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INSTITUTE OF SOIL CHEMISTRY & ENVIRONMENTAL SCIENCES

AYUB AGRICULTURAL RESEARCH INSTITUTE FAISALABAD

Contents

(Kharif-2019 & Rabi 2019-20)

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.

II. 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

RESEARCH WORK
SOIL CHEMISTRY

ENVIRONMENTAL POLLUTION

1. HEAVY METAL STATUS OF VEGETABLES AND FODDER IRRIGATED WITH WASTE WATER IN DIFFERENT DISTRICTS OF PUNJAB

Irrigation of vegetable and fodder crop with industrial and domestic wastewater has become common practice in many parts of the Pakistan, especially in suburban areas of Punjab. The use of wastewater on agricultural land has raised the concern of excessive quantity of heavy metals accumulation in plants. Therefore, present survey study was conducted to monitor the heavy metals lead (Pb) cadmium (Cd) and nickel (Ni) content in vegetable and fodder samples irrigated with wastewater in different districts of Punjab during year 2019-2020.

Heavy metal contamination in vegetable and fodder

The heavy metal contamination in vegetable and fodder samples irrigated with wastewater given in Fig. 1.1 showed that 71.4% vegetable and fodder samples were contaminated with Cd, 70.7% Pb, 66.9% with Ni and 33.1% with Cr in different districts of Punjab when compared with permissible limits (Cd: 0.30 mg/kg, Pb: 5.0 mg/kg, Ni: 10.0 mg/kg, Cr: 1.30 mg/kg). The order of contamination in vegetable and fodder samples was Cd>Pb> Ni>Cr.

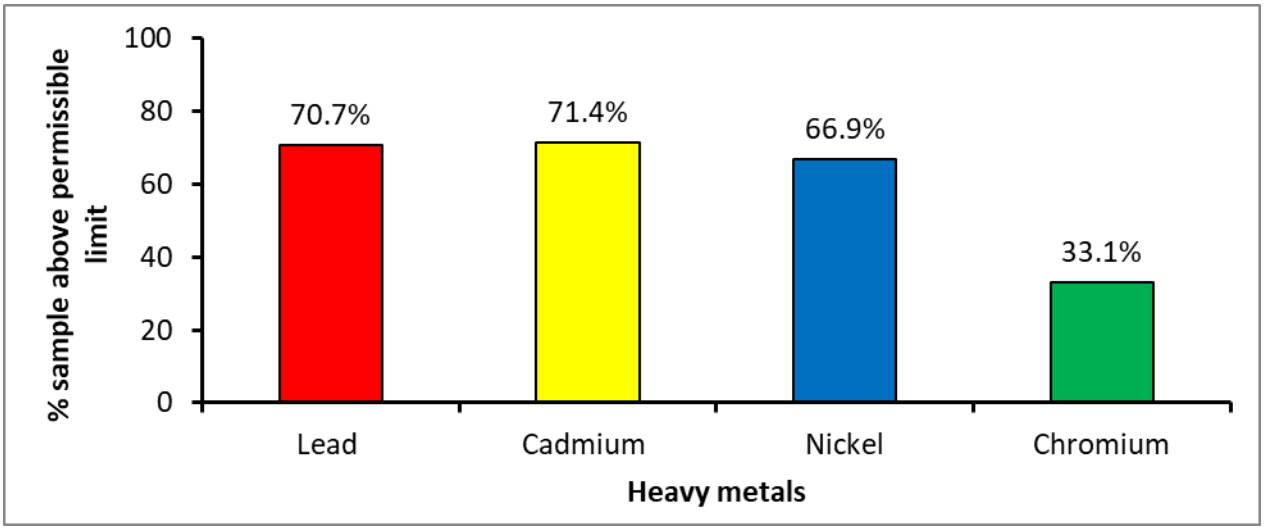

Fig. 1.1: Heavy metal contamination (%) in vegetable and fodder samples of wastewater irrigated areas of Punjab

Heavy metal contamination in soil

The data given in table 1.1 showed that 100% soil samples collected from wastewater irrigated areas of Punjab were contaminated with Cr, 65% with Pb, 62% with Ni and 41% with Cd. Cumulative results of different districts of Punjab showed that sites were found contaminated with Cr followed by Pb, Ni and Cd.

Table 1.1: Heavy metal contamination (%) in soils of wastewater irrigated areas of Punjab

Heavy metal	No. of sample analyzed	% Sample above permissible limit
Lead (Pb)	353	65
Cadmium (Cd)	147	41
Chromium (Cr)	41	100
Nickel (Ni)	195	62
Permissible limits: Pb: 13.0 mg/kg, Cd: 0.30 mg/kg, Ni: 2.6 mg/kg, Cr: 3.8 mg/kg		

Heavy metal contamination in wastewater

Heavy metal pollution in wastewater samples collected from different districts of Punjab revealed that maximum wastewater samples were found contaminated with Cd (Table 1.2). The data also showed that 61% samples were found polluted with Cd, 48% with Ni and 26% with Pb.

Table 1.2: Heavy metal contamination (%) in wastewater collected from different districts of Punjab

Heavy metal	No. of sample analyzed	% Sample above permissible limit
Lead	507	26
Cadmium	220	61
Nickel	257	48
Permissible limits: Pb: 5.0 mg/L, Cd: 0.01 mg/L, Ni: 0.2 mg/L		

2. IDENTIFICATION OF CROPS OTHER THAN VEGETABLE CROPS FOR GROWING UNDER WASTE WATER

Application of wastewater to agricultural land leads to accumulation of potentially toxic element in crops and vegetables which are not safe for human consumption. Keeping in view this issue, survey of wastewater irrigated areas of tehsil Jaranwala district Faisalabad was carried out during year 2018 and 55 vegetable samples were collected from and analyzed for heavy metals (lead, cadmium and nickel). Analysis results (Fig. 2.1) showed that 70% vegetable collected from different location of tehsil Jaranwala district Faisalabad were found contaminated with Cd, 27% Pb and 5% with Ni when compared with permissible limits (Pb: 5.0 mg/kg, Cd: 0.30 mg/kg, Ni: 10.0 mg/kg) . The trend of metal accumulation in vegetables was Cd> Pb>Ni.

Moreover, 57 ornamental, flowering and tree plant samples were also collected form landscape and green belt areas of district Faisalabad (Batala colony, People colony, Samundri road) and analyzed for heavy metals. Results showed that 94% flowering and ornamental plant samples were found contaminated with Cd, 46% Pb while 44% samples were contaminated with heavy metal Ni when compared with the permissible limits (Fig. 2.2). Uptake trend of heavy metals in all the plant samples were Cd> Pb>Ni.

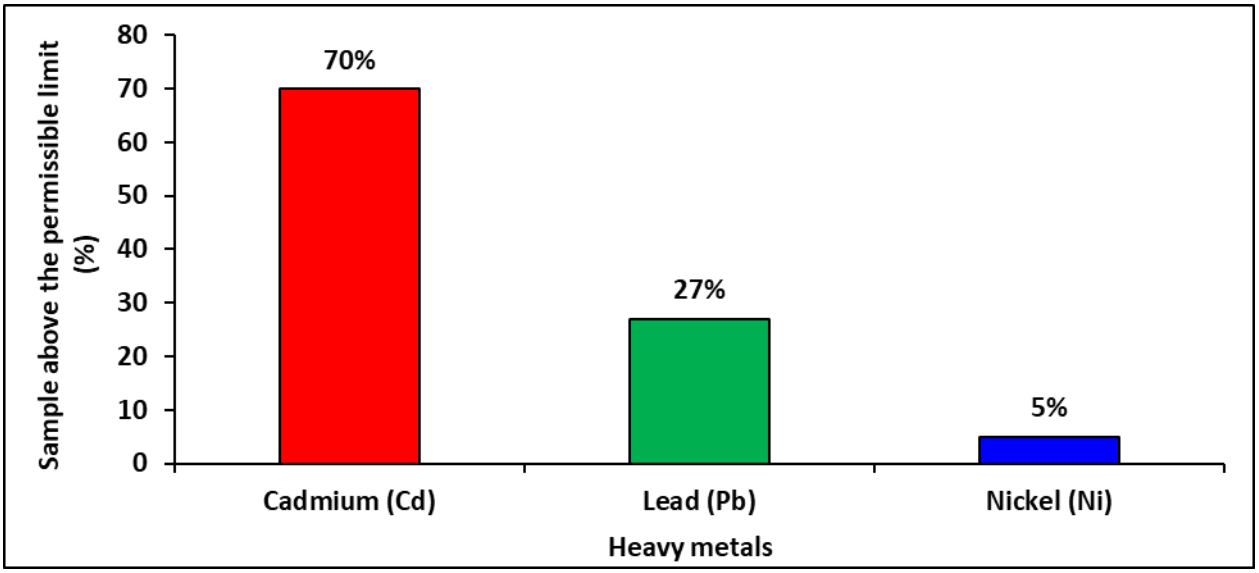

Fig. 2.1: Percentage vegetable samples contaminated with wastewater irrigation in of Faisalabad

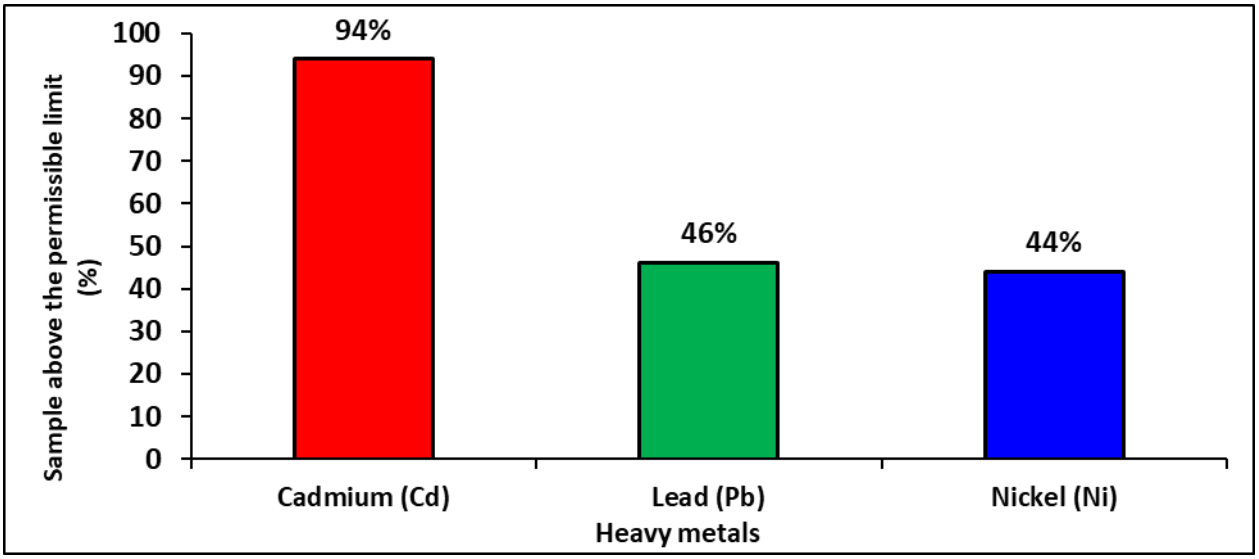

Fig. 2.2: Heavy metal contamination (%) in ornamental plants of Faisalabad

3. 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 108 were collected from different locations in Faisalabad district during kharif 2019. The analysis of samples done for lead (Pb) and cadmium (Cd) and Zinc (Zn), Copper (Cu), Iron (Fe) and Manganese (Mn) as per standard protocol.

Table 3.1: 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
Bitter gourd	0.09-3.04	1.19±0.81	95	0-6.53	2.24±1.46	5
White bringle	0.85-2.93	1.58±0.94	100	0.59-2.97	1.63±1.01	0
Long bringle	0.54-1.58	1.03±0.37	100	2.37-4.15	3.16±0.71	0
Raddish	0.6-1.37	0.91±0.26	100	1.07-7.12	4.57±1.96	38
Turnip	0.67-1.14	0.88±0.18	100	3.56-7.71	5.93±1.77	80
Black bitter gourd	0.57-1.29	0.93±0.50	100	3.22-3.22	3.22±0	0
Black bringle	0.93-1.35	1.09±0.22	100	2.95-3.29	3.13±0.17	0
Safe limit	0.3 ppm			5 ppm		

According to the results substantial amounts of heavy metals (Cd and Pb) found in all vegetable samples while (100%) samples of white bringle, long bringle, raddish, turnip, black bitter gourd and black bringle was above safe limit for cadmium, turnip (80%), radish (38%) and bitter gourd (5%) are above safe limit for lead. while black bitter gourd, black bringle , long bringle and white bringle are under safe limit for lead while on the other hand the micronutrients concentrations were below permissible limits. 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. Total 40 samples collected for different vegetables during rabi season 2019-20.

Table 3.2: Zinc and Copper Iron and Manganese status of different vegetables grown in tunnels in district Faisalabad.

Vegetable	Zn		Cu		Fe		Mn	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Bitter gourd	4.3-37.8	21.6±7.75	0.8-9.5	4.56±2.18	189.9-1068.7	386±230	36.8-94.8	62.5±14.7
White bringle	12.1-22.3	16.4±4.88	1.5-4.7	2.85±1.52	53-2479	223±416	42.4-90.3	66.6±23.5
Long bringle	2.1-28.7	12.8±9.38	0.4-6.7	2.46±2.31	131-1522	585±488	49.2-81.8	63.8±13.2
Radish	3.9-27.9	18.1±8.56	1-6.4	3.67±2	371-653	533±104	42.3-80.7	65.6±11.4
Turnip	12.3-27.3	19.8±6.36	1.5-6.2	3.88±1.99	302-1228	726±358.3	37-89.9	65.5-21.4
Black bitter gourd	4.09-51.5	28.2±12.5	0.98-16.4	6.63±5.85	132-1028	565±264	1.5-143	27.5±47.4
Black bringle	10.7-16.8	13.7±4.31	1.1-2.9	2±1.27	382.9-469.7	426.3±61.3	51.3-52.2	51.7±0.63

4. ARSENIC CONTAMINATION IN RICE GRAIN; A POTENTIAL HAZARD TO THE RICE GROWING AREAS

As is a very dangerous heavy metal and its contamination in groundwater is becoming a worldwide problem. Millions of people are at health risk from As contamination. Therefore, this study is planned during the period from May, 2019 to October 2019 at Soil Chemistry Section, Ayub Agricultural Research Institute (AARI) Faisalabad, to evaluate the As concentration in rice grains in different rice growing areas of Punjab.

For this purpose, rice grains and ground water samples were collected from rice growing areas of Punjab (Gujranwala and Sialkot). Tubewell operated rice fields were selected for collection of samples. At each sampling site, two subsamples of rice grains and straw were collected.

Table 4.1: Arsenic concentration in Ground Water and Rice Grains

Districts	Range/SD	Ground Water	Rice grains
		(ppb)	
Gujranwala	Range	1.0-3.0	2.0-39
	Mean ± SD	2.0±0.003	19.0±0.011
Sialkot	Range	1.0-4.0	3.0-43
	Mean ± SD	1.0±0.004	21.0±0.008
Permissible level FAO 1985, WHO 1989		(0.10 mg/L)	(1.00 mg/kg)

Results (Table 4.1) showed that the concentration of Arsenic in ground water of Gujranwala and Sialkot district was ranged from 1.0-3.0 and 1.0-4.0 ppb, respectively. Results also showed that the Arsenic concentration in rice grains of Gujranwala and Sialkot district varied from 2.0-39 and 3.0-43 ppb, with mean value of 19.0 and 21.0 ppb, respectively. This value is lower than most of the published data from other countries/regions and also from the WHO recommended permissible limit in rice (1.0 mg kg^{-1}).

5. STRUVITE FORMATION FROM THE WASTE WATER (LAB STUDY)

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

Table 5.1: Analysis of wastewater and its molar ratio calculation

Parameters	Unit	Waste water	Sources and quantity used for Molar Ratio per 1 L Waste water		
			NH_4Cl	$MgCl_2.H_2O$	Na_3PO_4
			(g)		
pH	-	6.78	-	2.46	2.67
EC	dSm^{-1}	4.86			
PO_4	(ppm)	39.90			
Mg		20.56			
N		610			
Pb		0.19			
Cd		0.09			
Ni		1.98			
Cr		3.32			
As		0.08			

Solution pH is a key factor that influences the formation of struvite as in study I, maximum struvite formation (0.158 g/L) was observed with pH 9. In study II, it was also found that reaction time affects struvite formation. Over all, maximum struvite formation (0.162 g/ L) was observed on 9 pH, at 60 minutes reaction time and 30°C with molar ratio of NH_4:PO_4:Mg (1:1:1). In struvite, the concentrations of P, Mg and N were 24.17, 9.25 and 6.10 % respectively (Table 5.2).

Table 5.2: Best ratio of pH, Reaction time and Temperature for formation of struvite in 3 studies

Treatment	pH	Reaction time (min)	Temperature (C^0)	Molar Ratio NH_4:PO_4:Mg	Struvite (g)	Conc.in Struvite (%)		
STUDY-I						**N**	**Mg**	**P**
T1	**7**	60	30	1:1:1	**0.004**			
T2	**8**	60	30	1:1:1	**0.063**			
T3	**9**	60	30	1:1:1	**0.158**			
STUDY-II						**6.10**	**9.25**	**24.17**
T1	**9**	30	30	1:1:1	**0.104**			
T2	**9**	60	30	1:1:1	**0.162**			
T3	**9**	90	30	1:1:1	**0.149**			

6. ESTIMATION OF HEAVY METALS FROM CANAL IRRIGATED VS. WASTEWATER IRRIGATED VEGETABLES

Contamination of vegetables with heavy metals may be due to irrigation with water contaminated by industrial and domestic wastes, the addition of fertilizers and metal-based pesticides, as well as from deposits on different parts of the vegetables exposed to the air from polluted environments and application of sludge in vegetable lands. Industrial and

municipal wastewater is mostly used for the irrigation of crops due to its easy availability, disposal problems and shortage of fresh water. In general, the application of wastewater led to changes in the physicochemical characteristics of soil and consequently heavy metal uptake by vegetables. This comparative study was planned to assess the heavy metal status of soils, vegetables and water sources from canal vs. wastewater irrigated vegetables. 80 vegetable samples, 36 soils, 36 water samples were collected from Faisalabad. The heavy metal contamination in vegetable samples irrigated with wastewater given in Fig. 6.1 showed that 82% vegetable samples irrigated with wastewater were found contaminated with Cd, 73% Cr, 15% with Pb and 8% with Ni in Faisalabad district while 71% vegetable samples were contaminated with Cd, 32% Cr, 11% with Pb and 01% with Ni. The permissible limits are (Cr: 1.30 mg/kg, Pb: 5.0 mg/kg, Cd: 0.30 mg/kg, Ni: 10.0 mg/kg). The order of contamination in vegetable samples was Cd>Cr>Pb>Ni both as irrigated with wastewater or canal water but more samples were contaminated due to wastewater.

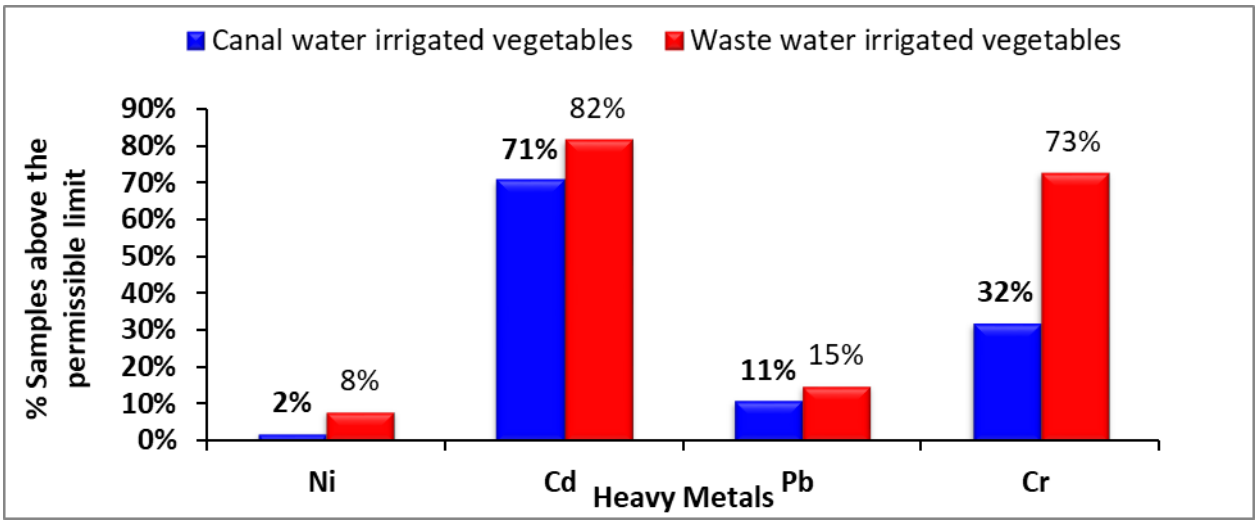

Fig 6.1: Percentage of vegetable samples found contaminated with wastewater irrigation vs. Canal water irrigation from 2 sites of district Sargodha (n=80)

Results showed that lead, cadmium, Nickel, chromium concentration in wastewater irrigated soil samples were ranged from 12.7-189 ppm, 0.1-2.6 ppm, 45.5-71.2 ppm, 112-198 ppm and in canal water irrigated soil samples 6.3-18.51ppm 0.10-0.6 ppm, 43.8-87 ppm, 76-132 ppm, respectively. The Nickel, chromium, lead and cadmium contents were high in wastewater irrigated soils as compared to canal water irrigated soils.

Table 6.1: Heavy metal content (ppm) in Soils of canal water vs. waste water irrigated of District Faisalabad (n=36)

Heavy Metals	Canal Water		Waste water	
	Range	Mean ± SD	Range	Mean ± SD
	(ppm)			
Lead (Pb)	6.3-18.51	14.2 ± 4.8	12.7-189	75.9 ± 42.2
Cadmium (Cd)	0.10-0.6	0.22 ± 0.2	0.1-2.6	1.12 ± 0.76
Nickel (Ni)	43.8-87	68.4 ± 13.2	45.5-71.2	56.7 ± 8.02
Chromium (Cr)	76-132	96 ± 16.0	112-198	125 ± 16.3
Safe limits: Pb 13.0 ppm; Cd 0.3; Ni 2.6 ppm; Cr 3.8 ppm				

To check the quality of water which was used for irrigation wastewater and canal water samples collected from different areas surrounding Faisalabad city. The results showed in table 8.2 that there was high value of EC and heavy metal in the composition of sewage water as compared to canal water. The average value of pH was 6.78, while EC was 4.79 dS m^{-1}. In case of heavy metals, the average value of 18 samples was Pb-0.45 ppm, Cd-0.08 ppm, Ni-0.10 and Cr 4.76 ppm.

Table 6.2: Heavy metal content (ppm) in canal water and waste water of District Faisalabad (n=36)

Irrigation Source	No. of Sample	pH	EC (dSm^{-1})	Pb (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
Canal Water	18	7.00	1.98	0.02	0.01	0.02	0.04
Sewage Water	18	6.78	4.79	0.45	0.08	0.10	4.76

7. HEAVY METAL DETERMINATION FROM PHOSPHATIC FERTILIZERS AVAILABLE IN PUNJAB

Some soil and plants samples analysis showed the availability of heavy metals to toxic level irrespective of that the plants or soil is irrigated with contaminated water or not. So, it is assumed that these contaminations are coming from the input sources i.e. irrigation water or fertilizers. It is cited that some phosphatic fertilizers (Rock Phosphate) may contain heavy metals like Cd & Ni. Therefore, this study was planned to assess the heavy metals in phosphatic fertilizers. Twenty six samples of different phosphatic fertilizers were collected from both soil and water testing laboratories of Faisalabad and Sargodha. The results showed in Table 7.1 that the concentration of Cd ranged in DAP (0-16.10 mg/kg), SSP (0-15.90 mg/kg), NP (0-11.2 mg/kg), NPK (0-0.25 mg/kg) and in other fertilizers (0-16.10 mg/kg). The concentration of Ni ranged in DAP (0-11.20 mg/kg), SSP (0-9.60 mg/kg), NP (0-2.8 mg/kg), NPK (0-0.18 mg/kg) and in other fertilizers (0-11.20 mg/kg).

Table 7.1: Heavy Metal (Cd & Ni) contents (Mean and Range) in Phosphatic Fertilizers

Phosphatic Fertilizers	Cadmium (Cd)		Nickel (Ni)	
	Mean	Range	Mean	Range
	(ppm)			
DAP	8.01	0-16.10	4.56	0-11.20
SSP	4.67	0-15.90	2.98	0-9.60
NP	2.35	0-11.20	1.15	0-2.80
NPK	0-0.25	0-0.50	0.09	0-0.18
Others (MAP, Zn, Fe, Humus)	2.11	0-16.10	2.09	0-11.20

The concentration of Cd found in 62 % samples and Ni in 50 % samples. This study showed that heavy metals were present in DAP, SSP, NP & NPK and their continuous use may buildup the level of heavy metal in soils that ultimately affect the soil health.

8. TO STUDY THE TOXICITY AND REQUIREMENT OF SELENIUM (SE) APPLICATION ON GROWTH AND YIELD OF WHEAT/MAIZE – A POT STUDY

Climate change is one of the most complex challenges that pose serious threats to poor people who rely heavily on agriculture particularly in climate-sensitive developing countries of the world including Pakistan. The negative effects of water scarcity, due to climate change, are not limited to productivity food crops but have far reaching consequences on livestock feed production systems. Selenium (Se) is considered essential for animal health and has also been reported to counteract various abiotic stresses in plants, selenium also plays an important role in the detoxification of heavy metals like Cadmium, thallium and Ag. However, understanding of Se regulated mechanisms for improving nutritional status of fodder crops remains elusive. Among the major role of the essential trace element selenium (Se) is used for the detoxification of heavy metals such as Cd, Hg, thallium (Tl) and Ag. Selenium at low concentrations doses protects the plants from cold, drought, desiccation and metal stresses. Its toxicity cause malformation of seleno-proteins (SeCys/SeMeth) and or inducing oxidative stress in plants So keeping in view the importance of this element, this study has been planned to assess the toxicity or other beneficial role of selenium in maize growth and yield of maize under pot culture. Six treatments were applied in pot culture Vs. T1= Control, T2= RD of NPK+ 0.50 µg g^{-1} Se, T3= RD of NPK+ 1 µg g^{-1}Se, T4= RD of NPK+ 1.50 µg g^{-1} Se, T5= RD of NPK+ 2.0 µg g^{-1}Se and T6= RD of NPK+ 3.0 µg g^{-1} Se .

The experiment was conducted in CRD design with 3 replications at wire house of Soil Chemistry Section ISCES AARI, Faisalabad. The composite soil samples were collected before sowing of the crop. Prior to sowing of the crop the pots filled with 12 kg of soil and applied the calculated amount of fertilizer. Treatment applied after ten days of germination. Before the filling of pots soil analyzed for basic soil characteristics. Maize (Zea Mays L.) the maize fodder variety Malka was sown on 21-06-2019 and recommended dose of NPK @ 275-125-75 kg/ha was applied as per treatment plan.

Table 8.1: Pre-sowing soil analysis

Soil depth	**pH_s**	**EC_e**	**O.M**	**Av. P**	**Av. K**	**Se**	**Texture**
Cm		dSm^{-1}	%	ppm		mg kg-1	
0-15	8.03	1.36	0.7	7.24	188	0.031	Sandy Clay loam

The Basic Soil analysis of the collected soil from field which was used for the sowing of maize crop showed that the soil was free from salinity and sodicity, low in organic matter and phosphorus while potash was medium.

Table 8.2: Effect of selenium on maize fodder yield (g/pot), selenium, potassium and phosphorous contents

Treatments	Fodder yield	Se	K	P
	g/Pot	ppm	%	
T1= Control	215.0 F	3.95 E	8.5 C	0.002 B
T2= RD of NPK+ 0.50 µg g^{-1}Se	248.9 E	4.50 E	12.2 B	0.001 B
T3= RD of NPK+ 1.0 µg g^{-1}Se	290.7 C	9.54 D	12.0 B	0.003 B
T4= RD of NPK+ 1.5 µg g^{-1}Se	326.7 B	13.47 C	9.0 C	0.006 B
T5= RD of NPK+ 2.0 µg g^{-1}Se	362.0 A	16.33 B	17.1 A	0.010 A
T6= RD of NPK+ 3.0 µg g^{-1}Se	267.7 D	19.63 A	9.2 C	0.016 B
LSD	2.71	0.72	1.05	0.014

Maize crop was harvested on 22-08-2019 maize fodder yield data was recorded. The data regarding maize fodder yield (Table 8.2) showed that maximum maize fodder yield of (362 g/pot) was obtained where recommender NPK applied along with 2.0 µg g^{-1} Se while minimum (215 g/pot) was observed in case of control. While toxic effect of selenium was observed in treatment 6 where as decline in yield (267.7 g/pot) was observed in treatment RD of NPK+ 3.0 µg g^{-1} Selenium applied. While, minimum yield was observed in control.

Wheat

Wheat crop was sown on rabi season 27-11-2019 and was harvested on 22-04-2019. Fertilizers were applied as per treatment plan. Recommended dose of NPK @ 120-90-60 kg/ha

Table 8.3: The fertility status of the field

Soil depth	pH_s	EC_e	O.M	Av. P	Av. K	Texture
Cm		dSm^{-1}	%	ppm		
0-15	7.96	1.34	0.73	7.22	186	Sandy Clay loam

The basic soil analysis of the soil of the field which was used for the sowing of wheat crop showed that the soil was free from salinity and sodicity, low in organic matter and phosphorus while potash was medium.

Table 8.4: Effect of selenium on wheat grain yield (g/pot)

Treatments	Wheat grain yield
	g/Pot
T1= Control	17.6 F
T2= RD of NPK+ 0.50 µg g^{-1} Se	21.2 E
T3= RD of NPK+ 1 µg g^{-1} Se	28.6 A
T4= RD of NPK+ 1.50 µg g^{-1} Se	24.5 C
T5= RD of NPK+ 2.0 µg g^{-1} Se	25.8 B
T6= RD of NPK+ 3.0 µg g^{-1} Se	23.4D
LSD	2.17

Wheat was harvested on 22-04-2019 and grain yield data was recorded. The data regarding grain yield showed that maximum grain yield 26.6 g/pot was obtained where recommended dose of NPK along with selenium 1 µg g^{-1} applied whereas minimum grain yield was observed in treatment T6 where higher level of selenium applied.

9. ASSESSMENT OF HEAVY METALS IN GROUND WATER OF FAISALABAD

Water is the elixir of life and one of the most critical, scarce, precious and replenish-able 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 survey study has been planned to assess the heavy metal concentration in ground water samples collected from the different areas (Satyana road, Partap Nagar and Chakera) of district Faisalabad. The results of pH, EC, Ni & Cd contents in groundwater samples are in-progress.

NUTRIENT USE EFFICIENCY

10. 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 24-07-2019. The composite soil samples (0-15 and 15-30 cm depth) were taken before the start of the experiment and analyzed (Table 10.1).

Table 10.1: Pre-sowing soil analysis

Depth	pH	ECe	Organic matter	Av. P	Av. K	Texture
(cm)		(dS/m)	(%)	(mg/kg)		
0-15	8.18	1.11	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 31-10-2019. The data regarding paddy yield is presented in Table 10.2.

Table 10.2: Effect of different residue management practices and treatments on the paddy yield (t/ha)

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	3.36 CDE	2.99 E	3.06 E	3.21 C
T2: 50% of recommended dose of NPK	3.64 ABCD	3.22 DE	3.53 BCD	3.44 BC
T3: 75% of recommended dose of NPK	3.79 AB	3.52 BCD	3.72 ABC	3.63 B
T4: 100% of recommended dose of NPK	4.01 A	3.75 ABC	3.97 A	3.91 A
Mean	3.70 A	3.37 B	3.57 AB	
LSD of Group= 0.262, LSD of treatments= 0.269				

The results showed that paddy yield was maximum in the traditional, sub plots where 100% RD fertilizer was applied (3.70 t ha^{-1}). Comparing all the three main plots it was observed that Traditional plots gave maximum paddy yield (3.70 t ha^{-1}). The yield in rotavated and burntl plots was (3.97 and 3.75 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 (4.01 t ha^{-1}) while minimum yield (2.99 t ha^{-1}) was observed in the treatment where no fertilizer was added in burnt 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 10.3, 10.4 and 10.5, 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 10.3: 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	0.28 G	0.17 H	0.60 DE	0.35 D
T2: 50% of recommended dose of NPK	0.32 G	0.45 F	0.89 C	0.55 C

T3: 75% of recommended dose of NPK	0.41 F	0.51 EF	1.08 B	0.67 B
T4: 100% of recommended dose of NPK	0.64 D	0.55 DE	1.45 A	0.88 A
Mean	0.41 B	0.42 B	1.00 A	
LSD of Group=0.07, LSD of treatments= 0.08				

Table 10.4: 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	5.43 F	5.73 EF	5.80 EF	5.71 C
T2: 50% of recommended dose of NPK	5.60 EF	6.10 DE	6.40 CD	5.97 C
T3: 75% of recommended dose of NPK	7.20 B	6.53 CD	6.73 BC	6.82 B
T4: 100% of recommended dose of NPK	8.40 A	8.00 A	8.30 A	8.23 A
Mean	6.82 A	6.42 B	6.80 A	
LSD of Group=0.56 , LSD of treatments =0.29				

Table 10.5: 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	208.7 E	222.2 DE	228.9 CD	219.9 D
T2: 50% of recommended dose of NPK	228.9 CD	235.6 BCD	242.4 BC	235.6 C
T3: 75% of recommended dose of NPK	242.4 BC	242.4 BC	249.1 AB	244.6 B
T4: 100% of recommended dose of NPK	249.1 AB	249.1 AB	262.6 A	253.6 A
Mean	232.3 B	237.3 AB	245.7 A	
LSD of Group= 14.1, LSD of treatments= 11.1				

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 10.6, 10.7 and 10.8. 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 10.6: Effect of different residue management practices and treatments on the nitrogen (%) content of paddy

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	2.45 ABCD	2.23 BCD	1.94 D	2.22 B
T2: 50% of recommended dose of NPK	2.48 ABCD	2.56 ABC	2.03 CD	2.39 AB
T3: 75% of recommended dose of NPK	2.50 ABCD	2.69 AB	2.39 ABCD	2.57 A
T4: 100% of recommended dose of NPK	2.58 ABC	2.83 A	2.65 AB	2.60 A
Mean	2.50 A	2.58 A	2.25 A	
LSD of Group=0.35 , LSD of treatments= 0.31				

Table 10.7: Effect of different residue management practices and treatments on the Phosphorus (%) content of paddy

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	0.27 H	0.34 G	0.30 H	0.30 D
T2: 50% of recommended dose of NPK	0.36 FG	0.39 EF	0.37 FG	0.37 C
T3: 75% of recommended dose of NPK	0.44 BC	0.41 DE	0.43 CD	0.42 B
T4: 100% of recommended dose of NPK	0.47 AB	0.44 BC	0.50 A	0.47 A
Mean	0.38 A	0.39 A	0.40 A	
LSD of Group=0.017 , LSD of treatments= 0.019				

Table 10.8: Effect of different residue management practices and treatments on the Potash (%) content of paddy

Treatments	Traditional plots	Burnt Plots	Rotavated Plots	Mean
T1: Control	0.20 E	0.20 E	0.30 D	0.23 D
T2: 50% of recommended dose of NPK	0.36 C	0.20 E	0.40 B	0.32 C
T3: 75% of recommended dose of NPK	0.40 B	0.20 E	0.60 A	0.40 B
T4: 100% of recommended dose of NPK	0.60 A	0.40 B	0.60 A	0.53 A
Mean	0.39 B	0.25 C	0.47 A	
LSD of Group=0.0189 , LSD of treatments= 0.0169				

Wheat:

In the same layout wheat was sown on 19-11-2019. All the treatments were applied according to the treatment plan. Crop was harvested on 22-04-2020 and yield data was recorded. The wheat yield data is presented in Table 10.9.

Table 10.9: 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	2.94 H	3.12 H	3.35 GH	3.14 D
T2: 50% of recommended dose of NPK	3.58 FG	3.69 EFG	4.10 CDE	3.79 C
T3: 75% of recommended dose of NPK	3.99 DEF	4.20 CD	4.52 BC	4.23 B
T4: 100% of recommended dose of NPK	4.70 AB	4.87 AB	5.02 A	4.86 A
Mean	3.80 C	4.01 B	4.21 A	
LSD of plots= 0.35, LSD of treatments= 0.43				

The results showed that wheat grain yield was maximum (5.02t ha^{-1}) in rotavated plot while in burnt and traditional plots the yield was 4.87 and 4.70 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 10.10 and 10.11 and 10.12. 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 10.10: 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	2.57 GH	2.30 H	2.45 H	2.44 C
T2: 50% of recommended dose of NPK	2.92 EFG	2.49 GH	2.68 FGH	2.69 C
T3: 75% of recommended dose of NPK	3.09 EF	3.74 D	3.15 E	3.32 B
T4: 100% of recommended dose of NPK	4.43 C	5.01 B	6.27 A	5.24 A
Mean	3.18 B	3.45 A	3.63 A	
LSD of plots=0.249 , LSD of treatments= 0.262				

Table 10.11: 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	0.28 H	0.45 E	0.54 D	0.43 D
T2: 50% of recommended dose of NPK	0.36 G	0.51 D	0.60 C	0.49 C
T3: 75% of recommended dose of NPK	0.40 F	0.53 D	0.64 B	0.52 B
T4: 100% of recommended dose of NPK	0.45 E	0.54 D	0.70 A	0.56 A
Mean	0.37 C	0.51 B	0.62 A	
LSD of Group=0..0238 , LSD of treatments= 0.0231				

Table 10.12: 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	0.44 BC	0.24 D	0.37 C	0.35 C
T2: 50% of recommended dose of NPK	0.44 BC	0.44 BC	0.44 BC	0.44 B
T3: 75% of recommended dose of NPK	0.44 BC	0.44 BC	0.44 BC	0.44 B
T4: 100% of recommended dose of NPK	0.65 A	0.51 B	0.65 A	0.60 A
Mean	0.49 A	0.40 B	0.47 A	
LSD of Group=0.0475 , LSD of treatments= 0.0479				

The soil samples were collected after harvesting of wheat crop and were analyzed for OM, P and K content. The analysis for OM, P and K is under process.

11. YIELD AND POTASSIUM UPTAKE OF WHEAT/MAIZE USING DIFFERENT SOURCES OF NITROGEN

High nitrogen losses by ammonia volatilization are predictable when urea is used as the source of nitrogen which is mainly due to high pH of alkaline calcareous soils of Pakistan. With the introduction of high yielding varieties in our cropping system, the elimination of nutrients from the soils has enhanced many folds. Oxides of nitrogen and ammonia are potential cause of climate change in current scenario. Ammonium ions being monovalent may 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 by using calcium ammonium nitrate (CAN) and urea as sources of nitrogen along with half and full dozes of potassium in maize. Nitrogen was applied according to the treatments plan while phosphorus @ 125 kg/ha was applied in all plots except control. Eight Treatments applied were; T1: Control (no fertilizer), T2: RD of N (1st½ as urea + 2nd½ as urea) + K @ 0 kg/ha, T3: RD of N (1st½ as urea + 2nd½ as urea) + K @ 50% of recommended, T4: RD of N (1st½ as CAN + 2nd½ as CAN) + K @ 50% of recommended , T5: RD of N (1st½ as urea + 2nd½ as CAN) + K @ 50% of recommended, T6: RD of N (1st½ as urea + 2nd½ as urea) + K @ 100% of recommended, T7: RD of N (1st½ as CAN + 2nd½ as CAN) + K @ 100% of recommended, T8: RD of N (1st½ as urea + 2nd½ as CAN) + K @ 100% of recommended.

Maize

The experiment was conducted in RCBD design with 3 replications at research farm of Soil Chemistry Section ISCES AARI, Faisalabad. The composite soil samples were collected before sowing of the crop and analyzed for basic soil characteristics. Maize (Zea Mays L.) Pioneer hybrid V-4040 crop was sown on 10-08-2019 and recommended dose of NPK @ 275-125-75 kg/ha was applied as per treatment plan.

Table 11.1: Pre-sowing soil analysis

Soil depth	pH_s	EC_e	O.M	Av. P	Av. K	Texture
Cm		dSm^{-1}	%	Ppm		
0-15	8.01	1.37	0.73	6.9	172	Sandy Clay loam

The Basic Soil analysis of the collected soil from field which was used for the sowing of maize crop showed that the soil was free from salinity and sodicity, low in organic matter and phosphorus while potash was medium.

Maize crop was harvested on 20-11-2019 and grain and straw yield data was recorded. The data regarding grain yield (Table 11.2) showed that maximum grain yield of (7.56 t/ha) was obtained where urea as 1st half and 2nd as CAN source of nitrogen along with full doze of potassium while minimum (4.70 t/ha) was observed in case of control. Nitrogen and potassium uptake data revealed that, highest nitrogen and Potassium uptake (154 kg/ha, 91 kg/ha) was observed in T8 where 1st half as urea and 2nd half CAN as source of nitrogen .

Table 11.2: 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)	
Control (no fertilizer)	4.70 F	82	51
RD of N (Ist ½ as urea + 2nd ½ as urea) + K @0 kg/ha	5.87 D	121	79
RD of N (Ist ½ as urea + 2nd ½ as urea) + K @ 38 kg/ha	6.71 C	131	82
RD of N (Ist ½ as CAN + 2nd ½ as CAN) + K @ 38 kg/ha	5.69 E	130	88
RD of N (Ist ½ as urea + 2nd ½ as CAN) + K @ 38 kg/ha	6.75 C	132	74
RD of N (Ist ½ as urea + 2nd ½ as urea) + K @ 75 kg/ha	6.99 B	135	73
RD of N (Ist ½ as CAN + 2nd ½ as CAN) + K @ 75 kg/ha	7.07 B	140	81
RD of N (Ist ½ as urea + 2nd ½ as CAN) + K @ 75 kg/ha	7.56 A	154	91
LSD	0.16		

Table 11.3: Effect of different sources of nitrogen and varying rates of potassium on grain NPK contents (%)

Treatments	N (%)	P (%)	K (%)
Control(no fertilizer)	0.96 E	0.22 B	0.33 D
RD of N (Ist ½ as urea + 2nd ½ as urea) + K @ 0 kg/ha	1.29 D	0.24AB	0.37C
RD of N (Ist ½ as urea + 2nd ½ as urea) + K @ 38 kg/ha	1.32 CD	0.28AB	0.41B
RD of N (Ist ½ as CAN + 2nd ½ as CAN) + K @ 38kg/ha	1.34 C	0.29AB	0.42B
RD of N (Ist ½ as urea + 2nd ½ as CAN) + K @ 38 kg/ha	1.39 B	0.23AB	0.42B
RD of N (Ist ½ as urea + 2nd ½ as urea) + K @ 75 kg/ha	1.41 B	0.27AB	0.43B
RD of N (Ist ½ as CAN + 2nd ½ as CAN) + K @75 kg/ha	1.47 A	0.24AB	0.44B
RD of N (Ist ½ as urea + 2nd ½ as CAN) + K @ 75 kg/ha	1.42 B	0.30 A	0.51A
LSD	0.01	0.09	0.11

The data regarding grain NPK contents (Table 11.3) showed that maximum nitrogen and potassium contents of 1.42 and 0.51 % respectively were found where half dose of nitrogen from urea and 2nd half from CAN along with full doze of potassium was used, however these concentration were non-significant with all other treatments except control. Phosphorus concentration on the other hand was showed not significant in all treatments.

12. TO STUDY THE ROLE OF Ni AS ESSENTIAL PLANT NUTRIENT IN WHEAT/MUNG BEAN UNDER ALKALINE CALCAREOUS SOILS OF PAKISTAN – A POT STUDY

It has been reported that Ni is essential element for plant growth. Ni is essential component of urease enzyme in plants and microorganisms especially in nodule forming crops like Mungbean. This pot study was planned to assess the role of nickel as a nutrient

in growth and yield parameters of Mungbean under alkaline calcareous soil. The experiment was conducted in the wire house of Soil Chemistry Section, AARI, Faisalabad.

Mungbean:

To assess the role of nickel as a nutrient in growth and yield parameters of Mungbean six different treatments Vs. T1: Control (Recommended NPK),T2: NPK+ 2 mg kg^{-1}, T3: NPK+ 4 mg kg^{-1}, T4: NPK+ 6 mg kg^{-1}, T5: NPK+ 8 mg kg^{-1}, T6: NPK+ 10 mg kg^{-1} were tested by using Complete Randomized design with three replications (Recommended dose of NPK = 12.5-30-30 mg kg^{-1}).

The mungbean crop was sown on 21-07-2019. The composite soil samples were taken before sowing and analyzed (Table 12.1)

Table 12.1: Pre sowing soil analysis

Parameters	pH	ECe (dS/m)	Organic matter (%)	Av. P (mg/kg)	Av. K (mg/kg)
Values	8.10	1.19	0.84	8.32	180

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

The data regarding agronomic parameter is presented in Table 12.2. The obtained results showed that maximum shoot length (30.83 cm) was obtained where 10 mg $kg^{-1}$was applied with recommended NPK as basal dose. The maximum shoot fresh and dry weight (17.17 and 9.47g, respectively) was obtained in treatment where 10 mg kg^{-1} was applied and minimum was obtained in case of control (recommended dose of NPK only).

Table 12.2: Effect of Ni on shoot length, fresh weight and dry weight of Mungbean crop

Treatments	Shoot Length(cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)
Control (Recommended NPK)	23.67 f	14.10 d	6.43 e
NPK+ 2 mg kg^{-1}	24.33 e	14.20 cd	7.13 d
NPK+ 4 mg kg^{-1}	25.17 d	15.13 c	7.63 cd
NPK+ 6 mg kg^{-1}	26.83 c	15.87 c	7.80 c
NPK+ 8 mg kg^{-1}	27.67 b	16.70 b	8.43 b
NPK+ 10 mg kg^{-1}	30.83 a	17.17 a	9.47 a
LSD	0.674	0.321	0.312

The data regarding grain yield and Ni content in grain is presented in Table 12.3. The obtained results showed that maximum grain yield (473.17 g) and Ni content (4.74 µg g^{-1}) was obtained where 10 mg $kg^{-1}$was applied with recommended NPK as basal dose. The minimum Ni content (0.41 µg g^{-1}) was obtained in control (recommended dose of NPK only).

Table 12.3: Effect of Ni on mungbean yield and Ni content of the grain

Treatments	Yield(kg ha^{-1})	Ni (µg g^{-1})
Control (Recommended NPK)	429.52 f	0.41 f
NPK+ 2 mg kg^{-1}	435.92 e	0.89 e
NPK+ 4 mg kg^{-1}	448.54 d	1.20 d
NPK+ 6 mg kg^{-1}	460.77 c	2.93 c
NPK+ 8 mg kg^{-1}	466.29 b	3.50 b
NPK+ 10 mg kg^{-1}	473.17 a	4.74 a
LSD	5.1423	0.0593

13. BIO-FORTIFICATION OF CHICKPEA/MUNGBEAN (*VIGNA RADIATA* L.) WITH MICRONUTRIENTS (Zn & Fe) APPLICATION IN SANDY CLAY LOAM SOILS

Malnutrition is a serious problem to human health in Pakistan especially in children. The micronutrients most commonly associated with human health problems are Fe and Zn. After cereals, pulses are used as staple food on everyday basis in Pakistan. Therefore, this study is planned to improve the Zn and Fe concentrations in mungbean through bio-fortification of mungbean with Zn and Fe application as soil and foliar. An experiment was carried out at the research area of soil chemistry section, AARI, Faisalabad. Design was split plot RCBD with three replications.

Treatments:

Without Poultry Manure	**With Poultry Manure (5 tons/ha)**
Recommended dose (RD)	Only Poultry Manure
Zn @ 5 kg/ha + (RD)	Zn @ 5 kg/ha + (RD)
Fe @ 4 kg/ha + (RD)	Fe @ 4 kg/ha + (RD)
0.5 % $ZnSO_4$ Soln. + (RD)	0.5 % $ZnSO_4$ Soln. + (RD)
0.2 % $FeSO_4$+ (RD)	0.2 % $FeSO_4$ Soln.+ (RD)
Zn @ 5 kg/ha + Fe @ 4 kg/ha+ (RD)	Zn @ 5 kg/ha + Fe @ 4 kg/ha+ (RD)
0.5 % $ZnSO_4$ Soln.+ 0.2 % $FeSO_4$ Soln.+(RD)	0.5 % $ZnSO_4$ Soln.+ 0.2 % $FeSO_4$ Soln.+(RD)

The soil analysis showed that the field was free from salinity and sodicity hazard, inadequate in O.M., adequate in available phosphorus, potassium, iron and zinc.

Table 13.1: Pre-sowing Soil Analysis

Depth	**EC_e**	**pH_s**	**OM**	**P**	**K**	**Fe**	**Zn**
(cm)	**(dSm^{-1})**		**(%)**	**(mg/kg)**		**ppm**	
0-15	1.68	7.39	0.75	7.5	296	3.6	1.9
15-30	1.53	7.42	0.55	5.3	222	2.5	0.7

Crop was sown on 27-05-2019 and was harvested on 21-08-2019. Yield data (Table 13.2) showed that the integrated use of organic manure with inorganic fertilizer increased the grain yield of the crop. The highest grain yield (0.67 t ha^{-1}) was recorded in plot where inorganic fertilizer was applied as soil application along with PM. The minimum grain yield (0.28 t/ha) was obtained in case of control (NPK). Zn & Fe fertilizer application strategy influence grain yield.

Table 13.2: Effect of Zn and Fe application on Yield of Mungbean

Treatments	**Grain Yield (t/ha)**		
	With Poultry Manure	**Without Poultry Manure**	**Mean**
NPK	0.41 e	0.28 f	0.35 D
NPK+Soil Zn	0.56 bcd	0.40 e	0.48 BC
NPK+Soil Fe	0.50 cde	0.47 cde	0.49 BC
NPK+Foliar Zn	0.60 abc	0.44 de	0.52 B
NPK+Foliar Fe	0.43 e	0.41 e	0.42 BC
NPK+Soil Zn+Fe	0.67 a	0.57 abc	0.62 A
NPK+Foliar Zn+Fe	0.62 ab	0.48 cde	0.55 AB
Mean	0.54 A	0.44 B	
LSD Main plots	0.09		
LSD Subplots	0.08		

Chickpea:

Pakistani soils generally have high pH, and low organic matter, which reduce the availability of micronutrients. The micronutrients most commonly associated with human health problems on a global scale include Zn and Fe. For estimating the effect of integrated application of organic fertilizer (PM) and micronutrient fertilizers (Zn, Fe) on agronomic traits and yield components of chickpea, an experiment was carried out at the research area of soil chemistry section, AARI, Faisalabad. Design was split plot RCBD with three replications.

Treatments:

Treatments	Without Poultry Manure	With Poultry Manure (5 tons/ha)
T1	Recommended dose (RD)	Only Poultry Manure
T2	Zn @ 5 kg/ha + (RD)	Zn @ 5 kg/ha + (RD)
T3	Fe @ 4 kg/ha + (RD)	Fe @ 4 kg/ha + (RD)
T4	0.5 % $ZnSO_4$ Soln. + (RD)	0.5 % $ZnSO_4$ Soln. + (RD)
T5	0.2 % $FeSO_4$+ (RD)	0.2 % $FeSO_4$ Soln.+ (RD)
T6	Zn @ 5 kg/ha + Fe @ 4 kg/ha+ (RD)	Zn @ 5 kg/ha + Fe @ 4 kg/ha+ (RD)
T7	0.5 % $ZnSO_4$ Soln.+ 0.2 % $FeSO_4$ Soln.+(RD)	0.5 % $ZnSO_4$ Soln.+ 0.2 % $FeSO_4$ Soln.+(RD)

Crop was sown on 30-10-2019 and was harvested on 05-05-2020. Pre-sowing soil analysis (Table 13.3) showed that the field was free from salinity and sodicity hazard and moderate in fertility.

Table 13.3: Pre-sowing Soil Analysis

Depth	EC_e	pH_s	OM	P	K	Fe	Zn
(cm)	(dSm^{-1})		(%)	(mg/kg)		ppm	
0-15	1.61	7.31	0.66	6.7	255	3.8	2.0
15-30	1.53	7.45	0.49	5.0	202	2.8	0.9

The integrated use of organic manure with inorganic fertilizer increased the grain yield of the crop. The highest chickpea grain yield (1.51 t ha^{-1}) was recorded in plot where inorganic fertilizer was applied along with PM. However, the lowest crop grain yield (0.50 t ha^{-1}) was recorded in control plots (Table 13.4).

Table 13.4: Effect of Zn and Fe application on Yield of Chickpea

Treatments	Grain Yield (t/ha)		
	With Poultry Manure	Without Poultry Manure	Mean
T1: NPK	0.86 bc	0.50 d	0.68 C
T2: NPK+Soil Zn	1.18 ab	0.63 cd	0.90 ABC
T3: NPK+Soil Fe	1.44 a	0.63 cd	1.04 AB
T4: NPK+Foliar Zn	1.19 ab	0.57 cd	0.88 BC
T5: NPK+Foliar Fe	1.47 a	0.63 cd	1.05 AB
T6: NPK+Soil Zn+Fe	1.51 a	0.75 cd	1.13 A
T7: NPK+Foliar Zn+Fe	1.49 a	0.71 cd	1.10 AB
Mean	1.31 A	0.63 B	
LSD Main plots	0.20		
LSD Subplots	0.24		

14. COTTON GROWTH AND YIELD IMPROVEMENT THROUGH FOLIAR APPLICATION OF MACRO AND MICRONUTRIENTS

Low cotton yield is very common problem in Pakistan. This low yield is mainly due to excessive flower, square and boll shedding at different growth stages and this happen even under recommended fertilizer application. To reduce its square, flower and boll shedding this study was planned to investigate the effect of foliar applied macro and micro nutrients at different growth stages of cotton on cotton growth. For this purpose following eight treatments were tested in RCBD (Randomized complete block design).

T1: Control RD of NPK (Recommended dose of NPK= 190-125-90 kg/ha)
T2: RD of NPK + foliar application (FA) of Boron (H_3BO_3) (3-spray @ 0.1%, 0.15% & 0.2%)
T3: RD of NPK + FA Magnesium ($MgSO_4$) (3-spray @ 0.25%)
T4: RD of NPK + FA Zinc ($ZnSO_4$) (3-spray @ 0.2%)
T5: RD of NPK + FA Urea (3-spray @ 2%)
T6: RD of NPK + FA Potassium Nitrate (KNO_3) (3-spray @ 0.25%)
T7: RD of NPK + FA (H_3BO_3 + $MgSO_4$ + KNO_3, 3-spray)
T8: RD of NPK + FA H_3BO_3 + $MgSO_4$ +$ZnSO_4$ +Urea+ KNO_3 (3-spray)

1st spray was applied after one month of sowing while 2nd & 3rd spray was applied with 15 days interval. The results indicated that maximum cotton yield was obtained in T8 where H_3BO_3 + $MgSO_4$ + KNO_3 + $ZnSO_4$ and urea was applied through foliar spray with RD of NPK and it showed 7.5% more yield as compared to control where only RD of NPK was applied. Similar trend was found in all growth parameters. Improved N, P, K contents in leaves (15, 15.5 and 15.55% increase respectively) as compared to control were found in the treatment with RD of NPK + Foliar application (FA) of H_3BO_3 + $MgSO_4$ + KNO_3 + $ZnSO_4$ and urea.

Table 14.1: Pre-soil analysis:

Depth (cm)	ECe (dSm^{-1})	pHs	OM (%)	N (%)	P (ppm)	K (ppm)	Textural class
0-15	1.31	7.89	0.67	2.3	6.4	178	Sandy Clay Loam
15-30	1.35	7.99	0.53	2.6	4.1	143	

Table 14.2: Effect of foliar application of macro/micronutrients on the agronomic and yield parameters of cotton crop

Treatment	Plant height (cm)	Internodal distance (cm)	No. of branches per plant	Yield (t/ha)
T1: Control (RD NPK :: 190-125-90 kg/ha)	127.50 A	4.2 ABC	10.7 AB	1.95 BC
T2: RD NPK + foliar application (FA) of Boron (H_3BO_3) (3-spray @ 0.1%, 0.15% & 0.2%)	123.33 A	4.0 ABC	10 AB	2.03 AB

T3: RD of NPK + FA Magnesium ($MgSO_4$) (3-spray @ 0.25%)	125.83 A	3.7 BCD	10.7 AB	1.98 ABC
T4: RD of NPK + FA Zinc ($ZnSO_4$) (3-spray @ 0.2%)	130.83 A	3.4 CD	12.4 A	1.85 C
T5: RD of NPK + FA Urea (3-spray @ 2%)	128.33 A	4.9 A	11.4 AB	1.97 ABC
T6: RD of NPK + FA Potassium Nitrate (KNO_3) (3-spray @ 0.25%)	128.33 A	4.4 AB	9.4 B	1.90 BC
T7: RD of NPK + FA (H_3BO_3 + $MgSO_4$+ KNO_3, 3-spray)	128.33 A	4.7 A	9 B	1.85 C
T8: RD of NPK + FA H_3BO_3 + $MgSO_4$+$ZnSO_4$ +Urea+ KNO_3 (3-spray)	122.27 A	3.0 D	12.7 A	2.1 A
LSD	14.319	0.93	2.8	0.1374

Table 14.3: Effect of foliar application of macro/micronutrients on the potassium and phosphorous contents of cotton straw

Treatment	Phosphorous in straw (%)	Potassium in straw (%)
T1: Control (RD NPK :: 190-125-90 kg/ha)	0.33 B	1.30 B
T2: RD NPK + foliar application (FA) of Boron (H_3BO_3) (3-spray @ 0.1%, 0.15% & 0.2%)	0.32 B	1.27 D
T3: RD of NPK + FA Magnesium ($MgSO_4$) (3-spray @ 0.25%)	0.31 B	1.122 DE
T4: RD of NPK + FA Zinc ($ZnSO_4$) (3-spray @ 0.2%)	0.35 B	1.21 E
T5: RD of NPK + FA Urea (3-spray @ 2%)	0.32 AB	1.38 A
T6: RD of NPK + FA Potassium Nitrate (KNO_3) (3-spray @ 0.25%)	0.34 AB	1.31 B
T7: RD of NPK + FA (H_3BO_3 + $MgSO_4$+ KNO_3, 3-spray)	0.34 AB	1.29 BC
T8: RD of NPK + FA H_3BO_3 + $MgSO_4$+$ZnSO_4$ +Urea+ KNO_3 (3-spray)	0.39 A	1.39 A
LSD	0.054	0.03

In all parameters (agronomic, chemical and yield), plots where RD of NPK + foliar application of H_3BO_3 + $MgSO_4$+$ZnSO_4$ +Urea+KNO_3 (3-spray) was applied showed improved results as compare to control where only recommended dose of NPK was applied.

NUTRIENT DYNAMICS

15. MICRONUTRIENTS STATUS OF FRUITS GROWN IN PUNJAB

Micronutrient (Zn, Fe, Mn, Cu) are very important elements for plant growth and fruit quality but their deficiency is reported in Punjab, Pakistan. So, keeping in view their importance; this study has been planned to assess the micronutrient status of citrus

orchards (Leaves + Fruit + soils) in Faisalabad, Sheikhupura, Toba Tek Singh and Sahiwal districts.

In Kharif season:

1. 200 samples were collected in Kharif season from Faisalabad and Sheikhupura districts
2. Guava samples 200 (80 guava fruit, 80 guava leaves, 40 soil).
3. Samples were oven dried and grinded for analytical work
4. Samples were prepared for analysis of micronutrients.
5. Micronutrient status of guava fruits were showed in (Table 15.1)

In Rabi season:

1. 400 samples were collected in Rabi season from Toba Tek Singh and Sahiwal districts
2. Citrus samples 200 (80 citrus fruit, 80 citrus leaves, 40 soil)
3. Guava samples 200 (80 guava fruit, 80 guava leaves, 40 soil).
4. Samples were oven dried and grinded for analytical work
5. Samples were prepared for analysis of micronutrients.

Table 15.1: Micronutrient concentration in Guava fruits of Punjab (Faisalabad and Sheikhupura)

Micronutrient	Guava (mg/kg) (n=80)	
	Range	Mean ± SD
Iron (Fe)	27.9-251.5	107.4 ± 34.6
Zinc (Zn)	0.0-19.0	1.26 ± 5.41
Cupper (Cu)	3.84-15.8	8.29 ± 1.70
Manganese (Mn)	0.0-51.2	16.85 ± 8.28

Fig 15.1: Fruit and leaves samples collected from different districts of Punjab

16. NUTRIENTS REMOVAL BY CROPS

Crops are good source of carbohydrates, proteins, vitamins and minerals but very little information is available about their nutrient removal from soil. To plan for a good soil/plant fertility program, it is essential to know the nutrients removed by the crops so that the same can be replenished to maintain soil fertility at a reasonably high level. Therefore, this study was planned to determine the removal of nutrients i.e., N, P, K, Zn,

Cu, Fe and Mn from soil by Moungbean and sugarcane. The samples of moungbean were collected from farm area of Pulses Research Institute and sugarcane crop from the farm of Sugarcane Research Institute. 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 moungbean is presented in Table 16.1, while analysis of sugarcane is under process.

Table 16.1: Dry matter yield and nutrients removed by Moungbean

Crops	Dry Yield	N	P	K	Zn	Cu	Fe	Mn
	kg/ha	------kg/ha-----			---- ---g/ha------			
Moungbean	694.8	161.3	2.8	14.7	34.8	0.0	126.9	43.4

17. TO STUDY THE MICRONUTRIENT DYNAMICS (Fe & Zn) BY USING MACRONUTRIENTS ALONG WITH FARM MANURE

No data or information is available regarding removing capacity of micronutrients (Fe, Zn) from farmyard manure and macronutrients. Therefore, field experiment was conducted at Farm area of Soil Chemistry Section, Ayub Agricultural Research Institute, Faisalabad to quantify micronutrients utilization by the plant under varied scenarios of N, P and K with and without farm manure on maize and onion.

Treatments

The two main plots were:

1: Without Farm Yard Manure (FYM)

2: With Farm Yard Manure (FYM)

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

Recommended dose of NPK 275-125-75 kg/ha and Pioneer 30Y87 hybrid variety was used for maize. In case of onion crop, recommended dose of NPK 130-50-100 kg/ha and Phulkara variety was used. 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 revealed that soil was free of sodicity and salinity (Table 17.1) and moderate in fertility status

Table17.1: Pre-Sowing physiochemical characteristics of soil

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

Maize crop was sown on 06-08-2018 and harvested on 13-11-2019. Results regarding grain yield showed that highest grain yield (7.54 t/ha) was observed in T8 where recommended dose of NPK was added along with FYM while minimum grain yield (4.05 t/ha) was observed in treatment receiving no fertilizer and no FYM (Table 17.2). However, grain yield (6.72 t/ha) obtained from T5 where recommend dose of NP was applied along with FYM was statistically at par with grain yield (6.66) of T8 receiving recommended dose of NPK.

Table 17.2: Effect of farm manure and macronutrients on maize grain yield

Treatments	Grain Yield (t/ha)		Mean
	Without FYM	With FYM	
T1: Control (No Fertilizer)	4.05 i	4.52 h	4.29 E
T2: Recommended dose (RD) of N	5.60 ef	6.25 c	5.92 C
T3: Recommended dose (RD) of P	5.09 g	5.87 de	5.48 D
T4: Recommended dose (RD) of K	5.28 fg	5.64 e	5.46 D
T5: Recommended dose (RD) of NP	6.11 cd	6.72 b	6.41 B
T6: Recommended dose (RD) of NK	6.25 c	6.30 c	6.27 B
T7: Recommended dose (RD) of KP	5.68 e	6.10 cd	5.89 C
T8: Recommended dose (RD) of NPK	6.66 b	7.54 a	7.10 A
Mean	5.59 B	6.12 A	
LSD Main Plots (With and without FYM)= 0.34, LSD Sub Plots (Treatment)= 0.32			

Results regarding zinc concentration in maize grain showed that maximum zinc content (36.0 mg/kg) was observed in T8 where recommended dose of NPK was applied along with FYM followed by T6 (33.6 mg/kg) where recommended dose of NK was applied along with FYM (17.3). However, minimum zinc concentration (22.3 mg/kg) was observed in T1 (receiving no fertilizer no manure).

Table 17.3: Effect of farm manure and macronutrients on zinc content in maize grain

Treatments	Zinc content in grain (mg/kg)		Mean
	Without FYM	With FYM	
T1: Control (No Fertilizer)	22.31 i	26.12 h	24.21 F
T2: Recommended dose (RD) of N	30.85 f	33.48 cd	32.17 C
T3: Recommended dose (RD) of P	25.89 h	26.93 gh	26.41 E
T4: Recommended dose (RD) of K	28.20 g	31.97 ef	30.09 D
T5: Recommended dose (RD) of NP	31.01 f	33.62 bcd	32.32 C
T6: Recommended dose (RD) of NK	32.49 de	34.66 b	33.58 B

T7: Recommended dose (RD) of KP	28.23 g	31.15 f	29.69 D
T8: Recommended dose (RD) of NPK	33.74 bc	36.06 a	34.90 A
Mean	29.09 B	31.75 A	
LSD Main Plots (With and without FYM)= 1.12, LSD Sub Plots (Treatment)= 1.30			

Onion:

Onion nursery was transplanted on 23-01-2019 and harvested on 13-05-2019. Data regarding onion bulb yield showed that highest bulb yield in T8 where recommended dose of NPK was applied along with FYM followed by T5 where NP was added along with FYM and T8 receiving recommended dose of NPK (Table 17.4). However, minimum bulb yield was observed in T1 receiving no fertilizer and no FYM.

Table 17.4: Effect of farm manure and macronutrients on onion bulb yield

Treatments	Bulb Yield (t/ha)		Mean
	Without FYM	With FYM	
T1: Control (No Fertilizer)	14.13 j	15.70 i	14.91 G
T2: Recommended dose (RD) of N	16.78 h	19.61 cd	18.19 D
T3: Recommended dose (RD) of P	16.53 hi	18.86 e	17.70 E
T4: Recommended dose (RD) of K	16.15 hi	17.88 fg	17.01 F
T5: Recommended dose (RD) of NP	18.35 ef	20.95 b	19.65 B
T6: Recommended dose (RD) of NK	17.69 fg	20.27 bc	18.98 C
T7: Recommended dose (RD) of KP	17.63 g	18.93 de	18.28 D
T8: Recommended dose (RD) of NPK	20.33 bc	21.96 a	21.14 A
Mean	17.20 B	19.27 A	
LSD Main Plots (With and without FYM)= 0.68, LSD Sub Plots (Treatment)= 0.48			

Analysis results regarding iron and zinc concentration in onion bulb are in progress.

18. EFFECT OF TEMPORAL AND DIFFERENTIAL APPLICATION OF NITROGEN AND POTASH ON GROWTH, YIELD AND QUALITY OF WHEAT/MAIZE

To get maximum production the fertilizer requirement, time and method of application is important. To evaluate the response of hybrid maize 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. The six different treatments were tested by using Randomized Complete Block design with three replications.

T1: Control (Recommended dose of 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}

Maize Crop:

The maize crop was sown on 06-08-2019 and was harvested on 13-11-2019. The composite soil samples (0-15 cm depth) was taken before sowing and analyzed (Table 18.1)

Table 18.1: Basic Soil Analysis

Depth	ECe	pH_s	OM	P	K	Texture
(cm)	dSm^{-1}		(%)	(mg/kg)		
0-15	1.49	7.71	0.69	8.89	186	Sandy clay loam

The soil analysis showed that the field was free from salinity and sodicity hazard, inadequate in O.M., moderate in available P and K.

Table 18.2: Effect of soil and foliar application of N & K on maize Grain yield and grain NPK contents.

Treatments	Maize Yield	N	P	K
	(t/ha)		(%)	
T1: Control (Recommended dose of NPK)	4.96 c	1.45	0.20	0.36 ab
T2: N (½ at sowing + 2 % Spray at 30 & 45 DAS) + RD of K	3.87 e	1.30	0.17	0.37 ab
T3: N + K (½ K at sowing + ½ at 30 DAS)	5.60 b	1.34	0.19	0.37 ab
T4: N + K (½ K at sowing + 2 % spray at 30 & 45 DAS)	5.61 b	1.33	0.22	0.41 a
T5: N (½ at sowing + 2 % Spray at 30 & 45 DAS) + K (½ K at sowing + ½ at 30 DAS)	4.15 d	1.34	0.20	0.34 b
T6: N (½ at sowing +2 % Spray at 30 & 45 DAS) + K (½ at sowing +2 % Spray at 30 & 45 DAS)	5.71 a	1.32	0.20	0.41 a
LSD	0.10	ns	ns	0.06

The data regarding yield of maize, N, P and K concentration in maize grain is presented in Table 18.2. The obtained results showed that maximum grain yield (5.71 t ha^{-1}) was obtained where half N & K applied at sowing and 2 % spray of N & K applied after 30 & 40 days after sowing. The minimum grain yield (3.87 t ha^{-1}) was obtained in T2 treatment.

19. EFFECT OF SULPHUR ON OIL QUANTITY OF COTTON/SUNFLOWER

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)

Cotton:

The cotton crop was sown on 15-05-2019. 1st picking of cotton was done on 17-11-2019 and 2nd picking was done on 02-12-2019. 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 19.1).

Table 19.1: Pre-sowing soil analysis

Depth	ECe	pHs	OM	P	K	S	B.D.	Texture
cm	dSm^{-1}		%	ppm				
0-15	1.29	7.21	0.87	8.03	276	11	1.45	Sandy Clay Loam
15-30	1.24	7.09	0.79	8.14	220	13	1.48	

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 cotton and oil contents is presented in Table 19.2. The results showed that T3, T4 and T5 were at par. Maximum cotton yield (2.2 t/ha) was obtained in T5 where 15 kg S was applied along with recommended fertilizer. The minimum cotton yield (1.82 t/ha) was obtained in control. Maximum oil contents (16.8 %) were also observed in T6 while minimum oil contents (10.6 %) were found in control.

Table 19.2: Effect of S on Cotton yield (t/ha) and Oil Contents (%)

Treatments	Cotton Seed	Oil Contents
T1: Control	0.93 C	6.24 BC
T2: RD of NPK	1.68 B	6.93 AB
T3: RD of NPK + 5 kg S/ha	1.96 AB	6.98 AB
T4: RD of NPK + 10 kg S /ha	2.25 A	7.65 A
T5: RD of NPK + 15 kg S /ha	2.22 A	5.57 CD
LSD	0.385	0.8184

Sunflower:

Sunflower crop was sown on 13-02-2020 and was harvested on 15-06-2020. The composite soil samples (0-15 and 15-30 cm depth) were taken before sowing and analyzed (Table 19.3)

Table 19.3: Pre-sowing soil analysis

Depth	ECe	pHs	OM	P	K	S	B.D.	Texture
cm	dSm^{-1}		%	Ppm				
0-15	1.29	7.2	0.9	8	276	11	1.45	Sandy Clay Loam
15-30	1.24	7.1	0.8	8.1	220	13	1.48	

The soil analysis showed that the field was free from salinity and sodicity hazard, inadequate in O.M. and sulphur, adequate in available phosphorus and potassium. The data regarding yield and oil contents of sunflower is presented in table 19.4. The results showed that maximum seed yield (3.8 tha^{-1}) was obtained in the treatment where 15 kg ha^{-1} S was applied with recommended fertilizer. The minimum grain yield (1.84 tha^{-1}) was obtained in control. Oil contents analysis is under process.

Table 19.2: Effect of S on Sunflower seed yield (t /ha)

Treatments	Sunflower Yield
	t/ha
T1: Control	1.84 E
T2: Rd NPK	2.54 D
T3: Rd NPK+ S (5 kg/ha)	2.83 C
T4: Rd NPK+ S (10kg/ha)	3.05 B
T5: Rd NPK+ S (15 kg/ha)	3.16 B
LSD	0.13 A

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

Severe deficiency of Sulphur has been reported in some oil seed crops. It may be due to low S in soil or no application of S containing fertilizer. As it is well recognized that S is secondary nutrient, so this study is planned to assess the S contents of soils in aresa where aoilseed crops are grown.

DISTRICT FAISALABAD

Soil samples, from 2 depths i.e. 0-15 cm and 15-30 cm, were collected from Faisalabad district from different sites i.e Samundri road and Sargodha road, where oilseed crops i.e. canola and mustards are grown. Soil samples were collected randomly following diagonal method. 52 soil samples were collected. The collected samples were analyzed for S contents.

Table 20.1: Sulphur Contents in soil of District Faisalabad

Soil Depth	Range	Average	Standard Deviation	Sufficient Range
	(ppm)			
0-15cm	12-95	43	23	20-May
15-30cm	11-91	38	22	

21. APPLICATION OF FERTILIZERS THROUGH FERTIGATION/CHEMIGATION TECHNIQUE TO IMPROVE THE FERTILIZER USE EFFICIENCY OF WHEAT/MAIZE CROP

Fertilizer use efficiency is very low due to low OM content, fixation and other problems in alkaline calcareous soils of Pakistan. So this study has been planned to test the fertigation techniques for improvement of nitrogen, phosphorus and potash use efficiency by using

maize/wheat as test crop at Soil Chemistry Section, Institute of Soil Chemistry and Environmental Sciences, Ayub Agricultural Research Institute Faisalabad. The eight different treatments were tested by using Randomized Complete Block design with three replications.

Maize Crop:

Treatments;

T1. Control
T2. RD NPK (275-125-75 kg/ha)*
T3. NPK through fertigation (½ at sowing + ½ at 1st irrigation) (UREA, DAP, SOP)
T4. NPK through fertigation (½ at sowing + ½ at 1st irrigation) (CAN, SSP, SOP)
T5. NPK fertigation (sowing+ 1st irrigation) (NPK: 17-17-17, Nitrophos, Urea)
T6. NPK by fertigation (sowing+ 1st irrig. + 2nd Irrig.) (UREA, DAP, SOP)
T7. NPK by fertigation (sowing+ 1st irrig. + 2nd Irrig.) (CAN, SSP, SOP)
T8. NPK fertigation (sowing+ 1st irrig. + 2nd Irrig.) (NPK: 17-17-17, Nitrophos, Urea)
*All P, K and ½ N will be applied at sowing while ½ N will be applied at 1st irrigation as Urea: DAP: SOP.

The maize crop was sown on 09-08-2019 and was harvested on 21-11-2019. The composite soil samples (0-15 cm depth) was taken before sowing and analyzed (Table 17.1)

Table 21.1: Basic Soil Analysis

Depth	ECe	pH_s	OM	P	K	Texture
(cm)	dSm^{-1}		(%)	(mg/kg)		
0-15	1.31	7.93	0.63	6.3	179	Sandy clay loam

The soil analysis showed that the field was free from salinity and sodicity hazard, inadequate in O.M., moderate in available P and K.

Table 21.2: Effect of fertigation technique on Maize yield, Grain P & K contents

TREATMENTS	Maize yield (t/ha)	Grain P (%)	Grain K (%)
T1: Control	3.37 g	0.23 e	0.26 c
T2: RD NPK (275-125-75 kg/ha)*	4.26 bc	0.27 d	0.31 bc
T3:NPK through fertigation (½ at sowing + ½ at 1st irrigation) (UREA, DAP, SOP)	3.64 f	0.28 d	0.36 ab
T4: NPK through fertigation (½ at sowing + ½ at 1st irrigation) (CAN, SSP, SOP)	3.88 e	0.27 d	0.36 ab
T5: NPK by fertigation (sowing+ 1st irrigation) (NPK:17-17-17, Nitrophos, Urea	4.14 d	0.36 a	0.37 a
T6: NPK by fertigation (sowing+ 1st irrigation + 2nd Irrig.) (UREA, DAP, SOP)	4.18 cd	0.33b	0.39 a
T7: NPK by fertigation (sowing+ 1st irrigation + 2nd irrigation) (CAN, SSP, SOP)	4.35 b	0.28 d	0.33 ab
T8: NPK by fertigation (sowing+ 1st irrig. + 2nd irrigation) (NPK:17-17-17, Nitrophos, Urea)	4.57 a	0.30 c	0.38 a
LSD	0.12	0.01	0.06

The data regarding yield of maize, P and K concentration in maize grain is presented in Table 21.2. The obtained results showed that maximum grain yield (4.57 t ha^{-1}) was obtained in T8 treatment while minimum grain yield (3.37 t ha^{-1}) was obtained in control.

Wheat

The wheat crop was sown on 25-11-2019 and was harvested on 21-04-2020.

Treatments

T1: Control

T2: RD NPK (120-90-60 kg/ha)*

T3: NPK through fertigation (½ at 1st irrigation + ½ at 2nd Irrig.) (UREA, DAP, SOP)

T4: NPK through fertigation (½ at 1st irrigation + ½ at 2nd Irrig.) (CAN, MAP, SOP)

T5: NPK by fertigation (½ at 1st irrigation + ½ at 2nd Irrig.) (NPK: 17-17-17, Nitrophos, Urea)

T6: NPK by fertigation (1st irrigation + 2nd Irrig. + 3rd irrig.) (UREA, DAP, SOP)

T7: NPK by fertigation (1st irrigation + 2nd Irrig. + 3rd irrig.) (CAN, MAP, SOP)

T8: NPK by fertigation (1st irrigation + 2nd Irrig. + 3rd irrig.) (NPK: 17-17-17, Nitrophos, Urea)

*All P, K and ½ N will be applied at sowing while ½ N will be applied at 1st irrigation as Urea: DAP: SOP.

Results showed that maximum wheat grain yield (4.85 t/ha) was obtained in T3 while minimum yield (3.04 t/ha) was obtained in control.

22. TO STUDY THE LONG-TERM EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON BIOFORTIFICATION OF WHEAT/MAIZE GRAIN WITH Zn & Fe

This study is planned to assess the Zn and Fe availability in maize and to increase their concentration in grain through bio-fortification under long-term study where organic and inorganic fertilizers are being applied. During 2019-20 Maize-wheat crop rotation was followed. This study is being conducted at research area of Soil Chemistry Section, ISCES, Faisalabad.

Maize:

Crop was sown on 02-08-2019 and was harvested on 04-11-2019. Before sowing the crop soil samples were collected from 0-15 cm depth for analysis purposes. Fertilizers NPK were applied @ 275-125-75 kg/ha according to the plan. FYM, calculated on nitrogen basis, was applied in the plots according to the permanent layout. Maize yield and pre-sowing soil analysis is given in Table 22.1.

Table 22.1: Effect of Fe and Zn Bio-fortification on Maize Yield (t/ha)

	No micronutrient	Fe Soil Application	Zn Soil Application	Fe Foliar Application	Zn Foliar Application
T1: Control	1.9	3.3	3.1	3.7	3.6
T2: N	5.7	6.6	6.4	5.2	5.2
T3: NP	6.1	6	6	5.6	5.7
T4: NPK	7.2	6.2	6.4	6.8	6.7
T5: All N from FYM	6.6	4.5	4.7	3.6	3.9
T6: ½ N from	6.5	7.7	7.6	6.2	6.5

urea + ½ N from FYM					
T7: ½ NP	4	5.7	5.8	6.1	9.5

Main plots are control, N Only, NPK, ½ N from urea + ½ N from FYM, FYM, ½ NP and NP, while subplots were No Micronutrient, Fe Soil Application, Zn Soil Application, Fe Foliar Application, Zn Foliar Application. Maximum yield was attained in ½ N from urea + ½ N from FYM with Zn Soil Application i.e. 7.6 tonns/hectare and minimum yield i.e. 1.9 tons/hectare was attained from control plot with no micronutrients application.

Wheat:

Crop was sown on 19-11-2019 and was harvested on 24-04-2020. Before sowing the crop soil samples were collected from 0-15 cm depth for analysis purposes. Fertilizers NPK were applied @ 120-90-60 kg/ha according to the plan. FYM, calculated on nitrogen basis, was applied in the plots according to the permanent layout. Wheat yield and pre-sowing soil analysis is given in Table 22.2.

Table 22.2: Effect of Fe and Zn Bio-fortification on Wheat Yield (t/ha)

	No micronutrient	**Fe Soil Application**	**Zn Soil Application**	**Fe Foliar Application**	**Zn Foliar Application**
T1: Control	0.9	1.6	1.3	1.3	2
T2: N	2.7	2.5	3.2	2.1	2.7
T3: NP	4.5	3.4	3.6	3.5	3.5
T4: NPK	3.1	4.4	2.9	3.9	3.3
T5: All N from FYM	3.4	4.3	3.2	3.5	2.9
T6: ½ N from urea + ½ N from FYM	4.5	3.2	2.5	3.7	3.4
T7: ½ NP	4.3	4.2	2	3.2	3.8

Results clearly reveals that control plot which were no fertilized has shown a stark effect of micronutrients application, i.e. control plot with no Fe and Zn application has a yield of 0.9 tonns/hac and rest of subplots have a boosted yield. In rest of plots, treatments showed a variable result, that may be due to different nutrients interactions, which will be further studied in some other study.

23. TO STUDY THE ROLE OF CEC ON NUTRIENT DYNAMICS IN ALKALINE CALCAREOUS SOILS OF PAKISTAN

This study is planned to determined the CEC of light (sandy loam), medium (loam) and heavy textured (Clay loam) soils in relation to nutrient dynamics under low OM content in maize crop. This study was planned and started in Kharif 2019. During 2019-20 Maize-wheat crop rotation was followed. This study is being conducted at Wirehouse of Soil Chemistry Section, ISCES, Faisalabad.

Maize:

Crop was sown on 02-08-2019 and was harvested on 04-11-2019. Before sowing the crop soil samples were collected from 0-15 cm depth for analysis purposes. Fertilizers NPK were applied @ 275-125-75 kg/ha according to the plan. FYM, calculated on nitrogen

basis, was applied in the plots according to the permanent layout. Maize yield and pre-sowing soil analysis is given in Table 23.1.

Table 23.1: Pre-sowing soil analysis and Maize yield

Sr. No.	Soil Texture	Fertilizer	EC (dS/m)	pH	Ex.K (ppm)	Yield (g/plot)
1	Loam	T1	1.78	7.21	198	22.1
		T2	1.78	7.14	188	33.1
		T3	1.79	7.21	195	25.4
		T4	1.81	7.19	196	28.7
2	Clay Loam	T1	1.79	7.24	212	22.4
		T2	1.75	7.14	208	36.8
		T3	1.79	7.05	192	23.9
		T4	1.82	7.01	184	23.4
3	Sandy Loam	T1	1.67	7.01	188	15.4
		T2	1.68	7.06	195	32.0
		T3	1.71	7.16	196	19.5
		T4	1.72	7.24	200	16.3

Results have revealed that in each kind of soil T2 i.e. the recommended dose f fertilizer has performed better in term of yield parameter. Its has given maximum yield, while control treatment i.e. no fertilizer has given minimum yield.

Wheat:

Crop was sown on 21-11-2019 and was harvested on 29-04-2020 Before sowing the crop soil samples were collected from 0-15 cm depth for analysis purposes. Fertilizers NPK were applied @ 120-90-60 kg/ha according to the plan. FYM, calculated on nitrogen basis, was applied in the plots according to the permanent layout. Wheat yield and pre-sowing soil analysis is given in Table 23.2.

Table 23.2:Pre-sowing soil analysis and Wheat yield

Sr. No.	Soil Texture	Fertilizer	EC (dS/m)	pH	Ex.K (ppm)	Yield (g)
1	Loam	T1	1.85	**6.77**	184	9.37
		T2	1.81	7.12	188	10.83
		T3	1.89	7.21	195	8.27
		T4	1.80	7.19	196	9.23
2	Clay Loam	T1	1.91	7.24	212	9.13
		T2	1.72	7.14	205	11.1
		T3	1.78	7.05	192	8.47
		T4	1.85	7.10	184	7.03
3	Sandy Loam	T1	1.81	7.01	188	4.36
		T2	1.89	7.06	195	12.4
		T3	1.80	7.16	196	6.72
		T4	1.91	7.33	212	8.72

Results have revealed that in each kind of soil T2 i.e. the recommended dose f fertilizer has performed better in term of yield parameter. Its has given maximum yield, while control treatment i.e. no fertilizer has given minimum yield.

FERTILIZERS AND SOIL HEALTH

24. DIRECT AND RESIDUAL EFFECT OF SULFUR FERTILIZATION BY USING INTEGRATED APPROACH IN ALKALINE CALCAREOUS SOILS

Continuous use of sulfur free fertilizers like DAP, Urea under intensive cropping system and lack of addition of organic manures over the years resulted in the emergence of S deficiency. It has been claimed that direct use of sulfur is not recommended by researchers because of its immediate non availability to crop in which it is added. So, keeping in view the above facts, this study has been planned to assess the direct and residual effect of sulfur fertilization by using integrated approach in alkaline calcareous soils. For direct effects different doses of sulfur with and without OM were applied on maize crop with following treatments.

The five different treatments (sub plot) were:
T1: Control (RD NPK)
T2: RD NPK + Sulfur 5 kg/h
T3: RD NPK + Sulfur 10 kg/h
T4: RD NPK + Sulfur 15 kg/h
T5: RD NPK + Sulfur 20 kg/h
The two main plots were:

1: With organic matter @ FYM @5 tons/h
2: Without organic matter

Maize Crop

Maize crop was sown on 10-08-2019 and harvested on 15-11-2019. The results indicated that the yield of OM applied plots significantly high than without OM plots. Plots with OM treatment maximum yield was observed in treatment with maximum dose of sulfur which is 5.88 tonnes/ha (Table 24.1). Potassium and phosphorus content in different treatments showed non significant differences (Table 2) further plant analysis is in progress. Basic soil analysis showed the moderate soil fertility without salinity and sodicity hazards (Table 24.3). Residual effects of sulfur will be determined in next wheat crop.

Table 24.1: Effect of direct sulfur fertilization on maize grain yield

Treatments	With Organic Matter	Without Organic Matter
	Yield (t/ha)	
T1: Control (RD NPK)	5.312 bc	4.989 c
T2: RD NPK + Sulfur 5 kg/h	5.314 bc	5.171 bc
T3: RD NPK + Sulfur 10 kg/h	5.531 ab	5.285bc
T4: RD NPK + Sulfur 15 kg/h	5.563 ab	5.371 b
T5: RD NPK + Sulfur 20 kg/h	5.878 a	5.483 ab
Tukey HSD critical value= 5.151		

Table 24.2: Effect of direct sulfur fertilization on maize grain Potassium and Phosphorus contents

Treatments	Phosphorus (%)		Potassium (%)	
	With Organic matter	Without Organic matter	With Organic Matter	Without Organic matter
T1: Control (RD NPK)	1.213 DE	1.749 AB	1.749 A	1.254 A
T2: RD NPK + Sulfur 5 kg/h	1.708 ABC	1.419 CD	1.419 A	1.790 A
T3: RD NPK + Sulfur 10 kg/h	1.089 E	1.584 BC	1.584 A	1.048 A
T4: RD NPK + Sulfur 15 kg/h	1.502 BCD	1.914 A	1.997 A	1.460 A
T5: RD NPK + Sulfur 20 kg/h	1.708 ABC	1.584 BC	1.295 A	1.708 A
LSD G	0.19		0.098	
LSD T	0.204		NS	

Wheat Crop

Wheat crop was sown on 25-11-2019 with the same treatments but all plots were divided into two sub-plots. One sub-plot was for studying the direct effect of S on wheat and the 2nd plot was for studying the residual effect of S on wheat crop applied to previous maize crop. Crop was harvested on 23-04-2020. Before sowing and after harvesting of wheat crop the composite soil samples (0-15 and 15-30 cm depth) were taken and analyzed for basic soil analysis (Table 24.3). Further analysis is in progress.

Table 24.3: Pre-sowing Soil Analysis

Depth	ECe	pHs	OM	N	P	K	B.D.	Texture
Cm	dSm^{-1}		%		ppm			
0-15	1.33	7.91	0.65	2.2	6.5	180	1.45	Sandy Clay Loam
15-30	1.37	7.97	0.49	2.8	3.9	147	1.48	

25. INTEGRATED IMPACT OF BIO AND CHEMICAL FERTILIZERS ON SOIL HEALTH, GROWTH AND YIELD OF PUMPKIN/ONION

Pumpkin is one such important vegetable belongs to family cucurbitaceae. It is one of the largest family in vegetable kingdom consisting of largest number of edible type species. Pumpkin fruits are extensively used as vegetables both in mature and mature stage. Pumpkin is rich in carotene which is the precursor of vitamin A. The fertility status of Pakistani soils is much low which may be due climatic conditions and intensive cropping system to meet the food requirements of the increasing population. the fertility status depleted rapidly, the productivity of our soils is decreasing, due to low soil fertility, poor management practices, imperfect use of organic fertilizers. Intensive cultivation and excessive use of chemical fertilizers resulted in harmful and long term impact on the health of soil and also unstable yield of crops therefore integrated nutrient management has become necessary for increasing productivity of crops. Vegetables are very vital part of human diet with many positive effects on human health. Pumpkin Is one of the most popular vegetable that form of daily diet in Pakistan, pumpkin is an important commercial

crop widely grown in different parts of the country. So keeping in view the above stated facts this project was planned to assess the integrated impact of bio and chemical fertilizer on soil health, growth and yield of pumpkin/onion. Pumpkin crop was sown on 21-05-2019 and harvested on 27-09-2019. RD of NPK was 87-75-62 kg/ha bio fertilizer used was BioZort Max @ (3 kg/ha) and FYM @ (5 t.ha). Treatment plan of the project was as under

T1: Control
T2: 100% RD of NPK
T3: BIO FERTILIZER (Biozot max) @3kg/ha + @ 5 t/ha FYM
T4: 50 % RD of NPK+3kg/ha (Biozot max)
T5: 50% RD of NPK +3kg/ha (Biozot max))+ OM @ 5 t/ha FYM
T6: 75 % RD of NPK+3kg/ha (Biozot max)
T7: 75% RD of NPK +3kg/ha (Biozot max) + OM @ 5 t/ha FYM
T8: 100 % RD of NPK+3kg/ha (Biozot max)
T9: 100% RD of NPK +3kg/ha (Biozot max) + OM @ 5 t/ha FYM

Table 25.1: The fertility status of the field before sowing of the crop

Soil depth	**pH_s**	**EC_e**	**O.M**	**Av. P**	**Av. K**	**Bulk Density**	**Porosity**	**Texture**
Cm		dSm^{-1}	%	Ppm		(g/cm^3)	(%)	Sandy Clay loam
0-15	8.02	1.29	0.69	6.4	176	1.66	38.9	

The pre sowing analysis of the soil (Table 25.1) collected from field which was used for the sowing of pumpkin crop showed that the soil was free from salinity and sodicity, low in organic matter (0.69%) and phosphorus (6.4 ppm) while potash (176 ppm) was sufficient. Bulk density of soil was 1.66 g/cm^3 and porosity was 38.9%.

The data regarding pumpkin yield (Table 25.2) indicated that maximum pumpkin yield ($40tha^{-1}$) was observed in the treatment receiving 75% recommended dose of NPK along with Biofertilizer and FYM followed by treatment receiving recommended dose of NPK and Biofertilizer (37.2 t ha^{-1}). While minimum pumpkin yield (22.04 t/ha) was obtained in control (no fertilizer).

Table 25.2: integrated Effect of Bio and Chemical Fertilizers on pumpkin Yield (t/ha) Potassium and Phosphorous contents

Treatments	**Pumpkin yield**	**Potassium**	**Phosphorous**
	(t/ha)	**(%)**	
T1: Control	22.04 G	0.14 F	0.02
T2: 100% RD NPK	24.16 F	0.19 E	0.03
T3: Biofertilizer (Biozot) @ 3Kg/ha + OM (5 t/ha FYM)	27.6 E	0.22 D	0.03
T4: 50% RD of NPK + Biofertilizer (Biozot) @ 3Kg/ha	25.06 F	0.29 C	0.03
T5: 50% RD of NPK + Biofertilizer (Biozot) @ 3Kg/ha + OM (5t/ha FYM)	30.4 D	0.32 B	0.03
T6: 75% RD of NPK + Biofertilizer (Biozot) @ 3	34.2 C	0.27 C	0.03

Kg/ha			
T7: 75% RD of NPK + Biofertilizer (Biozot) @ 3 Kg/ha + OM (5 t/ha FYM)	40 A	0.39 A	0.03
T8: 100% RD of NPK + Biofertilizer (Biozot) @3 Kg/ha	37.2 B	0.28 C	0.03
T9: 100% RD of NPK + Biofertilizer (Biozot) @3 Kg/ha + OM (5 t/ha FYM)	36.2 B	0.33 B	0.03
LSD	1.3	0.01	NS

Results showed that maximum potassium (%) concentration (0.39 %) in pumpkin was obtained in T7 where 75 % recommended dose of NPK along with bio fertilizer and farm yard manure was applied to the crop followed by T9 receiving recommended dose of NPK. The minimum K contents were observed in control where no fertilizer was applied. The gradual improvement was seen in all soil health related parameters.

Table 25.3: Integrated Effects of Bio and Chemical Fertilizers on soil health

Treatments	**pH**	**Ec**	**P**	**Soil K**	**B.D**	**Porosity**
		(dS/m)	**(mg/kg)**		**(g/cm^3)**	**(%)**
T1: Control	8.08	1.33	7.2	181	1.66	40.2
T2: 100% RD NPK	7.94	1.26	7.3	188	1.66	38.9
T3: Biofertilizer (Biozot) @ 3Kg/ha + OM (5 t/ha FYM)	7.86	1.29	7.5	203	1.66	39.2
T4: 50% RD of NPK + Biofertilizer (Biozot) @ 3Kg/ha	8.01	1.21	8.4	191	1.66	39
T5: 50% RD of NPK + Biofertilizer (Biozot) @ 3Kg/ha + OM (5t/ha FYM)	7.89	1.3	9.4	209	1.66	41.03
T6: 75% RD of NPK + Biofertilizer (Biozot) @ 3 Kg/ha	8.01	1.34	8.6	201	1.66	40
T7: 75% RD of NPK + Biofertilizer (Biozot) @ 3 Kg/ha + OM (5 t/ha FYM)	7.84	1.43	8.6	203	1.66	43.1
T8: 100% RD of NPK + Biofertilizer (Biozot) @3 Kg/ha	7.95	1.39	8	189	1.66	42
T9: 100% RD of NPK + Biofertilizer (Biozot) @3 Kg/ha + OM (5 t/ha FYM)	7.83	1.22	11.9	213	1.66	43.4

Onion

The experiment was conducted in RCBD design with 3 replications at research farm of Soil Chemistry Section ISCES AARI, Faisalabad. The composite soil samples were collected before sowing of the crop and analyzed for basic soil characteristics. Onion crop was sown on 22-01-2020 and recommended dose of NPK @ 130-50-100 kg/ha was applied as per treatment plan.

Table 25.4: The fertility status of the field

Soil depth	pH_s	EC_e	O.M	Av. P	Av. K	BD	porosity	Texture
Cm		dSm^{-1}	%	mg/kg		g/cm^3	(%)	Sandy Clay loam
0-15	8.01	1.34	0.71	7.19	168	1.65	39.2	

The Basic Soil analysis of the collected soil from field which was used for the sowing of onion crop showed that the soil was free from salinity and sodicity, low in organic matter and phosphorus while potash was medium.

Onion crop was harvested on 27-04-2020 and bulb yield data was recorded. The data regarding onion yield (Table 2) which showed that maximum onion yield of (24.20 t/ha) was obtained where 100% of RD of NPK applied where as minimum (12.75) was observed in control.

Table 25.5: Integrated Effect of Bio and Chemical Fertilizers on onion Yield (t/ha)

Treatments	Onion yield (t/ha)
T1: Control	12.75 F
T2: 100% RD NPK	19.2 CD
T3: Biofertilizer (Biozot) @ 3Kg/ha + OM (5 t/ha FYM)	19.12 C
T4: 50% RD of NPK + Biofertilizer (Biozot) @ 3Kg/ha	18.8 E
T5: 50% RD of NPK + Biofertilizer (Biozot) @ 3Kg/ha + OM (5t/ha FYM)	20.60 BC
T6: 75% RD of NPK + Biofertilizer (Biozot) @ 3 Kg/ha	20.95 AB
T7: 75% RD of NPK + Biofertilizer (Biozot) @ 3 Kg/ha + OM (5 t/ha FYM)	19.91 BC
T8: 100% RD of NPK + Biofertilizer (Biozot) @3 Kg/ha	21.62 B
T9: 100% RD of NPK + Biofertilizer (Biozot) @3 Kg/ha + OM (5 t/ha FYM)	24.2
LSD	1.17

26. 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 26.1.
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 26.1: Pre-sowing Soil Analysis

Depth	pH	EC	CEC	Organic carbon	Organic matter	Av.P	Av.K	Bulk density	Porosity	Texture
Cm		$dS\ m^{-1}$	$cmol_c\ kg^{-1}$	$(g\ kg^{-1})$	%	$mg\ kg^{-1}$		gcm^{-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 17-07-2019 and harvested on 22-10-2019. 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, coper oxy-chloride and furadon were applied to control insects pests. Weediside sun-star and mechayti were applied to control weeds. The results given in Table 26.2 indicated that the maximum rice paddy yield (3.75t ha^{-1}) was obtained in T_3 where recommended dose of NPK fertilizer was applied along with green manuring, while minimum paddy yield (2.75 t ha^{-1}) was obtained in control (T_1). The results also showed maximum rice straw yield (10.83 t ha^{-1}) was obtained in T_4 while minimum straw yield (9.67 t ha^{-1}) was obtained in control (T_1).

Table 26.2: Effect of Green Manuring on Rice Paddy and Straw yield

Treatments	Paddy Yield	Straw yield
	$(t\ ha^{-1})$	
T1: Control	2.75 d	10.0 c
T2: NPK without green manuring	3.50 c	10.08 bc
T3: Recommended NPK + green manuring	3.75 a	10.17 b
T4: 75% of recommended NPK + green manuring	3.58 ab	10.83 a
T5: 50% of recommended NPK + green manuring	3.67 bc	9.67 d
LSD	0.1	0.11

Barseem
Barseem was sown on 28-10-2019. After taking four cuttings, the barseem on attaining full vegetative growth was incorporated into the soil according to the treatment plan on

15-05-2020. 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 marginal range (Table 26.3).
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 showed that maximum barseem biomass (99 t ha^{-1}) was obtained in T_3.

Table 26.3: Soil analysis before sowing of Barseem from 0-15 cm & 15-30 cm depth

Treatments	Depth (cm)	BD (g cm^{-3})	Porosity %	OM %	Av. P (mg/kg)	Av. K (mg/kg)
T1: Control	**0-15**	1.5	43.58	0.59	6.38	137
	15-30	1.62	39.92	0.51	5.97	115
T2: NPK without green manuring	**0-15**	1.53	42.43	0.69	7.59	159
	15-30	1.59	38.89	0.6	6.23	137
T3: Recommended NPK + green manuring	**0-15**	1.43	47.57	0.72	12.11	181
	15-30	1.57	44.48	0.68	10.81	167
T4: 75% of recommended NPK + green manuring	**0-15**	1.39	45.95	0.87	13.21	196
	15-30	1.47	40.79	0.79	11.85	174
T5: 50% of recommended NPK + green manuring	**0-15**	1.44	45.74	0.62	10.24	181
	15-30	1.44	45.81	0.61	8.91	159

27. EFFECT OF ORGANIC AMENDMENTS TO INCREASE SOIL HEALTH, CROP GROWTH, YIELD AND NUTRIENT USE EFFICIENCY UNDER WHEAT CROP

Overall organic matter is low in Pakistani soils due to climatic conditions and anthropogenic activities. Soil organic matter plays very important role in soil health and crop production. By keeping in mind the above mention statement. This study was planned to assess the effect of organic matter on soil physic-chemical properties and nutrient use efficiency under wheat/rice cropping system. The experiment was conducted at Soil Chemistry Section, AARI, Faisalabad. Eleven treatments were tested under RCBD (Randomized Complete Block Design).

T1: Recommended dose of NPK
T2: Half FYM+half crop residue+RD of NPK
T3: Half press mud+haif crop residue+RD of NPK
T4: Half poultry manure+half crop residue+RD of NPK
T5: FYM+ RD of NPK
T6: Press mud+ RD of NPK
T7: poultry manure+ RD of NPK
T8: Crop residue+ RD of NPK
T9: Crop residue+FYM+RD of NPK
T10: Crop residue+Press mud+RD of NPK
T11: Crop residue+poultry manure+RD of NPK

Organic amendments were applied @ 10 tons/ha.

Wheat was sown on 04-12-2019 and was harvested on 30-04-20. Pre-sowing soil analysis showed that the soil was moderately fertile without salinity and sodicity hazards (Table 27.1)

Table 27.1: Pre-sowing soil analysis (wheat experiment)

Depth	pH	EC	Organic matter	Av.P	Av.K
Cm		dS m^{-1}	%	mg kg^{-1}	
0-15	8.13	1.2	0.89	8.32	220
15-30	8.09	1.13	0.76	8.01	200

Table 27.2: Effect of organic amendments on plant physical parameters

Treatment	Plant height (cm)	Biomass production (g)	Grains yield (t/ha)
T1= Recommended dose of NPK	106 A	7.7 B	3.65 AB
T2= Half FYM+half crop residue+RD of NPK	102 A	8.7 A	3.10 C
T3= Half press mud+haif crop residue+RD of NPK	101 A	8.5 A	3.98 A
T4= Half poultry manure+half crop residue+RD of NPK	102 A	7.5 B	2.89 CD
T5= FYM+ RD of NPK	104 A	7 BC	2.72 D
T6= Press mud+ RD of NPK	99 B	6.1 C	2.72 D
T7= poultry manure+ RD of NPK	102 A	8:00 AM	3.17 BC
T8= Crop residue+ RD of NPK	102 A	6.8 CD	2.91 CD
T9= Crop residue+FYM+RD of NPK	103 A	5.7 D	2.16 E
T10= Crop residue+Press mud+RD of NPK	104 A	5.7 D	2.75 D
T11= Crop residue+poultry manure+RD of NPK	109 A	7.8 B	3.67 AB
LSD	9	0.8	0.18

Results (Table 27.2) showed that maximum grains yield was obtained from the plots where Crop residue+poultry manure+RD of NPK was applied. The chemical analysis is under process, final conclusion will be derived after chemical analysis.

28. 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 2019-20 Maize-wheat crop rotation was followed. This long term study is being conducted at research area of Soil Chemistry Section, ISCES, Faisalabad.

Maize:

Crop was sown on 02-08-2019 and was harvested on 04-11-2019. Before sowing the crop soil samples were collected from 0-15 cm depth for analysis purposes. Fertilizers NPK were applied @ 275-125-75 kg/ha according to the plan. FYM, calculated on nitrogen basis, was applied in the plots according to the permanent layout. Maize yield and pre-sowing soil analysis is given in Table 28.1.

Table 28.1: Maize yield and Pre-sowing soil analysis (0-15 cm)

Treatments	Maize Yield	pHs	ECe	O.M	Av.P	Ex.K
	(t/ha)		(dS m^{-1})	(%)	(ppm)	
T1: Control	1.90 H	7.6	1.9	0.6	7.3	180
T2: N	5.67 E	7.8	1.8	0.7	7	185
T3: NP	6.17 D	7.9	1.9	0.7	7.1	190
T4: NPK	7.20 A	7.9	1.8	0.7	7.1	195
T5: All N from FYM	6.63 B	7.8	1.9	1	7	210
T6: ½ N from urea + ½ N from FYM	6.47 C	7.7	1.7	0.9	7.1	200
T7: ½ NP	4.07 F	7.9	1.8	0.7	6.9	190

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 (38.9 t/ha). Maize yield was in the order of NPK >FYM>NP>½ N from urea + ½ N from FYM =N >½ NP >control.

Wheat:

Crop was sown on 19-11-2019 and was harvested on 24-04-2020. Before sowing the crop soil samples were collected from 0-15 cm depth for analysis purposes. Fertilizers NPK were applied @ 120-90-60 kg/ha according to the plan. FYM, calculated on nitrogen basis, was applied in the plots according to the permanent layout. Wheat yield and pre-sowing soil analysis is given in Table 28.3.

Table 28.3: Wheat yield and Pre-sowing soil analysis (0-15 cm)

Treatments	Wheat Yield	pHs	ECe	O.M	Av.P	Ex.K
	(t/ha)		(dS m^{-1})	(%)	(ppm)	(ppm)
T1: Control	0.90 E	7.8	1.85	0.61	7.3	184
T2: N	2.70 D	7.4	1.81	0.72	7	188
T3: NP	4.47 A	7.8	1.89	0.73	7.1	195
T4: NPK	4.50 A	7.8	1.8	0.71	7.1	196
T5: All N from FYM	3.53 C	7.7	1.91	0.98	7	212
T6: ½ N from urea + ½ N from FYM	2.93 D	7.6	1.72	0.89	7.1	205
T7: ½ NP	4.10 B	7.7	1.78	0.69	6.9	192

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. Wheat grain yield data

showed that use of chemical fertilizer NPK proved better to get higher yields (4.50 t/ha). Wheat yield was in the order of NPK >NP >½ NP >FYM >½ N from urea + ½ N from FYM =N >control.

CONCLUDED EXPERIMENTS

1. Effect of integrated nutrient management on growth and yield of hybrid maize/wheat
2. Effect of different levels of potassium and different sources of nitrogen on maize grain yield
3. Heavy metals in waste water collected from different main drains of FSD district
4. Assessment of nutrient removal by different weeds under different nutrition scenario
5. Mapping of physico-chemical characteristics of waste water irrigated soils from main districts of Punjab using arc GIS

PESTICIDES QUALITY CONTROL LABS

OVERVIEW

Pesticide Quality Control Laboratories are engaged in the analysis of pesticide samples received from the pesticide inspectors appointed by Government of Punjab under Punjab Agricultural Pesticide Act, 2012. The Pesticide Quality Control Laboratories located at Faisalabad, Kala Shah Kaku, Multan and Bahawalpur has been established to test the pesticides for its quality and provide report of analysis to the concerned pesticide inspector for further legal action under Punjab Agricultural Pesticide Act, 2012 if required. These laboratories are functioning in accordance with the provisions of the Agricultural Pesticide Act and providing the analytical services within their jurisdiction under the supervision of respective Agricultural Chemist (Pesticides). The Agricultural Chemist, Faisalabad has been declared Government Analyst for the purpose. In addition to pesticide regulatory work, these laboratories also conducts research work on various aspects of pesticides to resolve the issues emerging from the use of pesticides. A brief description of pesticide quality control and research work carried out by this Section during the year 2019-20 is given below.

Pesticide Samples Analysis

Pesticide laboratories located each at Faisalabad, Kala Shah Kaku, Multan and Bahawalpur received samples from the pesticide inspectors under Section-17 and purchasers of pesticides (farmers, pesticide companies / manufacturers / distributors, government departments & other allied agencies) under section-20 of Punjab Agricultural Pesticide Act, 2012. These samples were analyzed at the pesticide laboratories by the qualified technical staff following the internationally approved standard analytical techniques and methods. The analysis reports were prepared and dispatched to the concerned quarters. The summary of the pesticide samples received and analyzed at Pesticide Laboratories is given in table 1 to 3.

During this year, in total 9056 samples were analyzed for their quality, out of which 8652 samples were found fit (95.54 %) and 404 unfit (4.46%) (Table 1).

Table-1: No. of pesticide samples analyzed under section-17 of APO, 1971

1) Laboratory	Total	Fit	Unfit	%Unfit
Faisalabad	3085	2979	106	3.44
Kala Shah Kaku	1781	1706	75	4.21
Multan	2429	2269	160	6.59
Bahawalpur	1761	1698	63	3.58
Total	**9056**	**8652**	**404**	4.46

As far as Section-20 is concerned, total 102 samples were received from the purchasers of pesticides and analyzed for their quality. Out of these 74 were found fit and 28 did not qualify the standard specification limits (Table 2).

Table-2: **No. of pesticide samples analyzed under Section-20**

Laboratory	Total	Fit	Unfit
Faisalabad	65	40	25
Kala Shah Kaku	2	2	0
Multan	30	28	2
Bahawalpur	5	4	1
Total	**102**	**74**	**28**

Table-3: No. of pesticide samples received under Section-17

Laboratory	No. of Samples Received
Faisalabad	3263
Kala Shah Kaku	1930
Multan	2719
Bahawalpur	1736
a) Total	**9648**

RESEARCH WORK

STUDIES ON THE STORAGE STABILITY OF DIFFERENT PESTICIDE FORMULATIONS AT AMBIENT TEMPERATURE AND HUMIDITY

Various pesticide formulations were studied to check the stability of their registered specifications under ambient temperature and humidity over time. The samples were analyzed at the start of the experiment and subsequently with an interval of three months for their physico-chemical characteristics. Among the products studied at Faisalabad Lab. Imidacloprid 25 WP, Thiophanate Methyl 70 WP , Bifenthrin 10 EC and Chlorpyrifos 40 EC, at Kala Shah KakuLufenuron 5 EC, Emamectin Benzoate and Lambda Cyhalothrin 2.5 EC, at Multan Clopyralid 30%W/W, FluroxypyrMeptyl 30%W/W, and TribenuronMeptyl 6%W/W were kept under study during the period and at Bahawalpur Lab Bromoxynil+ MCPA 40 EC, Carbofuran 3G and Lambda Cyhalothrin 2.5 EC were kept under study during the period. All the pesticide kept under study found fit till the last analysis.

STANDARDIZATION OF ANALYTICAL METHODS FOR PESTICIDE FORMULATIONS

The analytical methods of newly introduced pesticides every year need to be standardized under prevailing local laboratory Conditions and facilities, before their application to the

regulatory samples. Hence, methods for the Thiocyclam, Fenaminstrobin and Lambda Cyhalothrin on HPLC were standardized.

42 Methods of different chemistries validated for ISO-17025 requirements.

ISO-17025 ACCREDITATION

Four Pesticide Quality Control Laboratories are accredited by Pakistan National Accreditation Council (PNAC) for ISO-17025 Standards. This year Surveillance Audit was due and all Labs also applied for extension in Scope. All the laboratories successfully qualifiedthe PNAC Surveillance Audit and further Scope Enhancement.

PESTICIDE RESIDUE LABORATORY

OVERVIEW

Pesticide Residue assessment from all commodities across the Punjab is necessary for the healthy food chain and the safe Environment. Pesticide residues have been detected in fruit, vegetables and cereals. The levels of these residues in food are often stipulated by regulatory bodies in many countries. Government of Punjab also intends to address this very issue of food safety.

Pesticide Residue Laboratory, Kala Shah Kaku, is the only laboratory in provincial setup working on this very significant issue of food safety.

Tasks/Objectives:

- Market survey to monitor the pesticide residues in fruit, vegetables and other commodities.
- To determine the withholding period for different pesticides in crops, fruit and vegetables.
- To provide pesticide residue assessment service to meet the WTO and international quality standards.

Activities:

- Pesticide Residue Monitoring across the Punjab for the evaluation of pesticide residues in fruit, vegetables and cereals.
- Controlled pesticide residual studies keeping in view the survey results.
- Analysis of pesticide residues from advisory samples.

WORK DONE DURING 2019-20

1. MONITORING OF PESTICIDE RESIDUES ACROSS THE PUNJAB

During the year 2019-20, one thousand six hundred and sixty eight (1668) samples, of various fruit, vegetables and cereals, were analyzed for pesticide residues under continuous activity for database development across the Punjab.

In addition, seven hundred (700) samples were also tested under method validation regarding accreditation to ISO-17025. In terms of analytical service for the sister organizations, eight hundred and seventy eight (878) samples of different commodities were also tested for pesticide residues and reported to concerned institutes.

While, three hundred and eighty two (382) samples of this laboratory own research trials were run on hi-Tech machines for pesticide residues analysis. Five hundred and six (506) samples of analytical standards were also run for method standardization and calibration purposes. The progress of analysis work during the year 2019-20 is provided in Table 1.

Results showed that a total of 46 (3%) samples out of 1668 were found carrying pesticide residues above the respective maximum residual limits (Figure 1).

2. RESEARCH WORK

During the year 2019-20, in addition to the monitoring/survey activity for pesticide residues determination from fruit, vegetables and cereals, across the Punjab; a total of fourteen (11) research trials for both the Kharif and Rabi seasons (06 and 05 trials, respectively) were conducted.

A. Research Trials Kharif 2019

Trial 1: Study of Chlorpyrifos 40 EC residues In Chillies

Trial 2: Study of Lambda cyhalothrin 50 EC residues in tomatoes

Trial 3: Studies on residual effect of insecticides on rice crop

Trial 4: Study of Lambda cyhalothrin 50 EC residues in grapes

Trial 5: Study of Imidacloprid 200 SL residues in Okra

Trial 6: Study of Thiophenate methyl 70 WP residues in Cucumber

B. Research Trials Rabi 2019-20

Trial 1: Study of s-Metolachlor 960 EC (herbicide) and Fipronil 50sc (insecticide) residues in cauliflower

Trial 2: Study of Pendimethalin 455 CS (herbicide) and Lufenuron 50 EC (insecticide) residues in cauliflower

Trial 3: Study of Pendimethalin 455 CS (Herbicide), Profenofos 500 EC (Insecticide), and Tebuconazole 25% EC (Fungicide) residues in Potato

Trial 4: Study of Metribuzin 70% WP (herbicide), Chlorpyrifos 40% EW (insecticide), and Difenoconazole 25% EC (fungicide) residues in potato

Trial 5: Study of Bifenthrin 10% EC and Azoxystrobin 50% SC residues in Strawberry.

Table 1: THE SUMMARY FOR THE PROGRESS OF ANALYSIS WORK (2019-20)

TASKS/ACTIVITIES	SAMPLES ANALYZED
Monitoring of Pesticide Residues in Fruit, vegetables & cereals across the Punjab (Survey)	1668
Method validation regarding Proficiency Testing for accreditation to ISO-17025.	700
Advisory service to various sister organizations	878
Research Trials of PRL KSK	382
Standards prepared & run for method accuracy checking	506
Total	**4134**

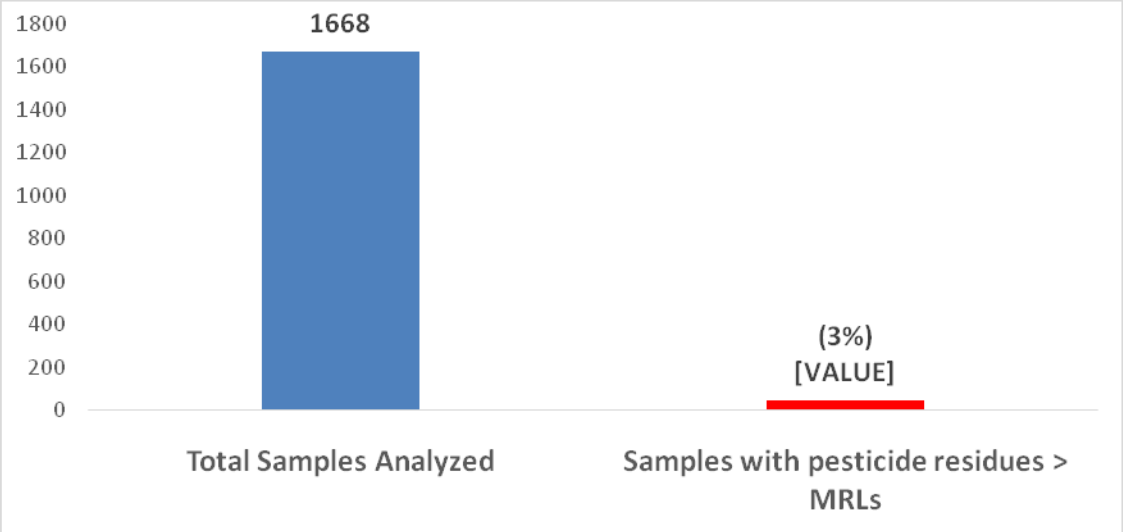

Figure 1: No of samples detected with Pesticide Residues above MRLs (2019-20)

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6 Urdu articles published in Zarat Nama

Pesticide quality control lab

1- Two papers published. One submitted for publication.

d. Radio Talks:(Soil Chemistry Section)

Sixteen radio talks on various topics were got recorded for broadcasting from Pakistan Broadcasting Corporation, Lahore / Faisalabad.

e. Trainings Workshops Attended (Soil Chemistry Section)

1. 2 officers got training on Finance, Administration, Management and E-Governance by ORIC, UAF
2. Six officers got trainings on ISO/IEC 17025 : 2017
3. Two officers got training workshop on "Integrating Emerging ICT Tool with Agriculture Research 21stCentury jointly organized by PASTIC and main library AARI FSD.
4. One officer got 1 day training on "Project Management and Evaluation" at RAEDC Vehari.
5. Four officers got 2 days training on " General Requirement and Implementation of ISO/IEC 17025/2017 at Lahore
6. One officer got training on "PC1 Preparation at Ministry and planning, Development and Reforms, Pakistan Planning and Management Institute, PPMI, Islamabad
7. Two officer got training on " PC1 preparation" at MPDD Lahore
8. One officer got training on "leadership skills" at MPDD Lahore
9. Two officials got training on "Basic IT skills" at MPDD Lahore

f. Workshops/ Seminars attended (Soil Chemistry Section)

1. International conference on climate resilient smart soil management focusing food security, ecosystem and environment. 3-5 March 2020, Haripur, Pakistan.

2. 1st International conference on agricultural and biological sciences, focusing food security and climate change. Organized by The University of Haripur on 27-30 March 2019
3. 1st International conference on surface science: innovations and applications for geo environmental challengesFaisalabad, Pakistan, 25-26 April 2019
4. 1st International Salinity Conference, Islamia University BahawalpurPakistan, 29 April 2019
5. 6th International conference on sustainable agriculture in changing climate strategies and management Rawalakot, Azad Jammu and Kashmir, Pakistan 19-21 June 2019

g. Seminars Delivered (Soil Chemistry Section)

- 1st International conference on agricultural and biological sciences, focusing food security and climate change. Organized by The University of Haripur on 27-30 March 2019
- 1st International conference on agricultural and biological sciences, focusing food security and climate change. Organized by The University of Haripur on 27-30 March 2019
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- 6th International conference on sustainable agriculture in changing climate strategies and management Rawalakot, Azad Jammu and Kashmir, Pakistan 19-21 June 2019

Miscellaneous (Pesticide Residue Lab)

1. 8 officers got Trainings on Finance, Administration, management & E. Governance for promotion under 4 Tier.

2- Two officers got training on Measurement Uncertainty arranged by PNAC at Lahore.

3- Five officers participated in Training Course for Labs Based on ISO/ IEC 17025:2017

4- One officer got training on Automation/Computerization of Departmental Libraries and AARI Website Applications

1. <u>ADVISORY SERVICE</u>(Pesticide Residue Lab)

Advisory service to various sister organizations and various departments of Ayub Agricultural Research Institute is provided to assess the pesticide residues load in different samples. The analysis reports are dispatched directly to the concerned quarters. A total of 878 samples of various commodities have been analyzed during the year 2019-20.

2. <u>ACHIEVEMENTS</u>(Pesticide Residue Lab)

A. Successful Surveillance of laboratory by the Pakistan National Accreditation Council (PNAC) for ISO-17025:2017

Pesticide Residue Laboratory, Kala Shah Kaku undergone the Surveillance activity regarding ISO/IEC 17025 accreditation with Pakistan National Accreditation Council (PNAC), from Tuesday to Friday; dated June 23-26, 2020.

The Laboratory has been RECOMMENDED for all the three purposes, applied for, including;

1. Surveillance on conformity with ISO/IEC 17025 standard.
2. Transition from the old ISO/IEC 17025:2005 to the required new version of ISO/IEC 17025:2017 standard.
3. Scope extension of the laboratory for the Pesticide Residues analysis, under the ISO quality assurance, for the customers, in the best of producers, merchants, exporters and the public at large.

B. INTER Laboratory Comparison

Pesticide Residue Laboratory, Kala Shah Kaku successfully accomplished an inter laboratory comparison with an ISO-17025 accredited laboratory from the PCSIR, Lahore.

C. Qualifications of Specifications for new hi-Tech machines for Prime Minister Emergency Program

Thursday, dated; 05/03/2020; meeting with Director AMRI, MULTAN. Dr. Abdullah Niaz explained the specifications of proposed machinery and equipment for the ISCES, KSK portion from the National Program for Enhancing Profitability through increasing productivity of Rice (Punjab Component). Syed SajjadHaiderKazmi also accompanied.

D. Successfully defense on proposed specifications on hi-Tech machinery of in Technical sub-committee

Dated 17/03/2020; Syed SajjadKazmi and Dr. Abdullah Niaz attended the Technical sub-committee meeting, chaired by the DGAR, for approval of specifications for new machinery.

E. Successfully Qualifying for the Central Specifications Standardizations Committee

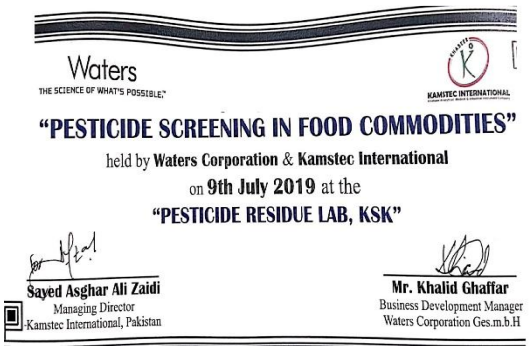
Meeting of Central Specifications Standardization Committee on 08/04/2020, chaired by Additional Secretary (Planning), Lahore. Syed SajjadHaiderKazmi and Dr. Abdullah Niaz joined the meeting for approval of specifications for the new machinery of first year, under the National Emergency Program of Prime Minister of Pakistan for rice crop.

F. Punjab Agriculture Pesticides Conference 2020

Dated 27-02-2020, Agriculture Department, Government of the Punjab, organized first Punjab Agriculture Pesticides Conference 2020. Syed SajjadHaiderKazmi along with Dr. Abdullah Niaz participated in the Conference.

G. Technical Seminar

A. One day seminar on "Pesticide Screening in Food Commodities" was organized by Waters Corporation &Kamstec International (Ltd.) on 09-07-2019 at the campus of PRL, KSK. Technical personnel from pesticide laboratories and the Directorate of ISCES, KSK participated to attend a knowledgeable Speaker, Mr. Khalid Ghaffar, from Waters Corporation.



H. Farmer Days

A. Tuesday, dated 19/11/2019, Dr. Abdullah Niaz delivered a talk regarding the vital aspect of Food Safety, Pesticide Residues; awareness, scenario, control strategies & recommendations, to a handsome gathering, comprising of progressive farmers, industry representatives, Government officers and the media men during a mega Farmers gathering, arranged by the District management of Agriculture Extension wing, District Gujrat.

B. On Thursday, dated 25-07-2019 a mega festival was arranged for rice growers and those of other kharif crops by the Agriculture Extension Gujrat wing in collaboration with Fatima Fertilizer (Sarbabz Fertilizer). Syed SajjadHaiderKazmi& Dr. Abdullah Niaz delivered lectures on safe use of pesticides, regarding Food Safety and the present scenario of pesticide residues in Agri. commodities across the Punjab.

3. TECHNICAL VISITS

A. Syed SajjadHaiderKazmi and Dr. Abdullah Niaz visited Pakistan Tobacco Board Sub-station, Okara on 23-04-2020. Discussions regarding Pesticide Residue Research trials on Tobacco crop and further collaboration, regarding research and survey activities, as per Government instructions.

B. On 23-04-2020; Syed SajjadHaiderKazmi and Dr. Abdullah Niaz joined Muhammad Hafeez Chaudhary, Assisstant Agricultural Chemist, Soil & Water Testing Laboratory, District Okara, regarding recent advice of Research Board to monitor pesticide residues in tobacco crop, grown extensively in Okara & Sahiwal Districts, to safeguard the consumers' safety and the valuable industry.

C. Team at District Gujrat for meetings with officers of Agriculture Extension wing to talk to them about the safe use of Pesticides and the Food Safety.

D. Wednesday, dated 22-01-2020, Technical Team of three Syed SajjadHaiderKazmi, Muhammad Siddique Shakir and Dr. Abdullah Niaz, visited FB research Laboratories, Lahore to monitor LCMSMS working, analysis of pesticide residues, instrument specifications and Technical discussions regarding subject matter and performance maintenance.

E. Wednesday, dated 08/01/2020, Technical team of two; Muhammad Siddique Shakir& Dr. Abdullah Niaz, visited Tti Testing Laboratories, a private firm dealing with Halal Testing and food toxins analysis, for orientation and awareness lecture about working of Liquid Chromatograph double mass spectrometer (LC-MS/MS; trippleQuadropole).

F. Syed Sajjad Haider Kazmi (Sajjad Kazmi), Ms. Umber Ghafoor, Muhammad Saddique Shakir, Dr. Abdullah Niaz and Ehsan Ahmad, joined a technical session at the PC Lahore, organized by Rays Technologies. Discussions regarding working of hi-Tech machinery including atomic absorption, ICP-OES and ICP-MS.

4. MEETINGS ATTENDED

A. Dated 28-01-2020, Devisional meeting on coordination between different wings of Agriculture department, at Agriculture House, Davis Road, Lahore; chaired by the Director General Agri. (Research). Syed SajjadHaiderKazmi and Dr. Abdullah Niaz participated in the meeting to present the real scenario of progressive working at the Laboratory.

B. Team at District Gujrat for meetings with officers of Agriculture Extension wing and to participate in a mega farmers meeting to talk to them about the safe use of Pesticides and the Food Safety.

C. Syed SajjadHaiderKazmi and Dr. Abdullah Niaz participated in a meeting held on 18/10/2019 at PQC Laboratory, Faisalabad; chaired by the Director ISCES-KSK, Dr. Ehsan UlHaq, to discuss on the possibilities to extend with the scope of all the laboratories for ISO/IEC 17025.

D. DGA (Research), Dr. AbidMehmood, chaired a meeting on 18/10/2019, at the Library seminar room of AARI, regarding progress on extension of scope for ISO/IEC 17025 by the already accredited twenty one (21) laboratories of AARI as well as the preparation on subject matter of new laboratories, going to get accredited for the first time. Syed SajjadHaiderKazmi and Dr. Abdullah Niaz participated.

ڈاکٹر عابد محمود (ناظم اعلیٰ زراعت برائے تحقیق) زرعی لیبارٹریوں کی کارکردگی جائزہ حوالے سے منعقدہ اجلاس کی صدارت کر رہے ہیں

5. CAPACITY BUILDING OF SCIENTISTS

A. Monday, dated 20/01/2020, Principal Scientist, Mr. Syed SajjadHaiderKazmi, received certificate of mandatory training course from worthy Vice Chancellor, University of Agriculture, Faisalabad. Training course continued for 04 weeks, covering all the elements of good management, including; financial, pressure, change, risk and human management as well as E-Governance, for officers of Government of the Punjab, BPS 19 and above.

B. October 11 & 12, 2019, the PNAC, Islamabad, arranged a two days training program for awareness regarding the changes asked by the new standard (ISO/IEC 17025:2017) and to facilitate the accredited laboratories to adapt for. The Scientific Officer/Technical Manager, Dr. Abdullah Niaz joined the training sessions.

C. Two training sessions were organized on 03-07-2019 at the Main Library of AARI, Fsd, for officers also working as Public Information Officers of various sections/sub-sections across the Punjab. Familiarization with the official AARI website and need based generation of information and dissemination were the themes of those training sessions. Dr. Abdullah Niaz was deputed for the training programs.

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