was free from salinity and sodicity hazard, deficient in OM, moderate in available P and sufficient in K. After taking the post-harvest soil samples from 0-15 and 15-30 cm, the straw of previous crop (wheat) were burnt and added to the burnt plot and in the rotavated plots straw was incorporated. The treatments were applied at random in all the three sub plots in three replications. The rice was harvested on 17-11-2017. The data regarding paddy yield is presented in Table 11.2.

Table 11.2; Effect of different residue management practices and treatments on the paddy yield (t/ha)

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	3.14 B	3.71 AB	4.00 AB	3.62 A
T2: 50% of recommended dose of NPK	3.52 AB	3.93 AB	3.90 AB	3.78 A
T3: 75% of recommended dose of NPK	4.19 A	3.71 AB	4.19 A	4.03 A
T4: 100% of recommended dose of NPK	4.00 AB	4.00 AB	4.28 A	4.09 A
Mean	3.7 A	3.8 A	4.09 A	
LSD of Group= 0.63, LSD of treatments= 0.54				

The results showed that paddy yield was maximum in the rotavated, sub plots where 100% RD fertilizer was applied (4.28 t ha^{-1}). Comparing all the three main plots it was observed that rotavated plots gave maximum paddy yield (4.09 t ha^{-1}). The yield in burnt and traditional plots was at par (3.7 and 3.8 t ha^{-1} respectively). All the sub plots were significantly different from each other.

Treatment in which 100% RD fertilizer was applied gave maximum yield (4.28 t ha^{-1}) while minimum yield (3.14 t ha^{-1}) was observed in the treatment where no fertilizer was added in traditional plot.

The soil samples were collected after harvesting of rice crop and were analyzed for OM, P and K content. The data for OM, P and K are presented in Table 11.3, 11.4 and 11.5, respectively. The results indicated that phosphorus and OM content of the soil samples in the burnt plots decreased comparing with the traditional and rotavated plots while potassium in burnt plot was more than traditional. The analysis showed that rotavation of straw proved better for increasing soil fertility either alone or combined with 100% RD of NPK application resulted in high O.M while minimum O.M was found in control where residues were burnt.

Table 11.3; Effect of different residue management practices and treatments on the OM (%) content of soil (0-15 cm)

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	0.52 E	0.39 F	0.72 BC	0.54 C
T2: 50% of recommended dose of NPK	0.62 D	0.49 E	0.74 AB	0.62 B
T3: 75% of recommended dose of NPK	0.64 CD	0.51 E	0.80 A	0.65 B
T4: 100% of recommended dose of NPK	0.65 BCD	0.64 CD	0.80 A	0.70 A
Mean	0.61 B	0.51 C	0.77 A	
LSD of plots=0.06, LSD of treatments= 0.04				

Table 11.4; Effect of different residue management practices and treatments on the phosphorus (mg kg^{-1}) content of soil (0-15 cm)

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	3.85 C	2.16 D	1.65 D	2.55 C
T2: 50% of recommended dose of NPK	4.10 C	2.58 D	4.02 C	3.57 B
T3: 75% of recommended dose of NPK	5.37 B	5.46 AB	4.69 BC	5.17 A
T4: 100% of recommended dose of NPK	6.55 A	4.09 C	5.60 AB	5.41 A
Mean	4.97 A	3.57 B	3.99 B	
LSD of Group=0.81 , LSD of treatments =0.63				

Table 11.5; Effect of different residue management practices and treatments on the potassium (mg kg^{-1}) content of soil (0-15 cm)

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	164.0 F	277.3 AB	230.7 CD	224.0 B

T2: 50% of recommended dose of NPK	210.7 DE	317.3 A	257.3 BC	261.8 A
T3: 75% of recommended dose of NPK	177.3 EF	304.0 A	257.3 BC	246.2 AB
T4: 100% of recommended dose of NPK	217.3 CDE	277.3 AB	224.0 CD	239.6 AB
Mean	192.3 C	294.0 A	242.33 B	
LSD of Group= 9.4, LSD of treatments= 24.1				

The paddy samples were collected after threshing and analyzed for N, P and K contents. The data regarding N, P and K are presented in Table 11.6, 11.7 and 11.8. The results indicated that all the treatments gave significantly different results. The treatment where 100% RD of NPK was applied gave highest N, P and K contents in all main plots.

Table 11.6; Effect of different residue management practices and treatments on the nitrogen (%) content of paddy

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	2.41 ABCD	2.66 AB	1.99 CD	2.35 AB
T2: 50% of recommended dose of NPK	2.47 ABCD	2.19 BCD	1.91 D	2.19 B
T3: 75% of recommended dose of NPK	2.45 ABCD	2.81 A	2.35 ABCD	2.54 A
T4: 100% of recommended dose of NPK	2.54 ABC	2.52 ABC	2.61 AB	2.56 A
Mean	2.47 A	2.54 A	2.21 A	
LSD of Group=0.35 , LSD of treatments= 0.31				

Table 11.7: Effect of different residue management practices and treatments on the phosphorus (%) content of paddy

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	0.23 CDE	0.21 E	0.21 DE	0.22 C
T2: 50% of recommended dose of NPK	0.25 BCDE	0.25 BCDE	0.27 BCD	0.26 B
T3: 75% of recommended dose of NPK	0.27 BCDE	0.26 BCDE	0.29 AB	0.27 B
T4: 100% of recommended dose of NPK	0.35 A	0.28 BC	0.30 AB	0.31 A
Mean	0.27 A	0.25 A	0.27 A	
LSD of Group=0.029 , LSD of treatments= 0.034				

Wheat Crop:

In the same layout wheat was sown on 29-11-2017. All the treatments were applied according to the treatment plan. Crop was harvested on 24-04-2018 and yield data was recorded. The wheat yield data is presented in Table 11.9.

Table 11.9; Effect of different residue management practices and treatments on the yield of wheat (t/ha)

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	2.09 D	2.03 D	2.43 CD	2.18 C
T2: 50% of recommended dose of NPK	2.71 BCD	3.26 ABC	3.60 AB	3.19 B
T3: 75% of recommended dose of NPK	3.76 A	3.30 ABC	3.66 AB	3.57 AB
T4: 100% of recommended dose of NPK	3.80 A	3.66 AB	4.10 A	3.85 A
Mean	3.09 B	3.06 B	3.45 A	
LSD of plots= 0.35, LSD of treatments= 0.43				

The results showed that wheat grain yield was maximum (4.1 t ha^{-1}) in rotavated plot while in burnt and traditional plots the yield was 3.06 and 3.09 respectively. All the treatments were significantly different and the treatment with NPK @ 100% gave better results.

The wheat grain samples were collected after threshing and analyzed for N, P and K contents. The data regarding N, P and K is presented in Table 10 and 11 and 12. The results indicated that all the treatments gave significantly different results. The treatment where 100% RD was applied gave maximum P and K content in all three sub plots.

Table 11.10; Effect of different residue management practices and treatments on the Nitrogen (%) content of wheat grain

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	2.34 E	2.47 E	2.38 E	2.37 C
T2: 50% of recommended dose of NPK	2.28 E	2.39 E	2.61 DE	2.45 C
T3: 75% of recommended dose of NPK	3.64 D	3.64 CD	3.08 DE	3.45 B
T4: 100% of recommended dose of NPK	4.58 BC	4.91 B	6.20 A	5.23 A
Mean	3.21 A	3.35 A	3.57 A	
LSD of plots=0.91 , LSD of treatments= 0.42				

The soil samples were collected after harvesting of wheat crop and were analyzed for OM, P and K content. The data for OM, P and K were presented in Table 11.13, 11.14 and 11.15, respectively. The results indicated that OM contents of soil samples differ significantly in main plots. Rotavated plot having full recommended fertilizer showed maximum organic matter % while minimum was observed in traditional plot where no fertilizer was added. Available P was significantly higher (20.9 mg/kg) in traditional plot where 100 % fertilizer was applied. While available K was found maximum in rotavated plot where 100% RD fertilizer was applied.

Table 11.11: Effect of different residue management practices and treatments on the phosphorus (%) content of wheat grain

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	0.29 E	0.36 CD	0.37 CD	0.34 D
T2: 50% of recommended dose of NPK	0.36 CD	0.35 D	0.38 BC	0.36 C
T3: 75% of recommended dose of NPK	0.36 CD	0.38 BC	0.39 B	0.38 B
T4: 100% of recommended dose of NPK	0.39 BC	0.38 BC	0.42 A	0.40 A
Mean	0.35 B	0.37 A	0.39 A	
LSD of Group=0.34 , LSD of treatments= 0.24				

Table 11.12: Effect of different residue management practices and treatments on the potash (%) content of wheat grain

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	0.41 BCD	0.40 CD	0.40 D	0.40 C
T2: 50% of recommended dose of NPK	0.42 ABCD	0.40 CD	0.41 BCD	0.41 BC
T3: 75% of recommended dose of NPK	0.42 ABCD	0.42 ABCD	0.42 ABCD	0.42 B
T4: 100% of recommended dose of NPK	0.44 A	0.44 AB	0.43 ABC	0.44 A
Mean	0.42 A	0.42 A	0.41 A	
LSD of Group=0.012 , LSD of treatments= 0.022				

Table 11.13: Effect of different residue management practices and treatments on the OM (%) content of soil (0-15 cm)

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	0.52 CD	0.49 D	0.65 B	0.55s C
T2: 50% of recommended dose of NPK	0.52 CD	0.52 CD	0.66 B	0.56 BC
T3: 75% of recommended dose of NPK	0.57 CD	0.54 CD	0.68 B	0.59 AB
T4: 100% of recommended dose of NPK	0.57 C	0.55 CD	0.74 A	0.62 A
Mean	0.54 B	0.52 B	0.68 A	
LSD of Group=0.04, LSD of treatments= 0.05				

Table 11.14: Effect of different residue management practices and treatments on the phosphorus (mg kg^{-1}) content of soil (0-15 cm)

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	15.3 F	16.4 F	18.4 E	16.7 D
T2: 50% of recommended dose of NPK	16.2 F	21.5 D	21.3 D	19.6 C
T3: 75% of recommended dose of NPK	21.3 D	22.7 CD	22.1 CD	22.0 B

T4: 100% of recommended dose of NPK	23.7 C	25.8 B	28.8 A	26.1 A
Mean	19.1 B	21.6 A	22.6 A	
LSD of Group=1.31 , LSD of treatments=0.78				

Table 11.15: Effect of different residue management practices and treatments on the potassium (mg kg^{-1}) content of soil (0-15 cm)

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	220.8 H	247.6 G	288.2 DE	252.2 C
T2: 50% of recommended dose of NPK	268.0 EFG	261.3 FG	328.6 AB	285.9 B
T3: 75% of recommended dose of NPK	281.5 DEF	288.2 DE	315.15BC	294.9 B
T4: 100% of recommended dose of NPK	288.2 DE	301.7 CD	342.1 A	310.7 A
Mean	264.6 B	274.7 B	318.52 A	
LSD of Group=11.9, LSD of treatments= 12.6				

12. EFFECT OF FOLIAR PHOSPHORUS APPLICATION ON THE YIELD OF RICE/ WHEAT

The use of chemical fertilizer is indispensable for maximum crop production to meet the requirements of increasing population. Phosphorus is an essential element classified as a macronutrient because relatively large quantity of Phosphorous required by the plant but it is immobile element in soil and its huge quantity is not available to the plants due to fixation on exchangeable soil sites. Therefore, this study was planned to evaluate the response of foliar application of phosphorus to rice.

Treatments:

T1: Control

T2: RD of NPK

T3: RD of NK

T4: RD of NK + 75 % P (soil) + 2 spray (2% P)

T5: RD of NK + 50 % P (soil) + 3spray (2% P)

T6: RD of NK + 25 % P (soil) + 4 spray (2% P)

Recommended dose of NPK (for Rice) = 150-90-60 kg ha^{-1}

Recommended dose of NPK (for wheat) = 120-90-60 kg ha^{-1}

Prior to sowing, the composite soil samples from 0-15 and 15-30 cm depths, were collected and analyzed. Pre-sowing soil analysis showed that the field was free from salinity and sodicity hazards with low organic matter status, moderate in available P and adequate in available K in Table 12.1.

Table 12.1: Pre-sowing soil analysis

Depth	pH	ECe	Organic matter	Av. P	Av. K	Texture
(cm)		(dS/m)	(%)	(mg/kg)		
0-15	8.18	1.42	0.76	7.69	180	**Sandy clay loam**
15-30	8.1	1.01	0.62	7.5	170	

RICE

Rice (Basmati super) was transplanted on 14-07-2017 and harvested on 01-11-2017. All the fertilizers were applied according to the plan. Potassium was applied before transplanting while nitrogen was broadcasted in three increments. The result (Table 12.2) showed that maximum paddy (3.40 t ha^{-1}) and straw yield (4.99 t ha^{-1}) was obtained in T2 where recommended fertilizer was applied in soil. Whereas minimum paddy and straw yield (1.26 and 2.63 t/ha) was observed in of T1 (control).

Table 12.2: Effect of foliar application of P on rice paddy and straw yield and on macronutrients (NPK) Concentration in paddy

Treatments	Paddy yield	Straw yield	N	P	K
	(t/ha)		(%)		
T1: Control	1.26 d	2.63 d	1.4 b	0.25	0.30
T2: RD of NPK	3.40 a	4.99 a	1.8 ab	0.32	0.39
T3: RD of NK	2.67 c	3.53 c	1.6 b	0.26	0.33
T4: RD of NK + 75 % P (soil) + 2 spray (2% P)	3.09 a	4.47 ab	2.2 a	0.34	0.41
T5: RD of NK + 50 % P (soil) + 3spray (2% P)	2.74 b	4.01 bc	1.9 ab	0.28	0.35
T6: RD of NK + 25 % P (soil) + 4 spray (2% P)	2.69 c	3.73 c	1.6 b	0.27	0.31
LSD	0.35	0.47	0.4	NS	NS

Paddy chemical analysis showed the maximum nitrogen contents were observed in T4 where 2 sprays of 2% P were applied on the other hand phosphorous and potassium (Table 3) contents of paddy were non-significant among the all treatments.

WHEAT

Wheat variety (Galaxy 2013) was sown on 20-11-2017 and harvested on 15-04-2018. The experiment was conducted in RCBD with 3 replications at Soil Chemistry Section ISCES Faisalabad.

Treatments

T1: Control

T2: RD of NPK

T3: RD of NK

T4: RD of NK + 75 % P (soil) + 2 spray (2% P)

T5: RD of NK + 50 % P (soil) + 3spray (2% P)

T6: RD of NK + 25 % P (soil) + 4 spray (2% P)

T7: RD of NPK+ 4 water spray at two leaves, tillering, booting and grain formation stage

Recommended dose of NPK = 120-90-60 kg/ha

The composite soil samples were collected before sowing of the crop and analyzed for basic soil characteristics.

Table 12.3: Pre-sowing soil analysis

Depth (cm)	pH	ECe (dS/m)	Organic matter (%)	Av. P (mg/kg)	Av. K (mg/kg)	Texture
0-15	8.2	1.57	0.61	8.2	195	Sandy clay loam
15-30	8	1.59	0.59	7.9	180	

Table 12.4: Effect of Foliar phosphorus application on wheat grain and straw yield and on leaf macronutrient concentration (%)

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	N (%)	P (%)	K (%)
T1: Control	2.46 c	4.03 d	2.8 c	0.17 c	3.10 c
T2: RD of NPK	4.32 a	7.55 ab	3.3 a	0.26 a	3.30 a
T3: RD of NK	3.43 b	6.36 c	3.2 b	0.22 b	3.25 a
T4: RD of NK + 75 % P (soil) + 2 spray (2% P)	4.16 a	7.65 a	3.2 b	0.26 a	3.28 a
T5: RD of NK + 50 % P (soil) + 3spray (2% P)	4.06 ab	6.97 bc	3.3 a	0.24 ab	3.27 a
T6: RD of NK + 25 % P (soil) + 4 spray (2% P)	3.55 b	7.06 b	3.1 a	0.24 ab	3.18 b
T7: RD of NPK+ 4 water spray at two leaves, tillering, booting and grain formation stage	4.02 a	7.11 b	3.3 a	0.25 ab	3.25 a
LSD	0.55	0.69	0.07	0.03	0.06

The data regarding grain NPK contents (Table 12.4) showed that maximum nitrogen and Phosphorous was observed in T7 and T4, however these concentrations were at par with all other treatments.

13. NUTRIENTS REMOVAL BY CROPS

Crops are grown throughout Pakistan and these are good source of carbohydrates, proteins, vitamins and minerals but very little information is available about their nutrient removal from soil. Therefore, this study was planned to determine the removal of nutrients i.e., N, P, K, Zn, Cu, Fe and Mn from soil by Cucumber and Onion crop. The Cucumber crops were grown at the farm area of Vegetable Research Institute and Onion crop was grown on the farm of Soil Chemistry Section, Institute of Soil and Environmental Sciences. Fertilizers were applied according to the recommendations. The yield data of the crops were recorded and plant samples were collected for N, P, K, Zn, Cu, Fe and Mn analysis. Nutrients removed by both crops are presented in Table 13.1.

Table 13.1: Dry matter yield and nutrients removed by Cucumber and Onion

Crop	Dry matter yield	N	P	K	Zn	Cu	Fe	Mn
	(kg/ha)				(g/ha)			
Cucumber	950	13.57	19	68.9	22.84	19	35.3	65.7
Onion	6015	173	32.2	45	238.9	53.9	850.2	177.6

Results indicated (Table 13.1) that dry matter yield of 950 kg/ha of cucumber removed 13.5 kg N, 19 kg P, 68.9 kg K, 22.84 g Zn, 19 g Cu, 35.3 g Fe and 65.7 g Mn /ha. The results revealed that dry onion of 6015 kg/ha removed 173 kg N, 32.2 kg P, 45 kg K, 238.9 g Zn, 53.9 g Cu, 850.2 g Fe and 177.6 g Mn/ha.

NUTRIENTS DYNAMICS IN SOIL

14. EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF HYBRID MAIZE

Integrated Nutrient Management (INM) is combine use of natural and man-made soil nutrients to increase crop productivity and preserve soil productivity for future generations. With the introduction of hybrid and high yielding varieties in our cropping system, the removal of nutrients from the soils has increased many folds. Therefore, this study was planned to assess the effects of integrated use of organic and inorganic fertilizers on nutrients use efficiency, growth and yield of hybrid maize and wheat.

Treatments

T1: Control (no fertilizer)

T2: 100% RD of NPK

T3: 75% of RD of NPK + FYM @ 5 t/ha

T4: 75% of RD of NPK + 2% foliar spray of NPK (30 and 45 DAS)

T5: 75% of RD of NPK + FYM @ 5 t/ha + 2% foliar spray of NPK (30 and 45 DAS)

T6: 100% of RD of NPK + FYM @ 5 t/ha

T7: 100 % of RD of NPK + 2% foliar spray of NPK (30 and 45 DAS)

T8: 100% of RD of NPK + FYM @ 5 t/ha + 2% foliar spray of NPK (30 and 45 DAS)

Maize Crop

Maize crop was sown on 25-07-2017 and harvested on 30-10-2017. The results revealed that maximum maize grain yields (7.47 t/ha) were obtained in T8 followed by T6 and T7 (Table 14.1). Maximum N, P and K (1.43, 0.28 and 0.42% respectively) concentration was also observed in T8 (Table 14.1). The integrated use of organic, inorganic and foliar also improves the soil health.

Table 14.1; Effect of integrated nutrient management on maize grain yield and Macronutrients concentration

Treatments	Grain yield	Macronutrients Concentration (Maize Grain) (%)		
	(t/ha)	N	P	K
T1: Control (no fertilizer)	4.89 b	1.03 d	0.15 a	0.29 c
T2: 100% RD of NPK	6.82 ab	1.35 abc	0.26 a	0.36 ab
T3: 75% of RD of NPK + FYM @ 5 t/ha	6.85 ab	1.34 abc	0.19 a	0.32 bc
T4: 75% of RD of NPK + 2% foliar spray of NPK (30 and 45 DAS)	7.02 a	1.30 c	0.26 a	0.37 ab
T5: 75% of RD of NPK + FYM @ 5 t/ha + 2% foliar spray of NPK (30 and 45 DAS)	6.52 ab	1.38 abc	0.21 a	0.36 ab
T6: 100% of RD of NPK + FYM @ 5 t/ha	7.35 a	1.32 bc	0.25 a	0.33 bc
T7: 100 % of RD of NPK + 2% foliar spray of NPK (30 and 45 DAS)	7.24 a	1.40 ab	0.21 a	0.35 bc
T8: 100% of RD of NPK + FYM @ 5 t/ha + 2% foliar spray of NPK (30 and 45 DAS.	7.47 a	1.43 a	0.28 a	0.42 a
LSD	**4.89**	**0.09**	**0.15**	**0.29**

Wheat Crop

Wheat crop was sown on 15-11-2017 and harvested on 26-04-2018. Before sowing and after harvesting of wheat crop the composite soil samples (0-15 and 15-30 cm depth) were taken and analyzed (Table 14.2)

Table 14.2: Basic Soil Analysis

Depth	ECe	pHs	OM	P	K	B.D.	Texture
(cm)	(dSm^{-1})		(%)	(mg/kg)		(g/cm^3)	
pre-sowing	1.34	7.54	0.76	7.17	165	1.49	Sandy Clay Loam
post-harvesting	1.35	7.62	0.88	8.4	202	1.42	

The soil analysis showed that the field was free from salinity and sodicity hazard and moderate in fertility. With the consecutive use of integrated nutrients the soil fertility status was improved.

Table 14.3: Effect of integrated nutrient management on grain yield of Wheat, and grain N, P and K contents

Treatments	Grain yield	Grain P	Grain K	Grain N
	(t/ha)	(%)		
T1: Control (no fertilizer)	2.22 d	0.15 b	0.36 c	1.81 b
T2: 100% RD of NPK	3.67 abc	0.25 a	0.45 ab	1.91 ab
T3: 75% of RD of NPK + FYM @ 5 t/ha	3.34 c	0.22 ab	0.41 b	1.91 ab
T4: 75% of RD of NPK + 2% foliar spray of NPK (30 and 45 DAS)	3.52 bc	0.23 ab	0.42 b	1.95 ab
T5: 75% of RD of NPK + FYM @ 5 t/ha + 2% foliar spray of NPK (30 and 45 DAS)	3.58 abc	0.21 ab	0.43 ab	2.02 ab
T6: 100% of RD of NPK + FYM @ 5 t/ha	3.90 ab	0.25 a	0.46 ab	2.15 a
T7: 100 % of RD of NPK + 2% foliar spray of NPK (30 and 45 DAS)	3.93 ab	0.26 a	0.45 ab	2.18 a
T8: 100% of RD of NPK + FYM @ 5 t/ha + 2% foliar spray of NPK (30 and 45 DAS.	4.01 a	0.27 a	0.48 a	2.18 a
LSD	0.62	0.14	0.03	0.02

The results (Table 14.3) showed that the highest wheat grain yield (4.01 t ha^{-1}) was observed in the T8 where 100% RD of NPK, FYM and foliar application of fertilizers were used together. Integrated application of nutrients not only improved the crop yield but also improves the nutrient contents of grain and soil health.

15. EFFECT OF TEMPORAL AND DIFFERENTIAL APPLICATION OF NITROGEN AND POTASH ON GROWTH, YIELD AND QUALITY OF MAIZE

To get maximum production the fertilizer requirement, time and method of application is important. To evaluate the response of hybrid maize and wheat to nitrogen and potassium fertilizer management through soil and foliar application at different time this study was conducted at Soil Chemistry Section, Institute of Soil Chemistry and Environmental Sciences, Ayub Agricultural Research Institute Faisalabad to. The six different treatments were tested by using Randomized Complete Block design with three replications.

T1: Control (RD NPK)
T2: N (½ at sowing + 2 % Spray at 30 & 45 DAS) + RD of K
T3: N + K (½ K at sowing + ½ at 30 DAS)
T4: N + K (½ K at sowing + 2 % spray at 30 & 45 DAS)
T5: N (½ at sowing + 2 % Spray at 30 & 45 DAS) + K (½ K at sowing + ½ at 30 DAS)
T6: N (½ at sowing +2%Spray at 30 & 45 DAS) + K (½ at sowing +2 % Spray at 30 & 45 DAS)
Recommended doses of NPK (for maize) = 275-125-75 kg ha^{-1}
Recommended doses of NPK (for wheat) = 120-90-60 kg ha^{-1}

Maize Crop:

The maize crop was sown on 28-07-2017 and was harvested on 09-11-2017. The composite soil samples (0-15 cm depth) was taken before sowing and analyzed (Table 15.1)

Table 15.1: Basic Soil Analysis

Depth	ECe	pHs	OM	P	K	Texture
(cm)	(dSm^{-1})		(%)	(mg/kg)		
0-15	1.58	7.79	0.78	6.7	151	Sandy Clay Loam
15-30	1.35	7.62	0.88	8.4	202	

The soil analysis showed that the field was free from salinity and sodicity hazard, inadequate in O.M., moderate in available P and sufficient in K. The data regarding yield of maize, P and K concentration in maize grain is presented in Table 15.2. The obtained results showed that maximum grain yield (7.29 t/ha) and K in grain (0.38 %) were obtained where recommended N applied and K was applied half at sowing as soil application and 2 % spray at 30 & 45 days after sowing. The minimum grain yield (5.39 t/ha) was obtained in control (RD NPK-fertilizer).

Table 15.2: Effect of soil and foliar application of N & K on maize Grain yield, N, P, K, Crud protein and Crud Fiber

Treatments	Yield	P	K	N	Crude Protein	Crude Fiber
	(t/ha)	(%)				
T1: Control (RD NPK)	5.39 d	0.2	0.31 bcd	0.46 AB	2.85 ab	1.70 c
T2: N (½ at sowing + 2 % Spray at 30 & 45 DAS) + RD of K	5.49 cd	0.16	0.28 cd	0.41 BC	2.57 bc	1.89 b
T3: N + K (½ K at sowing + ½ at 30 DAS)	6.01 c	0.19	0.27 d	0.33 D	2.06 d	1.73 bc
T4: N + K (½ K at sowing + 2 % Spray at 30 & 45 DAS)	7.29 a	0.22	0.38 a	0.39 CD	2.44 cd	1.87 b
T5: N (½ at sowing + 2 % Spray at 30 & 45 DAS) + K (½ K at sowing + ½ at 30 DAS)	6.62 b	0.2	0.32 bc	0.38 CD	2.39 cd	2.20 a
T6: N (½ at sowing +2% Spray at 30 & 45 DAS) + K (½ at sowing +2 % Spray at 30 & 45 DAS)	5.68 cd	0.2	0.34 ab	0.49 A	3.05 a	1.45 d
LSD	0.57	NS	0.049	0.064	0.4	0.16

The results reveled that maximum nitrogen in maize grain (0.49 %) and crude protein (3.05 %) was observed in T6 where half N and K at sowing while 2 % spray of N and K were applied at 30 & 45 DAS. Maximum fiber (2.20 %) was obtained in T5 where half N and K was applied at sowing while half K applied 30 DAS and 2 % spray of N at 30 and 45 DAS.

Wheat Crop:

The wheat crop was sown on 22-11-2017 and harvested on 24-04-2018. The composite soil samples (0-15 and 15-30 cm depth) were taken before sowing.

Table 15.3: Pre-sowing Soil Analysis

Depth	ECe	pHs	OM	Av. P	Av. K	Texture
(cm)	(dSm^{-1})		(%)	(mg/kg)		
0-15	1.11	7.62	0.99	22.8	188	Sandy Clay Loam
15-30	1	7.58	0.68	14.4	149	

The soil analysis (Table 4) showed that the field was free from salinity and sodicity hazard, inadequate in O.M., moderate in available P and K. The data regarding yield of wheat and K concentration in wheat grain is presented in Table 15.4. The obtained results showed that maximum grain (4.10 t/ha) yield and maximum P contents (0.42 %) were obtained where recommended N and K was applied half at sowing as soil application and 2 % spray at 30 & 45 days after sowing. The minimum grain yield (3.26 t/ha) was obtained in T1 (Control).

Table 15.4: Effect of soil and foliar application of N & K on maize Grain yield, N, P, K, Crud protein and Crud Fiber

Treatments	Yield	N	P	K	Crude Protein	Crude Fiber
	(t/ha)	(%)				
T1: Control (RD NPK)	3.26 c	1.62	0.38 ab	0.46 c	10.16	1.04
T2: N (½ at sowing + 2 % Spray at 30 & 45 DAS) + RD of K	3.75 b	1.69	0.40 ab	0.54 abc	10.57	1
T3: N + K (½ K at sowing + ½ at 30 DAS)	3.69 b	1.66	0.40 ab	0.49 bc	10.41	0.91
T4: N + K (½ K at sowing + 2 % Spray at 30 & 45 DAS)	4.10 a	1.61	0.42 a	0.50 bc	10.03	0.93
T5: N (½ at sowing + 2 % Spray at 30 & 45 DAS) + K (½ K at sowing + ½ at 30 DAS)	3.27 c	1.54	0.38 ab	0.57 ab	9.63	1
T6: N (½ at sowing +2% Spray at 30 & 45 DAS) + K (½ at sowing +2 % Spray at 30 & 45 DAS)	4.03 a	1.68	0.38 b	0.62 a	10.5	0.94
LSD	0.12	NS	0.041	0.1	ns	ns

16. INFLUENCE OF SULPHUR ON THE OIL QUALITY OF HYBRID MAIZE

Sulphur is secondary element, along with Mg and Ca, but it is sometimes called “the 4th major nutrient”. Some crops can take up as much S as P. Sulfur has become more important as a limiting nutrient in crop production. This study was planned to find the effect of suplhur on the quality of oil of oil seed crops. 5 treatments and 3 replications were tested in RCBD.

Treatments:

T1: Control

T2: Rd NPK

T3: Rd NPK+ S (5 kg/ha)

T4: Rd NPK+ S (10kg/ha)

T5: Rd NPK+ S (15 kg/ha)

Maize Crop:

The maize crop was sown on 8-08-2017 and was harvested on 13-11-2017. Soil of Soil chemistry farm area was analyzed for Sulphur contents. The field selected was deficient in Sulphur. Ammonium sulphate was applied to the soil as a source of sulphur. The composite soil samples (0-15 and 15-30 cm depth) were taken before the application of Sulphur and analyzed (Table 16.1)

Table 16.1: Pre-sowing soil analysis

Depth	**pH**	**ECe**	**Organic matter**	**Av. P**	**Av. K**	**Av. S**	**Texture**
(cm)		**(dS/m)**	**(%)**	**(mg/kg)**			
0-15	7.21	1.29	0.87	8.03	276	11	Sandy clay loam
15-30	7.09	1.24	0.79	8.14	220	13	

The soil analysis showed that the field was free from salinity and sodicity hazard, inadequate in OM, adequate in available phosphorus and potassium and deficient in sulphur.

The data regarding yield of maize and oil contents is presented in Table16.2. The results showed that maximum grain yield (4.98 t/ha) was obtained in T3 where 5 kg S was applied along with recommended fertilizer. The minimum grain yield (4.06 t/ha) was obtained in control. Maximum oil contents (5.53 %) were also observed in T5 while minimum oil contents (4.23 %) were found in control.

Table 16.2: Effect of Sulphur on grain yield and oil contents %

Treatment	**Grain Yield**	**Oil (grain)**
	(t/ha)	**(%)**
T1: Control	4.06 B	4.23 B
T2: Rd NPK	4.77 AB	4.43 B
T3: Rd NPK+ S (5 kg/ha)	4.98 A	4.80 B
T4: Rd NPK+ S (10kg/ha)	4.65 AB	4.76 B
T5: Rd NPK+ S (15 kg/ha)	4.56 AB	5.53 A
LSD	0.9	0.066

Canola

Canola crop was sown on 01-10-17 and was harvested on 27-03-2018. The composite soil samples (0-15 and 15-30 cm depth) were taken before sowing and analyzed (Table 16.3)

Table 16.3: Pre-sowing soil analysis

Depth	pH	ECe	Organic matter	Av. P	Av. K	Av. S	Texture
(cm)		(dS/m)	(%)	(mg/kg)			
0-15	8.21	1.31	0.77	7.53	230	10	Sandy clay loam
15-30	7.9	1.12	0.71	7.24	200	12	

The soil analysis showed that the field was free from salinity and sodicity hazard, inadequate in O.M., adequate in available phosphorus, potassium and sulphur. The data regarding yield and oil contents of canola is presented in table 16.4. The results showed that maximum grain yield (1.83 t ha^{-1}) was obtained in the treatment where 15 kg ha^{-1} S was applied with recommended fertilizer. The minimum grain yield (1.36 t ha^{-1}) was obtained in control.

Table 16.4: Effect of Sulphur on grain yield and oil contents %

Treatment	Grain Yield	Oil
	(t/ha)	(%)
T1: Control	1.36 D	40.6
T2: Rd NPK	1.62 BC	42.6
T3: Rd NPK+ S (5 kg/ha)	1.53 C	41.9
T4: Rd NPK+ S (10kg/ha)	1.75 AB	41.7
T5: Rd NPK+ S (15 kg/ha)	1.83 A	43.3
LSD	0.14	NS

The data reveled that maximum oil %age (43.3%) was obtained in the treatment where 15 kg S was applied Sulphur was applied.

17. EFFECT OF PHOSPHORUS AND ZINC APPLICATION AT TWO DIFFERENT GROWTH STAGES ON PHYTIN CONTENTS IN RICE GRAIN

Phosphorus is an essential element classified as a macronutrient because relatively large amount of P is required by plants. But most of the phosphates applied to the wheat convert to phytic acid (Phytate) which is not digestible to humans or non-ruminant animals. This study was planned to determine the best combination and time of phosphorus and zinc application to reduce phytin contents and improve Zn in rice/wheat grain.

RICE

Prior to sowing, the composite soil samples from 0-15 and 15-30 cm depths were collected and analyzed. Pre-sowing soil analysis (Table 17.1) showed that the field was free from salinity and sodicity hazards with low organic matter status, moderate in available P and adequate in available K.

Table 17.1: Pre-sowing Soil Analysis

Soil depth (cm)	pHs	ECe (dS m^{-1})	Av. P (mg/kg)	Av. K (mg/kg)	O.M (%)	Texture
0-15	7.9	1.45	7.9	163	0.67	Sandy clay loam
15-30	7.8	1.39	7.1	158	0.53	

Treatments

T1: Control
T2: P @ 60 kg/ha + Zn@ 5 kg ha^{-1}
T3: P @ 90 kg/ha+ Zn @ 5 kg ha^{-1}
T4: P @ 120 kg/ha + Zn @ 5 kg ha^{-1}
T5: P @ 60 kg/ha+ Zn @ 10 kg ha^{-1}
T6: P @ 90 kg/ha+ Zn @ 10 kg ha^{-1}
T7: P @ 120 kg/ha+ Zn @ 10 kg ha^{-1}

The recommended rate of NPK for wheat = 150-90-60 kg ha^{-1}.

The data presented in Table 17.2 indicated that the maximum paddy yield (4.80 t ha^{-1}) was obtained in the T7 where P @ 120 kg ha^{-1}+ Zn @ 5 kg ha^{-1} was applied at booting stage which was significantly more effective than all other treatment combinations. It was also observed that Zn application at tillering and booting stage had effect on yield of rice.

Table 17.2: Rice paddy yield (t ha^{-1}) after the application of Zn at two different growth stages

Treatments	Paddy Yield (t/ha)		
	Tillering	Booting	Mean
T1: Control	2.99 G	3.22 G	3.11 D
T2: P @ 60 kg/ha + Zn@ 5 kg ha^{-1}	4.00 F	4.10 EF	4.05 C
T3: P @ 90 kg/ha+ Zn @ 5 kg ha^{-1}	4.53 BC	4.47 CD	4.50 A
T4: P @ 120 kg/ha + Zn @ 5 kg ha^{-1}	3.90 F	4.80 A	4.35 B
T5: P @ 60 kg/ha+ Zn @ 10 kg ha^{-1}	4.20 E	4.60 BC	4.40 AB
T6: P @ 90 kg/ha+ Zn @ 10 kg ha^{-1}	4.30 DE	4.50 CD	4.40 AB
T7: P @ 120 kg/ha+ Zn @ 10 kg ha^{-1}	3.97 F	4.75 AB	4.36 B
Mean	3.98 B	4.35 A	
LSD Treatment	0.122		
LSD Group	0.173		

Data presented in table 17.3 showed that maximum P (0.55 mg/kg) was found in T6 and T7 when Zn was applied at booting stage and minimum value of P (0.29 mg/kg) was obtained in rice paddy in T1.

Table 17.3: P in Rice paddy (mg/kg) after the application of Zn at two different growth stages

Treatments	Phosphorus in Rice paddy (mg/kg)		
	Tillering	Booting	Mean
T1: Control	0.29 G	0.32 G	0.31 D

T2: P @ 60 kg/ha + Zn@ 5 kg ha^{-1}	0.48 DE	0.53 AB	0.53 AB
T3: P @ 90 kg/ha+ Zn @ 5 kg ha^{-1}	0.47 E	0.54 AB	0.51 B
T4: P @ 120 kg/ha + Zn @ 5 kg ha^{-1}	0.41 F	0.52 ABC	0.47 C
T5: P @ 60 kg/ha+ Zn @ 10 kg ha^{-1}	0.49 CDE	0.53 AB	0.51 AB
T6: P @ 90 kg/ha+ Zn @ 10 kg ha^{-1}	0.49 CDE	0.55 A	0.52 AB
T7: P @ 120 kg/ha+ Zn @ 10 kg ha^{-1}	0.51 BCD	0.55 A	0.53 A
Mean	0.45 B	0.51 A	
LSD Treatment	0.0241		
LSD Group	0.0341		

Table 17.4 shows data regarding Zn concentration in rice paddy. Maximum Zn contents (13.8 mg/kg) were present in T6 with P @ 90 kg ha^{-1}+ Zn @ 10 kg ha^{-1}at booting stage while control of tillering i.e. RD NPK has minimum amount of Zn (4.03 mg/kg) in rice paddy. Mean values of Zinc in rice paddy at tillering and booting stage are significantly different with more zinc uptake at tillering stage.

Table 17.4: Zinc in Rice paddy (mg/kg) after the application of Zn at two different growth stages

Treatments	**Zinc in Rice paddy (mg/kg)**		
	Tillering	**Booting**	**Mean**
T1: Control	4.03 L	5.03 K	4.53 G
T2: P @ 60 kg/ha + Zn@ 5 kg ha^{-1}	8.07 J	8.52 I	8.29 F
T3: P @ 90 kg/ha+ Zn @ 5 kg ha^{-1}	11.2 F	9.17 H	10.1 E
T4: P @ 120 kg/ha + Zn @ 5 kg ha^{-1}	13.0 B	12.5 C	12.7 B
T5: P @ 60 kg/ha+ Zn @ 10 kg ha^{-1}	11.0 G	12.0 D	11.5 D
T6: P @ 90 kg/ha+ Zn @ 10 kg ha^{-1}	13.0 B	13.8 A	13.4 A
T7: P @ 120 kg/ha+ Zn @ 10 kg ha^{-1}	12.6 C	11.3 E	11.9 C
Mean	10.4 A	10.3 B	
LSD Treatment	0.0653		
LSD Group	0.0924		

Table 17.5 shows the phytin content in rice paddy. Minimum Phytin contents (1.11%) were found in T3 where P @ 90 kg ha^{-1}+ Zn @ 5 kg ha^{-1} were applied at tillering stage, while control of tillering stage has Phytin content (1.12 %) and rest of all the treatments at both stages.

Table 17.5: Phytin content in Rice paddy (%) after the application of Zn at two different growth stages

Treatments	**Phytin content in Rice paddy (%)**		
	Tillering	**Booting**	**Mean**
T1: Control	1.12 G	1.24 EF	1.18 D
T2: P @ 60 kg/ha + Zn@ 5 kg ha^{-1}	1.31 CDE	1.37 BC	1.34 B
T3: P @ 90 kg/ha+ Zn @ 5 kg ha^{-1}	1.11 G	1.28 DE	1.19 D
T4: P @ 120 kg/ha + Zn @ 5 kg ha^{-1}	1.35 CD	1.18 FG	1.27 C
T5: P @ 60 kg/ha+ Zn @ 10 kg ha^{-1}	1.29 CDE	1.47 A	1.38 B

T6: P @ 90 kg/ha+ Zn @ 10 kg ha^{-1}	1.52 A	1.53 A	1.53 A
T7: P @ 120 kg/ha+ Zn @ 10 kg ha^{-1}	1.44 AB	1.24 EF	1.34 B
Mean	1.31 A	1.33 A	
LSD Treatment	0.0525		
LSD Group	0.0743		

WHEAT

Wheat crop was sown on 23.11.2017 and was harvested on 03.05.2018. Prior to sowing the composite soil samples from 0-15 cm depth, were collected and analyzed. Basic soil analysis showed that the field was free from salinity and sodicity hazards with low organic matter status and was marginal in available P and adequate in available K.

Table 17.6: Basic Soil Analysis

Soil depth (cm)	pHs	ECe (dS m-1)	Av. P (mg/kg)	Av. K (mg/kg)	O.M (%)	Texture
0-15	7.8	1.57	7.3	186	0.79	Sandy clay loam

Treatments

T1: Control
T2: P @ 60 kg/ha + Zn@ 5 kg ha^{-1}
T3: P @ 90 kg/ha+ Zn @ 5 kg ha^{-1}
T4: P @ 120 kg/ha + Zn @ 5 kg ha^{-1}
T5: P @ 60 kg/ha+ Zn @ 10 kg ha^{-1}
T6: P @ 90 kg/ha+ Zn @ 10 kg ha^{-1}
T7: P @ 120 kg/ha+ Zn @ 10 kg ha^{-1}

The recommended rate of NPK for wheat was 120-90-60 kg ha^{-1}.

The data presented in Table 17.7 indicated that the maximum grain yield (4.33 t ha^{-1}) was obtained in the T4 where P @ 120 kg ha^{-1}+ Zn @ 5 kg ha^{-1} were applied which was significantly more effective than all other treatment combinations. It was also observed that Zn application at tillering and booting stage showed no effect on yield of wheat.

Table 17.7: Wheat yield (t ha^{-1}) after the application of Zn at two different growth stages

Treatments	Wheat Yield		
	Tillering	Booting	Mean
T1: Control	1.12 G	1.24 EF	1.18 D
T2: P @ 60 kg/ha + Zn@ 5 kg ha^{-1}	1.31 CDE	1.37 BC	1.34 B
T3: P @ 90 kg/ha+ Zn @ 5 kg ha^{-1}	1.11 G	1.28 DE	1.19 D
T4: P @ 120 kg/ha + Zn @ 5 kg ha^{-1}	1.35 CD	1.18 FG	1.27 C
T5: P @ 60 kg/ha+ Zn @ 10 kg ha^{-1}	1.29 CDE	1.47 A	1.38 B
T6: P @ 90 kg/ha+ Zn @ 10 kg ha^{-1}	1.52 A	1.53 A	1.53 A
T7: P @ 120 kg/ha+ Zn @ 10 kg ha^{-1}	1.44 AB	1.24 EF	1.34 B
Mean	1.31 A	1.33 A	

LSD Treatment	0.053
LSD Group	0.074

The data presented in Table 17.8 indicated that the maximum phosphorus (0.49 mg/kg) was obtained in the T5 where P @ 60 kg ha^{-1}+ Zn@ 10 kg ha^{-1} were applied at booting stage which was significantly more effective than all other treatment combinations. It was also observed that Zn application at tillering and booting stage showed no effect on P concentration in wheat.

Table 17.8: Phosphorus (mg/kg) in Wheat after the application of Zn at two different growth stages

Treatments	Phosphorus (mg/kg) in Wheat Grain		
	Tillering	**Booting**	**Mean**
T1: Control	0.22 G	0.24 FG	0.23 E
T2: P @ 60 kg/ha + Zn@ 5 kg ha^{-1}	0.32 D	0.32 DE	0.32 C
T3: P @ 90 kg/ha+ Zn @ 5 kg ha^{-1}	0.51 A	0.48 AB	0.49 A
T4: P @ 120 kg/ha + Zn @ 5 kg ha^{-1}	0.27 EF	0.26 FG	0.26 DE
T5: P @ 60 kg/ha+ Zn @ 10 kg ha^{-1}	0.44 B	0.49 A	0.47 A
T6: P @ 90 kg/ha+ Zn @ 10 kg ha^{-1}	0.38 C	0.37 C	0.38 B
T7: P @ 120 kg/ha+ Zn @ 10 kg ha^{-1}	0.28 DEF	0.31 DE	0.29 CD
Mean	0.346 A	0.353 A	
LSD Treatment	0.034		
LSD Group	0.048		

Table 17.9 shows data regarding Zn concentration in wheat. Maximum concentration of Zn (31.8 mg/kg) was observed in T2 with P @ 60 kg/ha+ Zn @ 5 kg ha^{-1}at booting stage, while control of tillering stage has minimum amount of Zn (21 mg/kg) in wheat.

Table 17.9: Zinc (mg/kg) in Wheat after the application of Zn at two different growth stages

Treatments	Zinc (mg/kg) in Wheat		
	Tillering	**Booting**	**Mean**
T1: Control	21.0 F	24.9 CDE	23.0 D
T2: P @ 60 kg/ha + Zn@ 5 kg ha^{-1}	24.2 CDE	31.8 A	28.0 A
T3: P @ 90 kg/ha+ Zn @ 5 kg ha^{-1}	23.8 DE	28.1 B	26.0 BC
T4: P @ 120 kg/ha + Zn @ 5 kg ha^{-1}	23.2 EF	25.1 CDE	24.1 CD
T5: P @ 60 kg/ha+ Zn @ 10 kg ha^{-1}	26.2 BCD	27.9 B	27.1 AB
T6: P @ 90 kg/ha+ Zn @ 10 kg ha^{-1}	26.5 BCD	28.3 B	27.4 AB
T7: P @ 120 kg/ha+ Zn @ 10 kg ha^{-1}	26.8 BC	28.1 B	27.4 AB
Mean	24.5 B	27.8 A	
LSD Treatment	1.873		
LSD Group	2.652		

Table 17.1 shows the phytin content in wheat. Minimum Phytin content (0.23 %) was observed in T5 P @ 60 kg ha^{-1}+ Zn @ 10 kg ha^{-1}at tillering stage, while rest of all treatments has higher phytin content trend. Mean values of Phytin content at tillering and booting showed variation with lesser phytin content at tillering stage.

Table 17.10: Phytin content (%) in wheat after the application of Zn at two different growth stages

Treatments	Phytin content (%) in wheat		
	Tillering	**Booting**	**Mean**
T1: Control	0.38 A	0.36 A	0.37 A
T2: P @ 60 kg/ha + Zn@ 5 kg ha^{-1}	0.31 B	0.27 CD	0.29 B
T3: P @ 90 kg/ha+ Zn @ 5 kg ha^{-1}	0.25 DE	0.29 BC	0.27 C
T4: P @ 120 kg/ha + Zn @ 5 kg ha^{-1}	0.24 E	0.28 C	0.26 CD
T5: P @ 60 kg/ha+ Zn @ 10 kg ha^{-1}	0.23 E	0.29 BC	0.26 CD
T6: P @ 90 kg/ha+ Zn @ 10 kg ha^{-1}	0.25 DE	0.27 CD	0.26 CD
T7: P @ 120 kg/ha+ Zn @ 10 kg ha^{-1}	0.23 E	0.27 CD	0.25 D
Mean	0.27 B	0.29 A	
LSD Treatment	0.0171		
LSD Group	0.0241		

FERTILIZER AND SOIL HEALTH

18. EFFECT OF GREEN MANURING ON SOIL PHYSICO-CHEMICAL PROPERTIES UNDER RICE-BERSEEM CROPPING PATTERN

Green manuring is recognized as additive of organic matter thereby improving aeration and water holding capacity of soil. It also enriches the soil with organic matter and nitrogen hence improving crop production. Barseem (Trifolium elexandrium) is such a green manure crop which also serves as a fodder. So, incorporation of barseem as rabi crop in our cropping patterns may improve physico-chemical properties of soil. Therefore, this study was planned to assess the effect of green manuring on soil physico-chemical properties under rice-barseem cropping pattern. For this purpose, 5 treatments and 3 replications in Randomized Complete Block Design were tested in rice and barseem cropping system:

Treatments

T1: Control

T2: Recommended NPK

T3: Recommended NPK + green manuring

T4: 75 % of recommended NPK + green manuring

T5: 50 % of recommended NPK + green manuring

Treatments were replicated three times following. Prior to experimentation, composite soil samples were analyzed for various physical and chemical characteristics as given in Table 18.1. Pre-sowing soil analysis indicated that experimental site had sandy clay loam texture and free of salinity and sodicity problem, deficient in available phosphorous and organic matter while sufficient in available potassium.

Table 18.1: Basic Soil Analysis

Depth	pH	ECe	CEC	Organic carbon	Organic matter	Av. P	Av. K	Bulk density	Porosity	Texture
(cm)		(dS m^{-1})	($cmol_c$ kg^{-1})	(g kg^{-1})	(%)	(mg kg^{-1})		(g cm^{-3})	(%)	
0-15	7.67	1.43	5.5	0.8	0.67	5.7	156.3	1.66	42.4	Sandy clay loam
15-30	7.62	2.42	5.32	0.8	0.55	5	152.1	1.59	44.2	

RICE

Rice (Basmati super) was transplanted on 13-07-2018 and harvested on 30-10-2018. All the fertilizers were applied according to the plan. All phosphorous and potassium was applied before transplanting while nitrogen was broadcasted in two splits. Crop was irrigated as per requirement to ensure water stand. Pendimethalin, Cypermetharin, and furadon were applied to control pests. The results given in Table 18.2 indicated that the maximum rice paddy yield (4.41 t ha^{-1}) was obtained in T4 where 75% of the recommended dose of fertilizer was applied along with green manuring, while minimum paddy yield (2.07 t ha^{-1}) was obtained in control (T1). The results also showed maximum rice straw yield (15.1 t ha^{-1}) was obtained in T3 where 100% of the recommended dose of NPK was applied along with green manuring, while minimum straw yield (8.33 t ha^{-1}) was obtained in control (T1). T4 with 75% of recommended NPK + green manuring followed T3 in producing paddy and straw yield i.e. 4.41 and 14.96 t ha^{-1}, respectively.

Table 18.2: Effect of Green Manuring on Rice Paddy and Straw yield

Treatments	Paddy Yield	Straw Yield
	(t ha^{-1})	
T1: Control	2.07 d	8.33 c
T2: NPK without green manuring	3.37 c	13.84 b
T3: Recommended NPK + green manuring	3.98 b	15.07 a
T4: 75% of recommended NPK + green manuring	4.41 a	14.96 a
T5: 50% of recommended NPK + green manuring	3.48 c	13.55 b
LSD	0.22	0.96

BARSEEM

Barseem was sown on 10-11-2017. After taking four cuttings, the barseem on attaining full vegetative growth was incorporated into the soil according to the treatment plan on 6-05-2018. Pre-sowing soil analysis performed after harvesting of rice and before the sowing of barseem revealed that, soil was deficient in organic matter and phosphorous while potassium was present in sufficient quantity (Table 18.3).

All the fertilizers were applied according to the plan. All the nitrogen and phosphorous was applied at the time of seed bed preparation in the respective plots. The results shown in Table 18.4 indicated that maximum barseem biomass (105 t ha^{-1} and 105 t ha^{-1}) was obtained in T_3 and T_4 while minimum barseem biomass (56 t ha^{-1}) was obtained in control (T_1).

Table 18.3: Soil analysis before sowing of Barseem from 0-15 cm depth

Treatments	pH	BD	Porosity	OM	Av. P	Av. K
		(g cm^{-3})	(%)		(mg/kg)	
T1: Control	7.89	1.49	42.1	0.5	5.3	139
T2: NPK without green manuring	7.69	1.49	43.1	0.54	5.9	117
T3: Recommended NPK + green manuring	7.77	1.44	43.4	0.75	7.9	168
T4: 75% of recommended NPK + green manuring	7.9	1.44	44	0.81	7.8	163
T5: 50% of recommended NPK + green manuring	7.85	1.43	46	0.71	6.08	175

Table 18.4: Effect of Green Manuring on Barseem yield

Treatments	Berseem Yield (t ha^{-1})
T1: Control	56 d
T2: NPK without green manuring	87 b
T3: Recommended NPK + green manuring	105 a
T4: 75% of recommended NPK + green manuring	100 a
T5: 50% of recommended NPK + green manuring	78 c
LSD	2.4

19. QUANTIFY THE ROLE OF MACRONUTRIENTS IN MICRO NUTRIENTS REMOVAL FROM THE FARM MANURE UNDER FIELD CONDITIONS

Cereals and vegetables are very important component of human diet with many beneficial effects. Despite of their importance, their productivity is very low owing to low soil fertility, poor management practices, limited use of organic fertilizers as well as non-judicious use of chemical fertilizers. Therefore, a field experiment was conducted at farm area of Soil Chemistry Section, Ayub Agricultural Research Institute, Faisalabad to study the micronutrient dynamics (iron, zinc) by using macronutrients along with farm manure on maize (*Zea mays*) and onion (*Allium Cepa* L.) crop.

Treatment:
The eight different treatments (sub plot) were:
T1: Control
T2: Recommended dose (RD) of N
T3: Recommended dose (RD) of P
T4: Recommended dose (RD) of K
T5: Recommended dose (RD) of NP
T6: Recommended dose (RD) of NK
T7: Recommended dose (RD) of KP
T8: Recommended dose (RD) of NPK
The two main plots were:
1: Without Farm Yard Manure (FYM)
2: With Farm Yard Manure (FYM)
Recommended NPK (for maize) = 275-125-75 kg ha^{-1}
Recommended NPK (for onion) = 130-50-100 kg ha^{-1}
Pioneer 30Y87 (maize) and Phulkara (onion) varieties were sown. Experimental design was split plot randomized block design with three replications. Soil samples were taken at two depth 0-15 cm and 15-30 cm and analyzed for basic soil properties. Analysis results (Table 19.1) showed that organic matter was 0.93%, iron 4.02 mg/kg and zinc 1.64 mg/kg in surface soil while 0.62%, 2.94 mg/kg, and 0.49 mg/kg respectively in subsurface soil.

Table 19.1: Pre-sowing soil analysis

Depth	pH	ECe	Organic matter	Av. P	Av. K	Fe	Zn	Texture
(cm)		(dS/m)	(%)	(mg/kg)				
0-15	7.53	1.77	0.93	8.5	202.02	4.02	1.64	Sandy clay loam
15-30	7.63	1.6	0.62	6.6	114.47	2.94	0.49	

Maize Crop:
The data regarding the grain yield of maize in Table 19.2 showed that maximum grain yield (7.14 t ha^{-1}) was observed in T8 where recommended dose of NPK along with farm yard manure was applied followed by T5 receiving recommended dose of NP along with farm yard manure (6.77 t/ha). The minimum grain yield (3.94 t/ha) was obtained in control (no fertilizer and no farm yard manure.

Table 19.2: Effect of farm manure and macronutrients on maize grain yield

Treatments	Grain Yield (t/ha)		Mean
	Without FYM	With FYM	
T1: Control	3.94 g	4.07 g	4.00 F
T2: Recommended dose (RD) of N	5.25 def	5.86 bcde	5.56 CD
T3: Recommended dose (RD) of P	4.59 fg	5.69 cde	5.13 DE
T4: Recommended dose (RD) of K	5.08 ef	4.57 fg	4.82 E
T5: Recommended dose (RD) of NP	6.15 bcd	6.77 ab	6.46 AB
T6: Recommended dose (RD) of NK	5.95 bcde	6.32 abc	6.13 ABC

T7: Recommended dose (RD) of KP	5.30 def	6.29 abc	5.79 BCD
T8: Recommended dose (RD) of NPK	6.46 abc	7.14 a	6.80 A
Mean	5.33 B	5.84 A	
LSD Main plots 0.72			
LSD Subplot (treatments) 0.29			

Results (Table 19.3) showed that maximum Fe concentration (21.7 mg/kg) in grain was obtained in T8 where recommended dose of NPK along with farm yard manure was applied to the crop followed by T5 where recommended dose of NP along with farm yard manure was applied (Table 3). However, lowest Fe concentration (13.2 mg/kg) was observed in T1 where no fertilizer and farm yard manure was applied.

Table19.3: Effect of farm manure and macronutrients on iron concentration in maize grain

Treatments	**Fe concentration in grain (mg/kg)**		**Mean**
	Without FYM	**With FYM**	
T1: Control	13.2 f	14.1 f	13.7 F
T2: Recommended dose (RD) of N	17.6 e	19.7 bcd	18.6 BC
T3: Recommended dose (RD) of P	16.8 e	16.9 e	16.8 D
T4: Recommended dose (RD) of K	13.9 f	16.8 e	15.3 E
T5: Recommended dose (RD) of NP	18.1 cde	21.0 ab	19.5 AB
T6: Recommended dose (RD) of NK	17.8 de	18.3 cde	18.0 CD
T7: Recommended dose (RD) of KP	17.7 de	16.4 e	17.0 D
T8: Recommended dose (RD) of NPK	20.0 abc	21.7 a	20.9 A
Mean	16.9 B	18.1 A	
LSD Main plots (with and without farm manure) 1.00			
Subplot (treatments) 1.38			

Analysis results regarding zinc concentration in maize grain showed that maximum zinc concentration (27.9 mg/kg) in grain was obtained in T8 where recommended dose of NPK along with farm yard manure was applied to the crop followed by treatment receiving recommended dose of NPK (26.4 mg/kg) (Table 19.4). Moreover treatment receiving farm manure along with NP showed 21.0 mg/kg Zn concentration.

Table19.4: Effect of farm manure and macronutrients on zinc concentration in maize grain

Treatments	**Zn concentration in grain (mg/kg)**		**Mean**
	Without FYM	**With FYM**	
T1: Control	17.9 j	18.4 ij	18.2 E
T2: Recommended dose (RD) of N	24.5 bcde	26.1 abc	25.3 B
T3: Recommended dose (RD) of P	20.9 gh	19.6 hij	20.3 D
T4: Recommended dose (RD) of K	23.1 def	24.2 cde	23.6 C
T5: Recommended dose (RD) of NP	21.5 fgh	24.9 bcd	23.2 C
T6: Recommended dose (RD) of NK	26.0 abc	27.1 a	26.6 AB
T7: Recommended dose (RD) of KP	22.5 fg	20.3 hi	21.4 D

T8: Recommended dose (RD) of NPK	26.4 ab	27.9 a	27.1 A
Mean	22.8 B	23.2 A	
LSD Main plots (with and without farm manure) 1.00			
Subplot (treatments) 1.38			

Onion Crop:

The data regarding bulb yield in Table 19.5. showed that maximum bulb yield (20.6 t ha^{-1}) was observed in the treatment receiving recommended dose of NPK along with farm yard manure followed by treatment receiving recommended dose of NPK (19.5 t ha^{-1}) and treatment receiving recommended dose of KP along with farm manure (18.9 t ha^{-1}). The minimum grain yield (14.7tha^{-1}) was obtained in control (no fertilizer and no farm yard manure).

Table 19.5: Effect of farm manure and macronutrients on bulb yield of onion

Treatments	Bulb Yield (t ha^{-1})		Mean
	Without FYM	**With FYM**	
T1: Control	14.7 i	15.0 i	14.8 E
T2: Recommended dose (RD) of N	16.1 h	17.2 efg	16.6 C
T3: Recommended dose (RD) of P	15.1 i	16.8 fgh	15.9 D
T4: Recommended dose (RD) of K	16.6 gh	17.1 efg	16.8 C
T5: Recommended dose (RD) of NP	17.1 efg	18.5 cd	17.8 B
T6: Recommended dose (RD) of NK	17.7 def	17.9 de	17.8 B
T7: Recommended dose (RD) of KP	17.3 efg	18.9 bc	18.1 B
T8: Recommended dose (RD) of NPK	19.5 b	20.6 a	20.1 A
Mean	16.8 B	17.8 A	
LSD Main plots (with and without farm manure) 0.66			
LSD Subplot (treatments) 0.56			

Results showed that maximum Fe concentration (107.9 mg/kg) in bulb was obtained in T8 where recommended dose of NPK along with farm yard manure was applied to the crop followed by T5 receiving recommended dose of NP along with farm yard manure (Table 19.6). The minimum Fe contents in bulb (51.8 mg/kg) were observed in control where no fertilizer and farm manure was applied.

Table 19.6: Effect of farm manure and macronutrients on iron content of onion bulb

Treatments	Fe concentration in bulb (mg/kg)		Mean
	Without FYM	**With FYM**	
T1: Control	51.8 j	67.3 i	59.59 F
T2: Recommended dose (RD) of N	84.2 efg	93.3 cd	88.75 C
T3: Recommended dose (RD) of P	79.2 gh	82.8 fg	80.98 D

T4: Recommended dose (RD) of K	57.0 j	74.4 hi	65.71 E
T5: Recommended dose (RD) of NP	96.2 bcd	101.8 ab	99.00 AB
T6: Recommended dose (RD) of NK	92.8 cd	94.8 bcd	93.78 BC
T7: Recommended dose (RD) of KP	91.2 def	92.4 cde	91.78 C
T8: Recommended dose (RD) of NPK	99.8 abc	107.9 a	103.85 A
Mean	81.52 B	89.34 A	
LSD Main plots (with and without farm manure) 5.42			
LSD Subplot (treatments) 5.28			

While, maximum zinc concentration (42.2 mg/kg) in bulb (Table 19.7) was obtained in T8 where recommended dose of NPK along with farm yard manure was applied to the crop followed by T6 where recommended dose of NPK was applied (41.9 mg/kg) while minimum concentration (29.5 mg/kg) was observed in control (no fertilizer, no farm manure).

Table 19.7: Effect of farm manure and macronutrients content on zinc content of onion bulb

Treatments	**Zn concentration in bulb (mg/kg)**		**Mean**
	Without FYM	**With FYM**	
T1: Control	29.5 l	30.1 l	29.8 E
T2: Recommended dose (RD) of N	36.6 fg	38.7 de	37.6 B
T3: Recommended dose (RD) of P	33.6 jk	32.7 k	33.1 C
T4: Recommended dose (RD) of K	35.7 ghi	36.4 fgh	36.2 C
T5: Recommended dose (RD) of NP	34.1 ijk	37.5 ef	35.8 C
T6: Recommended dose (RD) of NK	40.0 cd	41.9 ab	40.9 A
T7: Recommended dose (RD) of KP	35.1 ghij	34.78hij	34.9 C
T8: Recommended dose (RD) of NPK	40.4 bc	42.2 a	41.3 A
Mean	35.6 B	36.8 A	
LSD Main plots (with and without farm manure) 0.72			
LSD Subplot (treatments) 1.77			

20. LONG-TERM EFFECT OF FERTILIZER USE ON SOIL PROPERTIES

The use of chemical fertilizer is indispensable for maximum crop production but it was perceived by the farmers that continuous use of chemical fertilizers would deteriorate the soil health and ultimately reduce the crop yields. This study was started in 1978 on a permanent lay out to assess the long-term effect of fertilizer use on the physical and chemical properties of the soil in intensive cropping system. During 2016-17 maize fodder-wheat crop rotation was followed. This long term study is being conducted at research area of Soil Chemistry Section, ISCES, Faisalabad.

Treatments:

T1: Control
T2: Recommended N
T3: Recommended NP
T4: Recommended NPK
T5: Recommended N from FYM
T6: 1/2 Recommended N from Urea +½FYM-N
T7: 1/2 of Recommended NP

Maize Fodder:

Crop was sown on 22-08-2017 and was harvested on 20-10-2017. Before sowing the crop soil samples were collected from 0-15 cm depth for analysis purposes. Fertilizers NPK were applied @ 136-57-57 kg/ha according to the plan. FYM, calculated on nitrogen basis, was applied in the plots according to the permanent layout. Maize fodder yield and pre-sowing soil analysis is given in Table 20.1.

Table 20.1: Pre-sowing soil analysis (0-15 cm) and Maize Fodder yield

Treatments	Yield (t/ha)	pH	ECe (dS m^{-1})	O.M (%)	P (mg/kg)	K
T1: Control	24.5	7.7	1.4	0.56	7.9	175
T2: Recommended N	35.6	7.8	1.54	0.65	7	190
T3: Recommended NP	43.2	8	1.62	0.7	7.1	200
T4: Recommended NPK	50	7.8	1.55	0.98	7.2	210
T5: Recommended N from FYM	43.3	7.9	1.6	1.1	7.3	220
T6: 1/2 Recommended N from Urea +½FYM-N	44.4	8.1	1.58	1	6.8	210
T7: 1/2 of Recommended NP	40.5	8	1.33	0.8	7.2	200

The pre-sowing soil analysis showed that addition of chemical fertilizer had no adverse effect rather it improved the soil health and fertility status of soil. Fodder yield data showed that use of chemical fertilizer NPK proved better to get higher yields (62.0 t/ha). Maize fodder yield was in the order of NPK >½ N from urea + ½ N from FYM>NP and FYM>1/2NP >N >control.

Wheat Crop:

After harvesting of maize crop, wheat variety Punjab 2011 was sown in same permanent layout on 27-11-2017. The chemical fertilizers and FYM were applied according to the plan. All agronomic practices were followed according to the recommendations. The recommended dose of NPK 120-90-60 kg/ha was applied. The crop was harvested on 24-04-2018. Wheat grain yield data and pre sowing soil analysis is presented in the following Table 20.2.

Table 2: Pre-sowing soil analysis (0-15 cm) and wheat grain yield.

Treatments	Yield (t/ha)	pH	ECe (dS m^{-1})	O.M (%)	P (mg/kg)	K
T1: Control	1.25	8	1.67	0.48	5.5	170
T2: Recommended N	2.71	8.1	1.8	0.53	6.2	240
T3: Recommended NP	3.4	7.9	2	0.6	6.5	200
T4: Recommended NPK	3.5	8	1.6	0.72	7.5	180
T5: Recommended N from FYM	3.15	7.9	1.9	0.99	7.9	190
T6: 1/2 Recommended N from Urea +½FYM-N	3.13	7.9	2	0.78	6.9	210
T7: 1/2 of Recommended NP	3.1	8.1	1.8	0.59	7.2	190

The pre sowing soil analysis indicated that in the plots where various nutrients alone or in combination with each other or even application of FYM alone or in combination were applied; an increase in fertility status as compared to control was observed. P status decreased in all treatments from maize fodder to wheat crop. However maximum wheat grain yield was found in treatment where NPK was applied. Grain yield data of wheat was taken and the order of decrease in grain yield was NPK>NP>FYM.