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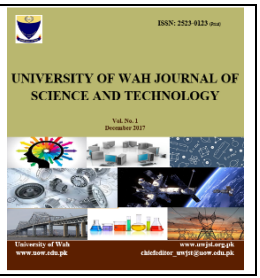

Effects of Organic and Inorganic Fertilizers on Growth and Yield of Two Maize (*Zea mays* L.) Varieties in Hazara, Pakistan

A. Qarni, Z. Ahmed, M. Billah, S. Ullah Khan, A. Khan and A. Munir

***Abstract*— Effectiveness of organic and inorganic fertilizers on growth and yield of maize (Zea maize L.) is investigated in this study. The field experiments were carried out at the research area of Awan nursery farm Haripur, Khyber Pakhtunkhwa during spring, 2013. The experiments consisted of six treatments: Control, Fresh Cattle Manure, Kahoon organic fertilizers, Poultry Manure, Higo-organic fertilizers, and inorganic fertilizers (NPK). All organic fertilizers were applied at a rate of 10 t ha^{-1} while recommended dose of NPK at the rate of 120-90-60 kg ha^{-1}. Randomized Complete Block Design (RCBD) was adopted with three replications of the treatments. Experiments were conducted on two different varieties of maize: Azam and Barani. Important parameters like plant growth and yield were studied for each variety during the experiments. Results show that all the parameters studied were higher in Barani as compared to Azam. The study also reveals that the parameters such as plant height, cob length, grains per cob, thousand grains weight and grain yield were significantly affected by use of different organic and inorganic fertilizers treatments. The outcome of the study demonstrates that chemical fertilizers NPK results in maximum cob length and grains per cob followed by Higo organic fertilizers with slight difference in performance. However, Higo organic fertilizers resulted in maximum grains weight and grain yield. It can be concluded that organic fertilizers can perform better in comparison with inorganic NPK fertilizers. Based on the parameters investigated the Barani variety is best suited for the soil of Haripur district.**

***Index Terms*— Organic, inorganic, maize yield.**

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I. INTRODUCTION

Maize (*Zea mays* L.) is considered the most valuable crop amongst the cereals. In Pakistan maize is grown on area of about 1.11 million hectares that produces about 4.04 million tons of grains per year with average yield of 3.62 tons per hectares [1]. However, we are still on the way to get maximum yield from the maize crop due to different reasons like under dose application, inadequate and low quality nutrients supply for the crop production [2].

Appreciable amount of organic matter in the form of humus is added from organic fertilizers leading to provision of essential nutrients, improvement in soil structure, field capacity and nutrient availability [3].

The availability of nutrients from organic manures being applied for longer periods to the soil is maximum for better crop production. Due to faster consumption of resources there is a decline in soil fertility and the attention in use of organic manures has increased worldwide. Potential polluting effects on environment are noticed because of long term use of chemical fertilizers [4].

Chemical fertilizers like SSP as phosphate fertilizer get fixed at the site of application by forming Ca-P compounds through surface adsorption [5]. Whereas, organic fertilizers increase nutrient availability by producing organic acids and chelation [6]. Organic farming in agriculture preserves our ecosystem by preventing hazardous chemicals and fertilizers use. The organic fertilizers help control pest and weeds, fostering soil biological activity and maintaining soil nutrient status. Chemical fertilizers are available in the market with very high prices and the Farmers in Khyber Pakhtunkhwa are poor and cannot afford the high prices of chemical fertilizers. Many commercial organic fertilizers have been launched in market but their potential effect on crop yield is not yet explored.

To elucidate the impact of organic and inorganic fertilizers on growth and yield of maize crop, present study was planned under Haripur environment.

II. MATERIALS AND METHODS

Experiments were conducted at Awan nursery farm Haripur, Khyber Pakhtunkhwa Pakistan. Initially soil samples taken from experimental site were analyzed for physicochemical properties. The soil properties of the experimental site are shown in Table I. The field was ploughed deeply and then cultivated. Randomized Complete Block Design was used for the experiment and was replicated thrice. Plot size was 4 by 5m, each plot was 5m long and consisted of 4 rows. Distance between the rows and plants were 75cm and 25cm, respectively. Experiment consisted of six different treatments of organic manures and chemical fertilizers namely control (T1), Fresh cattle manure (T2), Kahoon organic fertilizers (T3), Poultry manure (T4), Higo-organic fertilizer (T5), and chemical fertilizer (T6). All the manures and fertilizers are added to the soil and incorporated before sowing. Fertilizers Nitrogen was applied in two splits, half at the time of sowing while remaining half was applied at tesseling stage. Two maize verities Azam (V1) and Barani (V2) were sown on 17th of June 2013. Characteristics of the organic manure used during the experiments are shown in Table II. The data for different agronomic parameters included: days to 50% germination, plant height, days to 50% tesseling and silking, number of cobs plant^{-1}, grain cob^{-1},cob length, thousand grain weight (g), plant dry biomass (kg m^{-2}) and grain yield (t ha^{-1}). Plant height of ten plants from each plot selected randomly was measured with measuring tape and averaged. Data for number of cobs per plant was obtained by counting total cobs in a plot and dividing it by total plants. Ten cobs were selected from each plot and there length was measured and averaged to obtain cob length data. Data for 1000 gains was recorded by collecting ten samples from a plot each of thousand grains and weighed using balance and then averaged. Dried plants from each plot were weighed after harvesting and then converted to kg m^{-2}.

Statistical analysis. The data collected was analyzed statistically by using Statview Software [7]. A probability level of <0.05 was considered significant and means were separated by Fisher's Least Significant Difference (LSD) test.

TABLE I
PHYSIC-CHEMICAL ANALYSIS OF SOIL OF THE FIELD EXPERIMENT

Characteristics	Unit	Value
Soil texture		Silty clay loam
Soil pH		7.8
Soil EC	dS m^{-1}	1.6
Organic matter	%	0.78
Total nitrogen	%	0.04
Phosphorus (available)	mg kg^{-1}	0.89
Potassium (available)	mg kg^{-1}	87

TABLE II
NUTRIENT ANALYSIS OF ORGANIC MANURES USED

Characteristics	Unit	Cantle Manure	Poultry manures	Khoon Organic fertilizers	Higo organic fertilizers
Dry matters	%	14.67	31	36	49
Moisture	%	74	43	23	51
Nitrogen	%	0.34`	0.97	1.15	1.43
Phosphorus	%	0.17	0.67	0.98	0.91
Potassium	%	0.57	0.46	0.65	0.76

III. RESULTS AND DISCUSSION

A. Days to 50 % Germination

Results of days to 50% germination rate suggested that both varieties have good germination rate and it was reported as 8 and 11 days for Barani and Azam varieties, respectively as shown in *Fig. 1*. No significant difference was reported between the different fertilizer application and control but two maize varieties differed significantly ($p<0.01$) in germination. This germination depends on fertilization type. The results showed that the components like soil moisture and condition required for seed germination were comparable all through the field and consequently, crop response was similar to all fertilizer treatments. The results are in line with the findings of

[8] and [9] who reported that germination is not influenced by fertilizer treatment used.

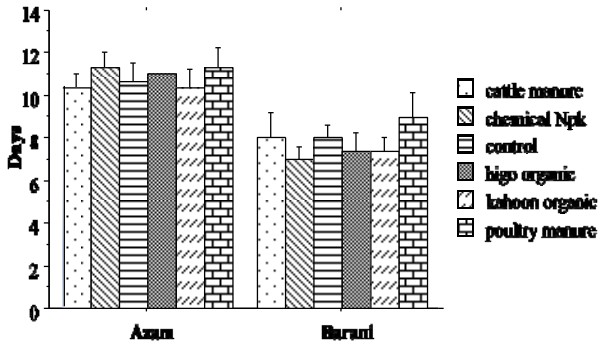

Fig 1. Effect of Fertilizers on days to 50% germination of two varieties.

B. Plant height (cm)

The data shows that plant height was significantly affected by varietal difference ($p<0.01$) and fertilizer treatments ($p<0.05$) while the interactive effect of variety x fertilizers, was not significant. Maximum height of 251cm was recorded from plots which received fertilizer treatment T3 (kahoon organic fertilizers) followed by higo organic fertilizers while the minimum height of 221cm was recorded from control plots as shown in *Fig. 2*. After twelve weeks the mean height of plants were recorded as 261 and 218cm for Barani and Azam respectively. Significantly different plant height was reported from fertilizer treatments over control and is an indication that abundant nutrients supply is correlated to growth. Results of the study demonstrate that maximum plant height was reported in plots that received chemical fertilizers followed by higo organic fertilizers. Variations in plant height by application of different amendments have been noticed. The chemical fertilizers application that produced the tallest plants was statistically at par with kahoon and Higo organic fertilizers. The significant increase in height by application of organic fertilizers may be attributed to increased amount of plant available nutrients provided by organic manures that are readily available to plant for absorption through root. Hence there was an increase in Vegetative plant growth. The results of the study are in accordance with the findings of [10] and [11] who reported increase in plant height by use of organic manures and fertilizers. Similar results have also been reported by [12] that organic manures significantly increased plant height over untreated control. Control plants had minimum plant height as they count on inherent soil nutrients which are low or even that might have been depleted due to continuous farming.

C. Days to 50% Tesseling

Statistical analysis of data as shown in Table III shows that days to 50% tesseling was not affected by different nutrient sources while two varieties differ significantly ($p<0.01$). Interaction of varities and fertilizer sources was also not significant. With respect to varietal performance, assesment of individual varieties means revealed that Azam variety took 46.1 days to complete its 50% tesseling while “Barani” took 49.8 days as shown in *Fig. 3*. Though fertilizers did not signicantly affect the days of 50% tesseling, however, maximum days (49.16 days) were taken by the plots treated with T5 (higo organic fertilizers) and minimum days (45.66days) were taken by the plots having T6 (chemical NPK).

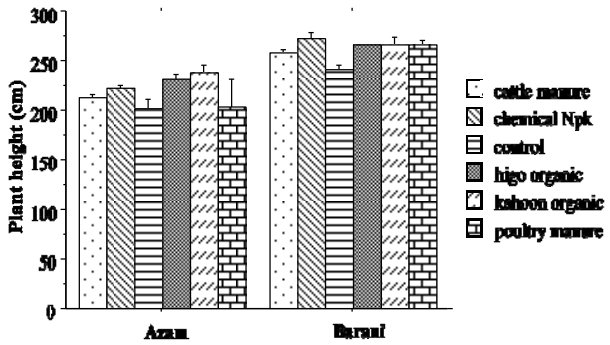

Fig.2. Effect of Fertilizers on plant height of two varieties at twelve weeks.

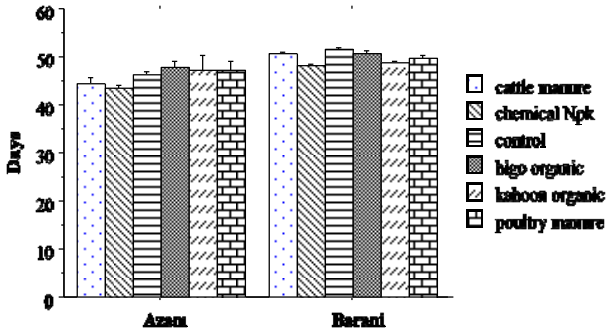

Fig. 3. Effect of Fertilizers on days to Tesseling of two varieties.

D. Days to 50% silking

Results of statistical analysis performed by using Stat View software demonstrated that the days to 50% silking was significantly affected ($p<0.05$) by varietal difference, while effect of fertilizers tretments was not found significant for days to silking. Also the combined effect variety x fertilizers was not significant. With respect to varietal performance assesment of individual varieties means indicated that 66.2 days were taken by the variety “Azam” to complete its 50% silking while 67.5 days were taken by the variety “Barani” to complete its 50% silking as shown in *Fig. 4*.

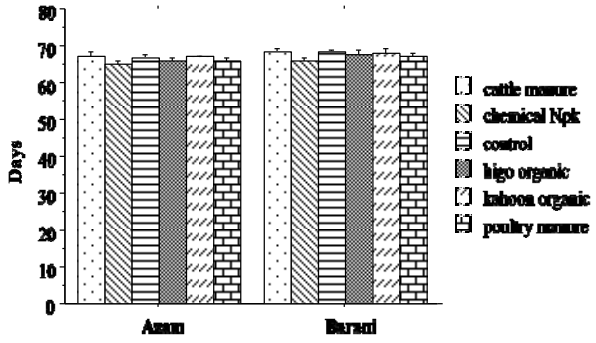

Fig. 4. Effect of Fertilizers on days to Silking of two varieties

E. Cob length (cm)

The data of Table IV depicts that application of orgnaic and inorganic fertilizers significantly affected ($p<0.01$) cob length but two varieties did not show any significant variation. Similarly, interaction of varities and fertilizer applicaton was also not significant.Among the different fertilizers applied maximum cob length (17.88cm) was recorded from the plots fertilized with chemical (T6) while minimum cob length (15.18cm) was recorded from the control as shwon in *Fig 5.*The order of superiority in cob length based on fertilizer treatments used was chemical fertilizers NPK> Higo organic fertilizers > kahoon organic fertilizers > poultry manures > cattle manures > control.

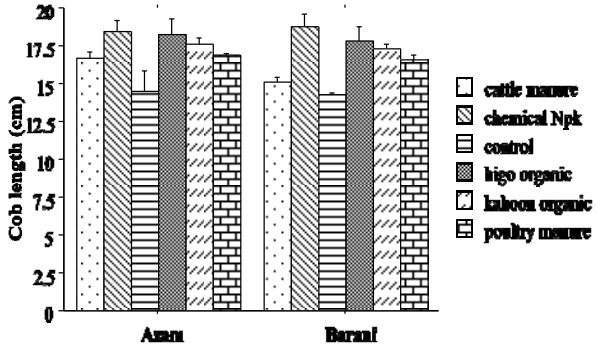

Fig. 5. Effect of Fertilizers on cob length of two varieties.

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Chemical fertlizers have highest cob length because Nitrogen is a vital obligation of cob growth. Higher cob length was found in the plots that received T6 (chemical NPK) that may be attributed to more photosynthetic activities of plant on the basis of ample supply of nitrogen in these treatments. Craw ford et al. reported tha maize cob is a temporary storage place and it transports nutrients to the developing kernaels. Therefore index of better economic yield of maize depends upon better development of cob length. Reference [13] and [14] reported similar results pertaining to increase in cob length with increased rate of nitrogen fertilizers.

F. Cob plant^{-1}

Analysis of variance in Table IV showed that the neither two varieties nor fertilizers affected per plant number of cobs. Genetic variability might be the reason for non-significant results rather than the organic fertilizers. Reference [15] reported no impact of fertilizer application on number of cobs per plant.

F. Cob weight (g)

Data presented in Table IV shows that "cob weight" was significamtly affected by two varieties while the fertilizers and interactive effect of variety and fertilizers were not significant. Fig 6 shows that the mean cob weight of variety Azam was recorded at 105.41g and the mean cob weight of variety Barani was recorded as 133.2g. Significantly heigher cob weight of veriety Barani may be attributed to the genetic quality of the individual veriety. Non significant effect of fertilizers tratments on cob weight may be attributed to the reason that cob weight and cob bearing potential is genetic quality of each genotype and has not been influenced by fertilization. The results are consistent with the findings of [16] who reported non significant affect of fertilizers treatments on cob weight.

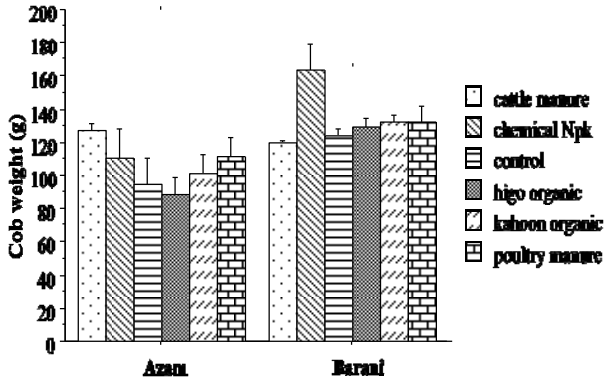

Fig 6: Effect of Fertizers on cob weight of two varieties

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H. Grains cob^{-1}

The data presented in Table IV shows that "grains per cob" was significantly affected ($p<0.01$) by the two varieties as well as by the fertilizer treatments while combined effect of variety and fertilizer was not significant. *Fig. 7* reveales that maximum grains per cob (438.8) were recorded in the plots where chemical fertilizers were applied followed by the plants that received Higo organic fertilizers (433.9) and plants that received poultry manures (424.9) while minimum grains per cob (248.6) were recorded in control plots. *Fig. 7* depicts that Azam variety produced an average of 374.6 grains per cob while Barani variety gave average of 429.7 grains per cob. The superiority order based on fertilizer applied was chemical fertilizers >Higo organic fertilizers > poultry manures > Kahoon organic Fertilizers > cattle manures > control.

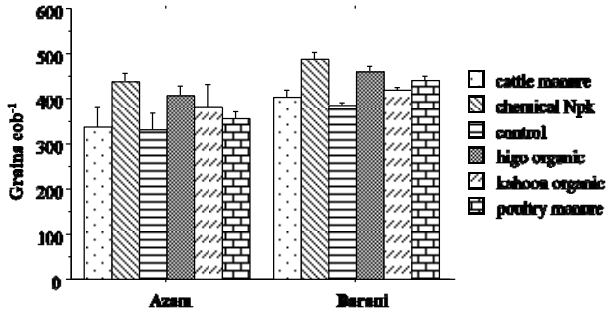

Fig 7: Effect of Fertilizers on grains per cob of two varieties

Number of Grains per cob was highest in the plots that received chemical NPK followed by T5 (Higo organic Fertilizers). Higo organic fertilizers may have enhanced the carbon content, soil aggregation and decreased the bulk density of soil. These results are in line with the findings of [17] who reported that organic manures increased the carbon content, aggregation of soil, water holding capacity and decreased the bulk density of soil where it is applied. Reference [18] reported that organic manures could have also increased water soluble and exchangeable potassium and magnesium which improved yield.

I. Thousand Grains weight (g)

Data presented in Table III reveales that effect of variety and fertilizers treatment on thousand grain weight was significant at level $p<0.01$ and $p<0.05$ respectivly while combined effect of fertilizers and variety (variety x fertilizers) was not significant. *Fig. 8* shows that with respect to fertilizers treatments plants that received Higo organic fertilizer resulted in highest thousand grains weight (298.33g) followed by the plants that received chemical fertilizers NPK (296.5). The lowest thousand grains weight (248.6g) was recorded from the plots where no fertilizers were applied T1(control). The order of superiority in thousand grains weight based on fertilizer treatments is Higo organic fertilizers > chemical fertilizers NPK > cattle manures > kahoon organic fertilizers > poultry manures > control.

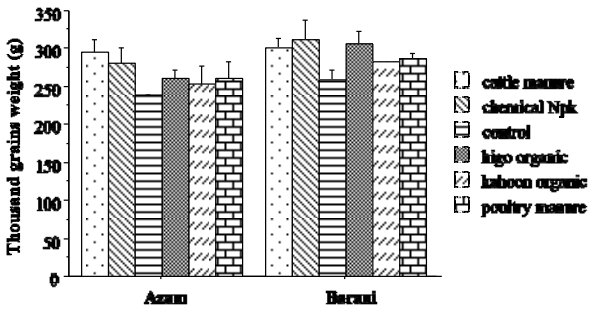

Fig. 8. Effect of Fertilizers on thousand grains weight of two varieties.

With respect to varietal performance results of the study indicates that Barani has higher thousand grains weight (291.2g) than Azam (264.8g). Higher thousand grains weight in all fertilizer treatments as compared to control may be attributed to balanced supply of nutrients [19].

J. Dry biomass (kg m^{-2})

According to the data presented in Table IV, effect of varieties on dry biomass was highly significant ($p<0.01$) while effect of fertilizers treatments alone and interactive effect of fertilizers and variety (fertilizers x variety) was not significant. With respect to varietal performance *Fig. 9* shows that the dry biomass of Barani variety (1.90kg) was found higher than Azam (1.33kg). However, maximum dry biomass (1.90kg) was recorded in the plots which fertilized with chemical NPK, followed by higo organic fertilizers while minimum drybiomass (1.35kg) was recorded in control plots.

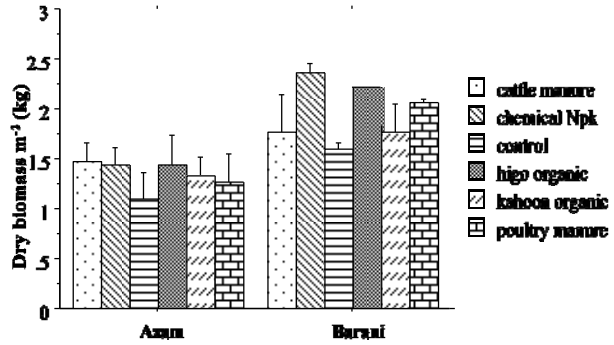

Fig. 9. Effect of Fertilizers on dry biomass of two varieties.

K. Grain yield (t ha^{-1})

Grain yield is the end result of different physical changes during the growth and development of the crop. The growing conditions are changed by different fertilizer treatments applied (organic and inorganic). Significant influence ($P<0.001$) on the grain yield of maize due to fertilizer application was recorded during the experiment. Varietal response to Grain yield t h^{-1} was also found significant (Table IV) while combined effect of variety and fertilizers (variety x fertilizers) was not significant. It is clear from the data that both the varieties differed highly significantly ($p<0.01$) in grain yield from each other. While concerning fertilizers treatments used organic and inorganic fertilizers applied to maize affected grain yield significantly. Assessment of individual fertilizer treatments means indicated that maximum grain yield (5.007 t ha^{-1}) was observed in the plots where fertilizer treatment T6 (chemical fertilizers) was applied followed by Higo organic fertilizers (4.15 t ha^{-1}) while

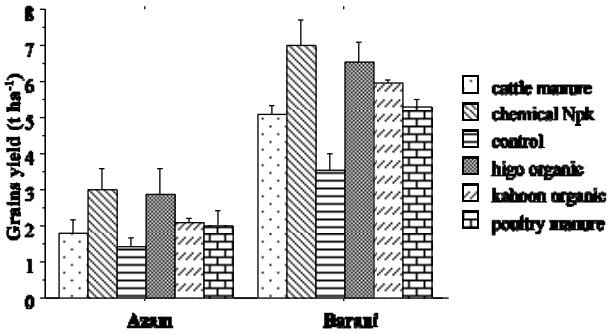

Fig 10: Effect of fertilizers on Grains yield of two varieties.

minimum Grain yield (2.48 t ha^{-1}) was observed from the control plots *Fig. 10*. The order of superiority in Grain yield based on fertilizer treatments was chemical fertilizers NPK> Higo organic fertilizers > kahoon organic fertilizers > poultry manures > cattle manures > control. With respect to varietal performance *Fig. 10* revealed that grain yield of variety Barani (5.51 t ha^{-1}) was statistically higher than grain yield observed in variety Azam (2.16 t ha^{-1}).

The higher maize Grain yield obtained from the plots where T6 (chemical fertilizers NPK) was applied could be attributed to the fact that nutrients being readily available from the chemical fertilizers as compared to nutrients from organic sources that must first undergo decomposition before they are available for the crop to uptake. Secondly the split application of N could have also resulted to minimal leaching losses and ultimately higher availability for the crop to uptake.
Reference [20] reported that split N application can increase plant N uptake and decrease potential N losses. While higher grain yield of Barani variety than Azam might be due to the genotypic variation between varieties.

Plant phosphorus uptake was significantly higher in all the fertilizers treatments compared to control. However higher plant phosphorus uptake (28 kg ha^{-1}) was recorded in plots that received Higo organic fertilizers followed by chemical NPK (26 kg ha^{-1}) while minimum phosphorus uptake (14 kg ha^{-1}) was recorded in control plots as shown in Table III. The increased phosphorus uptake by Higo organic fertilizers may be due to mineralization of phosphorus through ligand exchange reactions, with phosphate adsorbed on the surfaces of iron and aluminium oxides and release of cations in root rhizosphere [21]. Reference [22] reported that compost can significantly enhance phosphorus uptake in wheat crop.

IV. SOIL POST HARVEST NUTRIENT STATUS

Application of different organic and inorganic fertilizer sources significantly improved organic matter content of the soil as shown in Table V. Highest organic matter content (0.97%) were analyzed for Higo organic fertilizers followed by Kahoon organic fertilizers (0.92%) while minimum organic matter content (0.76%) were recorded in control plots. Organic matter is source of nutrient and microbial activity in soil. Thus increase in organic matter ultimately increase productivity because it enhances soil structure, infiltration rate, porosity, and water holding capacity of soil. Higo organic fertilizers proved very effective in enhancing organic matter status of the soil. The results are in line with the findings of [23] who reported increase in organic matter content by application of organic compost.

TABLE III
EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON P UPTAKE OF MAIZE CROP

Treatment	P uptake (kg ha^{-1})
Control	14 e
Cattle manure	19 d
Kahoon organic fertilizers	20 d
Poultry manures	23 c
Higo organic fertilizers	28 a
Chemical NPK	26 ab
LSD	1.88

TABLE IV
ANALYSIS OF VARIANCE (ANOVA) FOR DIFFERENT PARAMETERS STUDIED

	Days to 50% germination	Plant height at 4 weeks (cm)	Plant height at 8 weeks (cm)	Plant height at 12 weeks (cm)	Days to 50% tasseling	Days to 50% silking	Cob length (cm)	Cob/plant	Cob weight(g)	Grains/cob	1000grains weight(g)	Dry biomass/m^2	Grain yield(t ha^{1})
	<----------F value---------->												
Variety	43.2**	37.01**	14.44**	58.9**	30.7**	7.2*	NS	NS	20.7**	15.0**	8.48**	20.6**	172**
Fertilizers	NS	13.83**	9.20**	2.8*	NS	NS	10**	NS	NS	4.5**	2.87*	NS	8.4**
V x F	NS	2.88*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Significance level at $p<0.05$

Available P in post-harvest soil was maximum (10 mg kg^{-1}) in Higo organic fertilizer treatment followed by poultry manures (7.4 mg kg^{-1}) while minimum phosphorus content (2.4 mg kg^{-1}) was recorded in control. Phosphorus is one of the most important nutrients regarding quality of crop and its availability is affected by soil pH, calcareousness and clay content of the soil. Results of experiment demonstrated that Higo organic fertilizers contributed more in enhancing phosphorus availability than other organic and inorganic treatments. Higo organic fertilizers must have broken its bond with $caco_3$ which resulted in higher amount of phosphorus in plant available form. The results are in accordance with the findings of [24] who reported increase amount available phosphorus by application of organic composts as compared to inorganic fertilizers.

By application of organic and inorganic fertilizers water soluble potassium was significantly increased in soil. Highest value for water soluble potassium (110 mg kg^{-1}) was recorded in the plots that received higo organic fertilizers followed by kahoon organic fertilizers while minimum value was recorded in control plots (92 mg kg^{-1}) that was statistically at par with chemical fertilizers. Organic fertilizers when applied to soil release organic acids and by release of H^+ ions fixed potassium is replaced from exchange complex and released to soil solution that can be taken up by plants and hence the overall status of soil regarding potassium availability is improved. Similar results have also been described by [25] and [26] who reported increase in potassium availability by application of organic fertilizers.

TABLE V
POST-HARVEST NUTRIENT ANALYSIS OF ORGANIC AND INORGANIC FERTILIZERS

Fertilizers Used	P (mg kg^{-1})	K (mg kg^{-1})	OM (%)
Control	2.4 e	92e	0.76 e
Cattle Manures	4.8 d	98 d	0.86 d
Kahoon organic Fertilizers	5.5 c	106 b	0.92 b
Poultry Manures	7.4 b	102 c	0.88 c
Higo Organic Fertilizers	10 a	110a	0.97 a
Chemical NPK	3.6 de	94 de	0.81 e

V. CONCLUSIONS

Results showed that maize grain yield was increased with the application of chemical fertilizers followed by Higo organic fertilizers. However, Higo organic fertilizer performed best by providing significant increase in plant P uptake as well as soil post-harvest nutrient status. Hence, considering increase in post-harvest soil nutrients in addition to grain yield, it can be concluded that Higo organic Fertilizer perform best in combination with Barani variety of maize in soil and environmental conditions of Haripur district.

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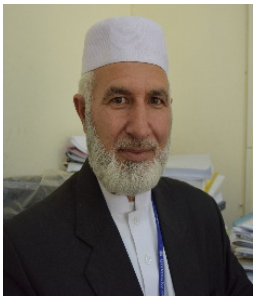

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