Research Article

Muqarrab Ali, Imran Khan, Muhammad Arif Ali, Shakeel A. Anjum, Umair Ashraf, Muhammad Ahmed Waqas*

Integration of organic sources with inorganic phosphorus increases hybrid maize performance and grain quality

<https://doi.org/10.1515/opag-2019-0032>

received April 18, 2018; accepted January 13, 2019

Abstract: Integrative use of organic and inorganic fertilizers not only fulfills the nutritional needs of crops, but also ensures sustainable production and environmental protection. Thus, this study was conducted to determine the influence of phosphorous application from integrated organic and inorganic fertilizers on maize. In this study poultry manure and press mud were integrated with single superphosphate (SSP) as the phosphorus source. Maximum amounts of time to 50% tasseling (47.75 and 47.63 days), 50% silking (53.07 and 53.11 days) and maturity (106.47 and 106.49 days) were recorded where the recommended dose of phosphorus was applied from only inorganic sources. For application of phosphorus from integrated sources, the treatment containing 25% poultry manure + 75% SSP provided the highest number of grains per cob (459.60 and 460.70), 100-grain weight (26.85 and 27.82), stover yield (9.61 and 10.41 t ha⁻¹), grain yield (7.14 and 7.82 t ha⁻¹) and grain protein content (8.59 and 8.63%) during both years. However, all treatments had non-significant effects on grain oil and starch content. Moreover, in given years, the integrated use of 75% poultry manure and 25% SSP resulted in a maximum benefit-cost ratio of 2.97 and 3.11 USD, respectively, as compared to integrated use of 25% poultry manure and 75% SSP, which produced a benefit-cost ratio of 2.58 and 2.81 USD. In conclusion, integration of organic sources

with inorganic phosphorus substantially improves the yield and economics of hybrid maize.

Keywords: organic and inorganic phosphorous, phenology, yield, hybrid maize quality.

1 Introduction

Maize (*Zea mays* L.) is a prime cereal crop around the globe. In Pakistan, it ranks as the third major cereal crop after rice and wheat. Currently, maize is cultivated on an area of 1,130 thousand hectares with a total annual production of 4,695 thousand tons, which is quite low compared to technologically more advanced countries (Govt. of Pakistan 2015). Imbalances in fertilization and exhaustive crops considerably reduce soil fertility and crop yield. Therefore, there is an urgent challenge and dire need to develop site-specific technology to increase maize productivity (Anjum et al. 2014). Among different agronomic practices, balanced use of nutrients has unique importance for achieving the maximum yield potential of maize (Hussain et al. 2006; Ahmad et al. 2008).

Phosphorus has special significance in crop nutrition as it plays a crucial role in the genetic makeup and enzymatic activities of plants (Tisdale et al. 1985). The introduction of exhaustive crops and intensive farming substantially increased the importance of phosphorus. Pakistani soils have low phosphorus content, therefore requiring the balanced application of phosphorus. Moreover, imbalanced fertilization (particularly with phosphorus and potassium) is a major yield limiting factor in cropping systems in Pakistan. Therefore, balanced application of fertilizers is required to sustain maximum maize productivity.

The use of chemical fertilizers does not necessarily lead to better farming; however, the combined use of chemical and organic fertilizers leads to better farming and sustainable production. The excessive use of chemical

*Corresponding author: Muhammad Ahmed Waqas, Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences, China,
Email: waqasclimate@hotmail.com

Muqarrab Ali, Department of Agronomy, Muhammad Nawaz Shareef University of Agriculture, Multan, Pakistan

Imran Khan, Shakeel A. Anjum, Umair Ashraf, Department of Agronomy, University of Agriculture, Faisalabad-38040, Pakistan

Muhammad Arif Ali, Department of Soil Science, Bahauddin Zakariya University, Multan, Pakistan

fertilizers along with agro chemicals badly degraded our soils, moreover, chemical fertilizers have destroyed traditional soil ecosystems (Palaniappan and Annadurai 1999). Thus, in order to cope with the aforementioned problems, cost effective, environmentally friendly and more productive farming systems need to be developed (Bhattacharya and Gehlot 2003).

Despite substantial fertilizer application, crop yield is either stagnant or not enhanced correspondingly, which is a clear reflection of lower fertilizer use efficiency. Several problems substantially reduce chemical fertilizer efficiency, including application method (Ibrahim et al. 2011), soil physical and chemical properties (Ibrahim et al. 2012), and unavailability and high cost of fertilizers (Ahmed 1994). Therefore, the use of organic manure along with chemical fertilizers will ensure better fertilizer use efficiency, soil health and sustainable production. There are different sources of organic manures that can be used along with the chemical fertilizers.

Among organic manure poultry manure is the most important organic fertilizer, as it is a rich source of major nutrients, including nitrogen, phosphorus, and potassium. Moreover, the addition of poultry manure in soils substantially improves organic matter, soil structure, nutrient use efficiency and soil water holding capacity (Deksissa et al. 2008). Meanwhile, Garg and Bahla (2008) reported that poultry manure more readily supplies phosphorus to plants than other organic sources. Similarly, Boateng et al. (2006) reported that application of poultry manure appreciably increased exchangeable cations and soil nitrogen content from 0.09% to 0.14%. The main logic behind the use of poultry manure is the addition of organic amendments to soils for nutrient provision and sustainable production (Warren et al. 2006). In addition, press mud (a byproduct of sugarcane) is another waste product which can be used as organic manure (Bokhtiar et al. 2001). Press mud contains nitrogen, phosphorus, potassium and other micronutrients which can in turn improve crop nutrients and organic matter, thus ameliorating soil properties (Razzaq 2001). The integrative use of organic manure and chemical fertilizers substantially increases the efficiency of chemical fertilizers; in addition, it also reduces environmental hazards (Ahmad et al. 1996).

Keeping in view the above facts, the present study was carried out to determine the influence of various combinations of organic (poultry manure and press mud) and inorganic (single super phosphate (SSP)) sources of phosphorous on the phenology, yield and quality of hybrid maize.

2 Materials and Methods

2.1 Experimental site and treatments

The experiment was conducted at the Agronomic Research Farm, University of Agriculture, Faisalabad, Pakistan, situated in a semi-arid environment, over two consecutive years (2008 and 2009). The experiment comprised the following treatments: T_1 : control (without phosphorus (P)); T_2 : 100% P from inorganic phosphate (SSP); T_3 : 75% P from organic source (OP (PoM*)) + 25% SSP; T_4 : 50% OP (PoM) + 50% SSP; T_5 : 25% OP (PoM) + 75% SSP; T_6 : 75% OP (PM**) + 25% SSP; T_7 : 50% OP (PM) + 50% SSP; and T_8 : 25% OP (PM) + 75% SSP (PoM* = poultry manure; PM** = press mud). The treatments were arranged in a randomized-complete-block-design (RCBD) with three replications; with a net plot size of 3 m × 5 m. Press mud and poultry manure were analyzed in a laboratory for their various chemical properties (Table 1).

Table 1: Chemical properties of poultry manure and press mud cake used during the study

Determinations	Unit	Poultry manure	Press mud cake
pH	-	8.01	7.59
EC	dS m ⁻¹	11.76	10.92
Organic Matter	%	41.26	43.14
Organic Carbon	%	23.10	24.86
Total Nitrogen	%	2.18	2.05
Available Phosphorus	g kg ⁻¹	1.06	0.91
Potassium	g kg ⁻¹	1.77	0.76

2.2 Soil analysis

Before conducting the experiment, a composite soil sample from the experimental field was taken and analyzed according to procedures described by Homer and Pratt (1961). The soil of the experimental site was sandy clay loam in texture, deficient in available phosphorous (6.3 and 6.1 ppm for 2008 and 2009, respectively), exchangeable potassium (122 and 118 ppm for 2008 and 2009, respectively) and organic matter (0.69% and 0.56% for 2008 and 2009, respectively); alkaline in nature pH (7.9 and 8.1 for 2008 and 2009, respectively), EC (1.48 and 1.9 d S m⁻¹ for 2008 and 2009, respectively) and low in total nitrogen (0.04% and 0.02% for 2008 and 2009, respectively).

2.3 Crop husbandry

The seedbed was prepared by double to triple cultivation with a tractor mounted cultivator, each time followed by planking. Maize hybrid FH-810 was sown on August 2008 and 2009 with the help of a dibbler, and maintaining a row to row distance of 75 cm and plant to plant distance of 20 cm, with a seed rate of 20 kg ha⁻¹. Nitrogen in the form of urea, phosphorous in the form of organic (press mud, poultry manure) or inorganic (SSP) source combinations, and potassium in the form of sulphate of phosphate (SOP), was applied at the rate of 296, 167 and 125 kg ha⁻¹, respectively. The full dose of phosphorus, potassium and one third of the total nitrogen was applied at the time of sowing, while the remaining nitrogen was top dressed in two equal splits, first at the knee height stage and later at the flowering stage. The organic sources for phosphorus were poultry manure and press mud, while the inorganic source was single super phosphate (SSP). The nutrient composition obtained from different components in each treatment is given in Table 2.

According to the need of the crop, irrigation (7.5 cm each) was used eight times at different growth stages, until the crop attained its physiological maturity. Carbofuran (Furadan 3-G) was applied at 0.6 kg of the active ingredient (a.i.) ha⁻¹ after thinning of the crop at the 3-4 leaf stage to shelter the crop from *Ostrinia nubilalis* and *Atherigona soccata*.

2.4 Observations Recorded

Ten plants were randomly taken from the central two rows in each plot and tagged. The number of days from sowing of the crop to 50% tasseling, 50% silking and days to maturity was calculated. Each year, maize was harvested manually in the second week of November. Grains from 10 randomly selected cobs were shelled for each treatment

and averaged for number of grains per cob. One hundred grains were counted from sub plots of each treatment type and weighed at 12% grain moisture content. The stover and grain yield was recorded on a per plot basis and then converted to t ha⁻¹. Quality parameters such as grain starch content were determined following the methods of Juliano (1971), in addition, grain oil and protein content were determined by following standard procedures described by Low (1990) and the microkjeldhal method (Anonymous, 1980), respectively.

2.5 Statistical and Economic Analysis

Data sets were analyzed by using the Analysis of Variance technique with the statistical package Statistix 8.1 (Analytical, Tallahassee, Florida, USA), while least significant difference (LSD) tests at 5% probability were used to compare treatment means (Steel et al. 1997). Economic analysis was conducted to investigate the comparative benefits of different agronomic practices used in this study. Marginal analysis was carried out according to procedures devised by CYMMIT (1998).

Ethical approval: The conducted research is not related to either human or animal use.

3 Results

Conjunctive use of organic manure and an inorganic phosphorus source significantly improved maize phenology (Table 3). In both years, the maximum number of days to 50% tasseling (47.57 and 47.63 days), 50% silking (52.71 and 52.95 days), and maturity (106.23 and 106.18 days) was recorded with the application of 25% OP (PoM) + 75% SSP. Meanwhile, the minimum time to 50% tasseling, 50% silking, and time to maturity was recorded with the control treatment (Table 3).

Table 2: Nutrient contents applied during the study through different organic and inorganic sources

Treatments	Manure used in kg ha ⁻¹	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)
T1= Control (without P)	-	296	-	125
T2= Recommended dose		296	167	125
T3= (75% PoM+25% SSP)	9500	186.3	40.5	15.75
T4= (50% PoM+50% SSP)	6300	223.1	81.9	51.5
T5= (25% PoM+75% SSP)	3170	259.9	123.3	86.75
T6= (75% PM+25% SSP)	10800	172.5	41.5	69
T7= (50% PM+50% SSP)	7200	211.6	81.9	87.25
T8= (25% PM+75% SSP)	3600	255.3	123.3	105

PoM= Poultry manure; PM= Press mud

Table 3: Effect of integrated phosphorus management through organic manures and inorganic fertilizer on maize phenology (Days)

Treatments	Time to 50% Tasseling		Time to 50% Silking		Time to maturity	
	Year I	Year II	Year I	Year II	Year I	Year II
T1= Control (without P)	47.00 c	47.01 d	52.18 d	52.25 d	105.17 e	105.13 e
T2= Recommended dose	47.53 ab	47.51 ab	53.07 a	53.11 a	106.47 a	106.49 a
T3= (75% PoM+25% SSP)	47.23 abc	47.24 bcd	52.38 cd	52.25 d	105.23 e	105.20 e
T4= (50% PoM+50% SSP)	47.30 abc	47.28 bcd	52.71 abc	52.95 ab	105.83 cd	105.84 c
T5= (25% PoM+75% SSP)	47.57 a	47.63 a	52.91 a	52.87 ab	106.23 ab	106.18 b
T6= (75% PM+25% SSP)	47.17 bc	47.14 cd	52.25 d	52.28 d	105.23 e	105.28 de
T7= (50% PM+50% SSP)	47.28 abc	47.25 bcd	52.44 bcd	52.49 cd	105.57 d	105.50 d
T8= (25% PM+75% SSP)	47.33 abc	47.34 abc	52.78 ab	52.79 bc	106.07 bc	106.06 bc
LSD (P ≤0.05)	0.37	0.32	0.39	0.31	0.3	0.27

Values sharing a letter in common within the column do not differ significantly at $p \leq 0.05$. PoM poultry manure; PM press mud

Table 4: Effect of integrated phosphorus management through organic manure and inorganic fertilizer on yield attributes of maize

Treatments	Number of grains cob-1		100-grain weight (g)		Stover yield (t ha ⁻¹)		Grain yield (t ha ⁻¹)	
	Year I	Year II	Year I	Year II	Year I	Year II	Year I	Year II
T1= Control (without P)	332.80 d	340.10 f	21.13 g	21.41 h	7.91 b	7.92 c	4.82 e	4.80 c
T2= Recommended dose	430.10 b	436.20 b	25.5 c	25.8 c	9.40 a	9.34 b	6.83 abc	6.81 b
T3= (75% PoM+25% SSP)	390.00 c	398.37 de	23.98 f	24.74 f	9.17 a	9.56 b	6.28 cd	6.61 b
T4= (50% PoM+50% SSP)	400.10 c	413.20 c	24.97 d	25.33 d	9.28 a	9.42 b	6.66 abc	6.81 b
T5= (25% PoM+75% SSP)	459.60 a	460.70 a	26.85 a	27.82 a	9.61 a	10.41 a	7.14 a	7.82 a
T6= (75% PM+25% SSP)	381.40 c	391.80 e	23.91 f	24.23 g	9.19 a	9.60 b	6.01 d	6.60 b
T7= (50% PM+50% SSP)	400.33 c	407.30 cd	24.75 e	25.19 e	9.30 a	9.56 b	6.55 bcd	6.79 b
T8= (25% PM+75% SSP)	430.70 b	438.50 b	26.03 b	26.9 b	9.62 a	10.32 a	7.04 ab	7.70 a
LSD (P ≤0.05)	24.84	9.49	0.202	0.087	0.53	0.66	0.58	0.5

Values sharing a letter in common within the column do not differ significantly at $p \leq 0.05$.

Different treatment combinations significantly affected the number of grains per cob (Table 4). However, the maximum number of grains (459.60 and 460.70) were recorded with the combined use of 25% OP (PoM) and 75% SSP. This treatment outperformed the rest of treatments in terms of grains per cob (Table 4). Integrated phosphorus management through the application of organic manure and chemical fertilizer significantly affected the 100-grain weight (Table 4). In both years' significant differences in 100-grain weight among various treatments were found. Similarly, an increase of 23.18% and 25.64% in 100-grain weight was recorded in both years with the application of 25% OP (PoM) + 75% SSP compared to the control treatment. In both years, lower 100-grain weights were recorded in the control treatment than in the other and conjunctive phosphorus management showed considerable differences both in stover and grain yield (Table 4). The application of 25% OP (PoM) + 75% SSP produced higher stover yields (9.61 t/ha and 10.41 t/ha) than all other treatments, however, it was statistically at par with the treatment where 100% SSP was applied.

Further, a maximum improvement of 46.05% and 60.42% in grain yield compared to the control was recorded with the application of 25% OP (PoM) and 75% SSP during 2008 and 2009 (Table 4). The increase in grain yield in treatment T₅ was not statistically different to that seen in treatment T₂ where 100% SSP phosphorus was applied. In addition, treatment T₂ was also at par with treatment T₄ where half of the phosphorus was applied from poultry manure with the remaining half applied from an inorganic source. Meanwhile, the lowest stover and grain yields were recorded in the control treatment in both years (Table 4).

Integrated phosphorus management markedly increased grain protein content. During both years, treatment with 100% inorganic phosphorus produced the highest grain protein contents of 8.51% and 8.53%. However, this was not significantly different to the other treatments, except for the control. No treatments had significant effects on grain oil and grain starch contents. However, the highest grain oil and starch content was recorded with the application of 25% OP (PoM) + 75% SSP. Similarly, the lowest grain protein, oil and starch content

Table 5: Effect of integrated phosphorus management through organic manures and inorganic fertilizer on qualitative attributes of hybrid maize

Treatments	Grain protein content (%)		Grain oil content (%)		Grain starch content (%)	
	Year I	Year II	Year I	Year II	Year I	Year II
T1= Control (without P)	7.89 c	7.92 a	4.31	4.03	64.23	64.39
T2= Recommended dose	8.51ab	8.53 a	4.64	4.64	67.67	67.79
T3= (75% PoM+25% SSP)	8.26 ab	8.30 ab	4.43	4.45	65.96	66.03
T4= (50% PoM+50% SSP)	8.41 ab	8.44 a	4.56	4.57	67.18	67.32
T5= (25% PoM+75% SSP)	8.59 a	8.63 a	4.67	4.72	68.04	68.22
T6= (75% PM+25% SSP)	8.22 bc	8.24 ab	4.38	4.37	65.19	65.39
T7= (50% PM+50% SSP)	8.35 ab	8.39 a	4.48	4.48	66.53	66.77
T8= (25% PM+75% SSP)	8.48 ab	8.50 a	4.57	4.59	67.34	67.45
LSD (P ≤0.05)	0.36	0.41	N.S	N.S	N.S	N.S

Values sharing a letter in common within a column do not differ significantly at $p \leq 0.05$.

Table 6: Effects of different sources of phosphorous on net income and benefit cost ratio (BCR) of hybrid maize during 2008 and 2009

Treatments	Year I				Year II			
	Total expenditure (USD ha ⁻¹)	Gross income (USD ha ⁻¹)	Net income (USD ha ⁻¹)	BCR	Total expenditure (USD ha ⁻¹)	Gross income (USD ha ⁻¹)	Net income (USD ha ⁻¹)	BCR
T1= Control (without P)	435.46	922.05	486.59	2.12	439.27	918.42	479.15	2.09
T2= Recommended dose	588.94	1306.55	717.61	2.22	592.76	1302.73	709.97	2.2
T3= (75% PoM+25% SSP)	403.97	1201.34	797.37	2.97	406.38	1264.47	858.09	3.11
T4= (50% PoM+50% SSP)	466.67	1274.03	807.37	2.73	469.55	1302.73	833.18	2.77
T5= (25% PoM+75% SSP)	529.44	1365.85	836.41	2.58	532.81	1495.94	963.13	2.81
T6= (75% PM+25% SSP)	446.37	1149.69	702.29	2.57	449.63	1262.55	812.92	2.81
T7= (50% PM+50% SSP)	494.88	1252.99	757.42	2.53	498.33	1298.90	800.57	2.61
T8= (25% PM+75% SSP)	543.75	1346.73	802.63	2.48	547.39	1472.98	925.59	2.69

was observed in the control treatment in both years (Table 5).

The results revealed that application of 25% OP (PoM) + 75% SSP resulted in a maximum net return of USD 836.41 ha⁻¹, (2008) and USD 963.13 ha⁻¹ (2009). Economic analysis also showed variations in benefit-cost ratio (BCR) during both years and is presented in Table 6. In 2008, the treatment with 75% OP (PoM) + 25% SSP resulted in the highest BCR (2.97), followed by treatment with 50% OP (PoM) + 50% SSP, which produced a BCR of 2.73. In 2009, a BCR of 3.11 was obtained from the application of 75% OP (PoM) + 25% SSP, followed by 25% OP (PoM) + 75% SSP and 75% OP (PM) + 25% SSP, which both gave a BCR of 2.81. Some variation in production cost during the growing seasons was due to variations in the input cost for crop production. Therefore, a sensitivity analysis relating to input costs was performed to examine the influence of price increases of 10% compared to current prices (year 2008-09). The significance of benefit-cost ratio results remained the same as for normal prices (Table 6).

4 Discussion

The integrative use of organic manure and chemical fertilizers substantially improved maize phenology. The maximum amount of time to 50% tasseling, 50% silking and time to maturity was seen in those plants fed with 25% OP (PoM) + 75% SSP. This improvement in phenology by application of organic and inorganic nutrients can be ascribed to better root development, which in turn enabled the plants to obtain more phosphorus and other important nutrients, leading to better growth and development. These results are consistent with previous findings by Mahmood et al. (2011), who also reported substantial improvement with the application of poultry manure and inorganic phosphorus.

Similarly, the application of 25% OP (PoM) + 75% SSP appreciably increased yield components, such as grains per cob and grain weight compared to other treatments in both years. The increase in yield components might be due to better availability of nutrients such as nitrogen,

phosphorus and potassium in poultry manure, because these nutrients are important determinants of yield components. The present results are supported by previous findings by Jama et al. (2000) and Udom and Bello (2009), who found remarkable increases in yield components with the application of organic manure. The results from the present study are also in line with previous findings by Silva et al. (2003), who also reported that application of poultry manure increased the release of major nutrients, which in turn enhanced yield components.

The integrative use of poultry manure and inorganic phosphorus significantly increased the yield during both years; however, the application of 25% OP (PoM) + 75% SSP outperformed the other treatments. The increase in grain yield could be due better leaf area, crop growth rate and prolonged leaf area duration. Integrative use of organic manure and chemical fertilizers, markedly increased the yield of sunflowers due to better uptake of nutrients, flowering, leaf area index and crop growth rate (Munir et al. 2007). Similarly, Plenet et al. (2000) reported that phosphorus deficiency reduced the number of leaves per plant, and thereby leaf area index and grain yield. The difference between treatments in stover and grain yield may be due to the difference in leaf area, leaf area duration and crop growth rate. Differences in grain yield between different treatments can be explained by differences in their leaf area duration (LAD) in the present study.

Conjunctive use of poultry manure and inorganic phosphorus significantly increased protein content; however, the application of 25% OP (PoM) + 75% SSP outperformed the other treatments in this regard. The increase in protein content can be ascribed to better availability of nitrogen. Meanwhile, all treatments had non-significant effects on grain oil and starch content. The present findings are consistent with previous results by Pujar (1995) and Sukanya (2002), who reported a non-significant effect of organic manure and inorganic fertilizer on the starch and oil content of maize crop.

The present study reports the highest benefit-cost ratio with the application of 75% OP (PoM) + 25% SSP, which could be due to lower input costs. Although treatment T_5 had a lower benefit-cost ratio compared to T_3 , the yield components in T_3 were high. These results are in line with previous finding by Ghaffari et al. 2011, who found high benefit-cost ratios with the integrative use of organic manure and recommended NPK for maize crop.

5 Conclusion

Integrative use of organic manure and inorganic phosphorus could be helpful in increasing the yield of maize crop. Based on the results of this study it is recommended that combined use of 25% poultry manure and 75% SSP is a viable strategy to improve the yield and profitability of hybrid maize.

Conflict of interest: Authors declare no conflict of interest.

References

- Ahmad N., Rashid M., Vaes A.G., Fertilizers and their uses in Pakistan, 1996, 142-149 and 172-175. In: NFDC
- Ahmed S., Agriculture-fertilizer interface in Asian and Pacific Region: Issue of growth, sustainability and vulnerability, Extension Bulletin No. 387, Food and Fertilizer Technology Center, Taipei, Taiwan ROC, 1994, 111
- Ahmad R.M., Naveed M., Aslam Z.A., Arshad M., Economizing the use of nitrogen fertilizer in wheat production through enriched compost. *Rev. Agri. Food Sys.*, 2008, 23, 243-249
- Anjum S.A., Ullah E., Ashraf U., Tanveer M., Qamar R., Khan I., Morphological and phenological attributes of maize affected by different tillage practices and varied sowing methods, *Amer. J. Plant Sci.*, 2014, 5, 1657-1664
- Anonymous, Association official Agriculture chemists, In: Official methods of analysis, editor W. Horwitz, 10th edition, Washington D.C, USA, 1980, 124
- Boateng S., Zickermann A.J., Kornahrens M., Effect of poultry manure on growth and yield of maize, *West Africa J. App. Eco.*, 2006, 9, 1-11
- Bokhtiar S.M., Sakurai K., Integrated use of organic manure and chemical fertilizer on growth, yield and quality of sugarcane in High Ganges River Floodplain Soils of Bangladesh, *Comm. Soil. Sci. Plant Anal.*, 2005, 36, 1823-1837
- Bhattacharya P., Gehlot D., Current status of organic farming at international and national level, *Agrobios News Letter*, 2003, 4, 7-9
- CYMMIT, From agronomic data to farmers recommendations: an economic training manual. Completely revised edition, Mexico, D.F., 1998
- Deksissa T., Short I., Allen J., Effect of soil amendment with compost on growth and water use efficiency of Amaranth, In: *Proceedings of the UCOWR/NIWR annual conference: International water resources: challenges for the 21st century and water resources education*, Durham, NC 2008, 22-24
- Garg S., Bahla G.S., Phosphorus availability to maize as influenced by organic manures and fertilizer P associated phosphatase activity in soils, *Biores. Tech.*, 2008, 99, 5773- 5777
- Government of Pakistan, Economic survey of Pakistan 2013-14, 2014, pp. 17-23. In: Ministry of Food, Agric. and Livestock Division (Economic Wing), Islamabad.
- Ghaffari A., Ali A., Tahir M., Waseem M., Ayub M., Iqbal A., et al., Influence of integrated nutrients on growth, yield and quality of maize, *J. P. Sci.*, 2011, 2, 63-69

- Homer D.C., Pratt P.F., Methods of analysis for soils, plants and waters, In: Univ. of California, agri. Sci. USA, 1961, 150-196
- Hussain M.Z., Rehmann N., Khan Roohullah M.A., Ahmed S.R., Micronutrients status of Bannu basen soils. *Sar. J. Agri.*, 2006, 22, 283-285
- Ibrahim M., Yamin M., Sarwar G., Anayat A., Habib F., Ullah S., et al., Farmmanure affect root growth and nutrient uptake of wheat and rice under semi-arid conditions of Pakistan, *Appl. Geochem.*, 2011, 26, 194-197
- Ibrahim M., Han K.H., Ha S.K., Zhang Y. S., Hur S.O., Physico-chemical characteristics of disturbed soils affected by accumulate of different texture in South Korea, *Sains Malaysiana* 2012, 41, 285-291
- Jama B., Swinkels R.A., Bunish R.J., Agronomic and economic evaluation of organic fertilizer. Mimeo, Ministry of Agriculture, Agric. section development strategies, Nairobi, Kenya
- Low N.H., 1990. Food analysis, 417/717, In: Laboratory manual, dept. of applied microbiology and food science, Univ. Saskatchewan, Canada, 2000, 37-38
- Juliano B.O., A simplified assay for milled-rice amylase, *Cereal Sci.* 1971, 16, 334
- Mahmood T., Maqsood M., Awan T.H., Effect of different levels of N and intra-row plant spacing on yield and yield components, *Pak. J. Agric. Sci.*, 2001, 38, 48-49
- Munir M.A., Malik M.A., Saleem M.F., Impact of integration of crop manuring and nitrogen application on growth, yield and quality of spring planted sunflower, *Pak. J. Bot.*, 2007, 39, 441-449
- Palaniappan S.P., Annadurai K., Organic Farming Theory and Practice, Jodhpur India, Scientific Publishers, 1999, 53-73
- Plenet D., Mollier A., Pellerin S., Growth analysis of maize field crops under deficiency, radiation-use efficiency, biomass accumulation and yield components, *Soil Sci. J.*, 2000, 165, 259-272
- Pujar S.S., Effect of distillery effluent irrigation on growth, yield and quality of crops. M.Sc. (Agri.) thesis, University of agricultural sciences, Dharwad, 1995
- Razzaq A., Assessing sugarcane filtercake as crop nutrients and soil health ameliorant. *Pak. Sugar J.*, 2001, 21, 15-18
- Silva S.A., Woods E.I., Colemann W.C., The Use of composted poultry manure as a fertilizer, In: University of Hawaii, 2003, 53
- Steel R.G.D., Torri J.H., Principles and procedures of statistics: A Biometrics Approach, 2nd ed. McGraw-Hill, New York, 1997
- Sukanya T.S., Agronomic investigation on use of distillery effluent on the performance of rabi maize and wheat. Ph.D. Thesis, University of agricultural sciences, Dharwad, 2002
- Tisdale S.I., Nelson W.L., Beaton J.D., Soil fertility and fertilizers. 4th ed. McMillan, New York, USA, 1985
- Udom G.N., Bello H.M., Effect of poultry litter on the yield of two maize varieties in the northern gulnea savanna, *J. Trop. Agric. Food Environ.*, 2009, 8, 51-54
- Warren J.G., Phillips S.B., Mullins G.L., Keahey D., Penn C.J., Environmental and production consequences of using alum-amended poultry litter as a nutrient source for corn, *J. Environ. Qual.*, 2006, 35, 172-182