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Effect of nitrogen, phosphorus and zinc on maize hybrid and their carry over effect on faba bean

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Key words: Nitrogen, Phosphorus, Zinc, Maize, Faba bean

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Abstract

Nitrogen, Phosphorus and Zinc are main and expensive inputs in crop production. But the repeated excessive used of these fertilizer are costly and may harmful for environment. A considerable amount of nutrient is left unutilized and may have positive impact on subsequent crop. A two years experiment was conducted to evaluate the effect of nitrogen (N) phosphorus (P) and zinc (Zn) on maize hybrid and their carry over effect on subsequent faba bean at the University of Agriculture, Peshawar, Pakistan during 2013-2014 and 2014-2015. Randomize complete block (RCB) design having three replication was used. Three levels of N (150, 200 and 250 kg ha^{-1}), P (75, 125 and 175 kg ha^{-1}) and Zn (5, 10, 15 kg ha^{-1}) along with control were applied to maize followed by faba bean grown on same plots without fertilizer application. Days to emergence of faba bean were significantly affected by year. More days to emergence of faba bean were recorded in 2013-2014 compared to 2014-2015. Days to maturity (DM) and biological yield (BY) of maize were significantly enhanced with each increment of N, P and Zn and maximum BY was recorded at N (250 kg N ha^{-1}), P (175 kg p ha^{-1}) and Zn (15 kg Zn ha^{-1}) across both years. The DM were higher with 250 kg N ha^{-1}, 75 kg P ha^{-1} and 15 kg Zn ha^{-1}. These elements significantly enhanced days to flowering (DF) and BY of subsequent faba bean. It is concluded that 250 kg N ha^{-1}, 175 kg P ha^{-1} and 15 kg Zn ha^{-1} performed better and recommended for obtaining maximum BY of maize and subsequent faba bean.

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Introduction

Limited published data regarding application of N, P and Zn to hybrid maize and their carry over effect on faba bean is available particularly in this part of the country. Purpose of this research was to investigate the influence of N, P and Zn on maize performance, production and their carry over effect on faba bean, because macro and micro nutrients applied to the maize are not fully utilized and remain to the subsequent faba bean. It was concluded that upon the residual effect of N, P and Zn faba bean showed better performance. Due to this study the cost of production is reduced and environment is also protected from the bad effect of macro and micro nutrients.

Maize yield is very low in Pakistan as compared with other maize producing countries such as USA, Canada, Egypt, etc(MINFA, 2013). Among other factors, indiscriminate applications of fertilizers including nitrogen, P and Zn are responsible for low yield (Khattak *et al*, 2006).

Maize is the second cereal crop after wheat in Khyber Pakhtunkhwa (MINFA, 2013). It is used as food for human, feed for poultry and animals. Maize is also used as raw materials for preparation of starch, corn soup, and corn flakes industries (Khaliq *et al*., 2004). Maize has 70% starch, 10% protein, 4.8% oil, 13.2% fiber and 2% ash as compared to other cereals crops (Enyisi *et al*., 2014).

Faba bean (*Viciafaba* L.) is an annual grain legume, mainly grown for its high protein content (30%). It is an important source of protein for humans and animals. Faba bean popularity has increased recently as its high yield makes it attractive to producers while its high protein content and low-price makes it attractive to consumers. Faba bean is an annual self pollinated crop with strong, hallow and erect stem (Pala *et al*., 2000).

N is extremely linked with dark green color of stem and leaves, strong growth, leaf expansion and its size. Nitrogen deficiency causes stunted growth, delayed maturity and pale green or yellow color (chlorosis) of the leaves (Haque *et al*., 2001).

Balanced nutrition is an essential component of nutrient management to play a significant role in mounting crop production (Abid *et al*., 2003; Saleem *et al*., 2009).

Several researchers have been reported that mineral fertilizers including N have carry over effect from one growing season to next growing season (Corbeels *et al*., 1998).

It has been observed that 63% of the applied phosphorus is used by the current rabi crop while 37% remain in the soil for the next crop as residual or 57% phosphorus is used by the current crop and 43% remain as residual (Tandon, 1992).

Zinc play an important role in pollination and seed formation and seed setting of maize and faba bean (Ziaeyan and Rajaiea, 2009).

Due to low mobility of Zn in the soil, positive effect of applied Zn on subsequent crops in the rotation may last over several years (Brennan, 2001).

In the first year N, P and Zn were applied first to maize in kharif season then faba bean was cultivated in rabi season without fertilizers application. In the second year the same experiment was repeated.

The objectives of this research were to investigate the effect of N levels on the performance of maize. To study the effect P levels on the yield and yield components of maize. To evaluate the effect of Zn on maize productivity. To study the interactive effect of N,P and Zn. To study the residual effect of N, P and Zn on subsequent faba bean.

Materials and methods

Experimental site, design and treatments

The experiment was conducted at University of Agriculture Peshawar, Pakistan. It is located at 34° N and 71.3° E at 350 m above sea level. Summer daily maximum mean temperature ranges from 40 to 44 °C, while winter minimum temperature ranges from 4 to 5 °C. Annual rainfall ranges from 450 to 750 mm with more than 60% rainfall occur in July and August.

Experimental plots were established in June 2013 at Agronomy Research Farms, University of Agriculture Peshawar Pakistan. Maize hybrid Rafhan-3305 was planted on the established plots on 14thJune, 2013 and harvested on 10th October 2013. Faba bean was sown on 20thNov, 2013 on the same established plots and harvested in May 2014. Maize was planted on the same plots on 14thJune, 2014 and harvested in October 2014. Faba bean was repeated on 21stOct, 2014 and harvested in May 2015. Experiment was conducted according to randomized complete block (RCB) design having three replications.

Three nitrogen levels (150, 200 and 250 kg N ha^{-1}), three phosphorus levels (75, 125 and 175 kg P ha^{-1}) and three zinc levels (5, 10 and 15 kg Zn ha^{-1}) along with control were applied to maize. A plot size of 3 m x 3.75 m having 5 rows 3 meter long, 75 cm apart was used. A plant to plant distance of 25 cm was maintained by thinning. Row to row distance of faba bean was 42 cm. Nitrogen was applied in three splits: 1st at time of sowing, 2nd at V5 (five leaf stage) and 3rd at VT stage (when tassel is completely out) (Khalil and Shah, 2008). N, P and Zn were applied to maize hybrid 3305 each year, followed by faba bean to which no N, P and Zn were applied. Residual effect of the above treatments was observed on faba bean. Metrological data was recorded at weather station located at Regional metrological centre Peshawar (Fig. 1).

Soil analysis

Composite soil samples at 0-30 cm depths were taken from the experimental field before planting and after harvest of maize and faba bean from each plot in 2013-2014 and 2014-2015. Soil total nitrogen (Bremner, 1982), soil P (Soltonpour and Scheab, 1977) and soil zinc content (Whitney, 1998). The soil was low P, N and Zn content (Table 1).Data were recorded on days to emergence, emergence m^{-2}, days to maturity and biological yield kg ha^{-1} of maize. Data of faba bean were recorded on days to emergence, days to flowering and biological yield kg ha^{-1}.

Statistical analysis

The data was analyzed statistically according to Randomized Complete Block design. Least significant differences (LSD) test was employed upon obtaining significant F-value (Steel *et al.*, 1997). The analysis was done through statistics software named "STATISTIX 8.1."

Results and discussion

Maize parameters

Days to emergence

Days to emergence were significantly affected by year (Y), while the effect of N, P Zn control vs rest and interactions were non significant (Table 2). More days to emergence were taken in 2013 as compared with 2014. The fertilizers applied did not respond considerably due to the reason that at initial stages plant takes its food from seed storage tissues and there was no effect of any external nutrients. Similar results were reported by Sahoo and Panda (2001) and Asif *et al.* (2013) who reported that fertilizer has no effect on days to emergence of crop.

Table 1. Pre- sowing chemical properties of soil (0-30cm depth).

Property	Values/type
Clay (%)	31.23
Silt (%)	51.5
Sand (%)	17.23
Textural class	Silty clay loam
Total Nitrogen (%)	0.04
Phosphorus (mg kg^{-1})	1.15
Zinc (mg kg^{-1})	0.7

Emergence m^{-2}

Y, N, P, Zn, control vs. rest and all the interactions non-significantly affected emergence m^{-2} of maize (Table 3). The probable reason for this might be that at earlier stages the seedling uptake its food from the storage tissues of the seed and there was no effect of any external nutrients application. Moreover emergence m^{-2} is controlled by the seed rate applied and uniform seed rate did not vary the emergence m^{-2}. Similar results were reported by Khan *et al.* (2014) who reported that fertilizer did not affect the emergence m^{-2}.

Table 2. Days to emergence of maize as affected by year, nitrogen, phosphorus and zinc levels.

Nitrogen (kg ha^{-1})	Year		Mean
	2013	2014	
150	6.6	5.7	6.1
200	6.6	5.5	6.0
250	6.2	5.4	5.8
Phosphorus (kg ha^{-1})			
75	6.7	5.6	6.2
125	6.3	5.4	5.9
175	6.4	5.6	6.0
Zinc (kg ha^{-1})			
5	6.4	5.4	5.9
10	6.5	5.6	6.0
15	6.5	5.6	6.1
Control	7	6	7
Rest	6	6	6
Mean	6.9	5.6	

LSD (0.05) for N = NS,

LSD (0.05) for P = NS,

LSD (0.05) for Zn = NS

Means followed by different letters in each category are significantly different at 5% level of probability using LSD test.

Days to maturity

Days to maturity of maize were significantly affected by Y, N, P, Zn, Control vs rest and N x Zn interaction (Table 4). Maturity was delayed (100) in 2013 as compared with 2014. Lesser days to maturity were noted in control plots as compared to fertilized plots. More days to maturity (98.5) were recorded with 250 kg N ha^{-1}. Days to maturity were higher (97.1) in plots where P was applied at the rate of 75 kg ha^{-1}. 15 kg Zn ha^{-1} resulted 97.2 higher days to maturity.

Table 3. Emergence m^{-2} of maize as affected by year, nitrogen, phosphorus and zinc levels.

Nitrogen (kg ha^{-1})	Year		Mean
	2013	2014	
150	25.2	25.7	25.4
200	25.3	25.7	25.5
250	25.0	25.9	25.4
Phosphorus (kg ha^{-1})			
75	25.4	25.9	25.6
125	25.1	25.7	25.4
175	25.0	25.6	25.3
Zinc (kg ha^{-1})			
5	25.3	25.8	25.6
10	25.1	25.3	25.2
15	24.9	26.2	25.6
Control	25	25	25
Rest	25	26	25
Mean	25.1	25.2	

LSD (0.05) for N = NS,

LSD (0.05) for P = NS,

LSD (0.05) for Zn = NS

Means followed by different letters in each category are significantly different at 5% level of probability using LSD test.

Table 4. Days to maturity of maize as affected by year, nitrogen, phosphorus and zinc levels.

Nitrogen (kg ha^{-1})	Year		Mean
	2013	2014	
150	100.6	90.9	95.7 c
200	100.7	91.7	96.2 b
250	103.1	93.9	98.5 a
Phosphorus (kg ha^{-1})			
75	101.7	92.5	97.1 a
125	102.0	92.1	97.0 a
175	100.8	92.0	96.4 b
Zinc (kg ha^{-1})			
5	101.0	91.5	96.3 b
10	101.7	92.3	97.0 a
15	101.7	92.7	97.2 a
Control	98	87	93 b
Rest	101	92	97 a
Mean	100 a	90 b	

LSD (0.05) for N = 0.5

LSD (0.05) for P = 0.5

LSD (0.05) for Zn = 0.5

Means followed by different letters in each category are significantly different at 5% level of probability using LSD test.

The N x Zn interaction indicated that more days to maturity were taken with 250 kg N and 75 kg P ha^{-1}. Maturity was delayed with each increment of N at all levels of P (Fig 2). The delayed maturity due to increasing nitrogen might be attributed to the fact that nitrogen delay senescence of leaves and increase the vegetative growth, therefore the plant remain succulent and stayed greener for long time. These results are in line with Dawadi and Shah (2012) and Dahal *et al.* (2014) who reported delayed maturity with increasing N.

Table 5. Biological yield (kg ha^{-1}) of maize as affected by year.

Nitrogen (kg ha^{-1})	Year		Mean
	2013	2014	
150	10511	12578	11545 c
200	11316	13398	12357 b
250	11934	13975	12955 a
Phosphorus (kg ha^{-1})			
75	10625	12757	11691 b
125	11455	13486	12471 a
175	11681	13708	12694 ab
Zinc (kg ha^{-1})			
5	11028	13051	12040 b
10	11183	13207	12195 ab
15	11549	13694	12622 a
Control	9123	11129	10126 b
Rest	11254	13317	12285 a
Mean	10189 b	12223 a	

Nitrogen, phosphorus and zinc levels.

LSD (0.05) for N = 253

LSD (0.05) for P = 253

LSD (0.05) for Zn = 253

Means followed by different letters in each category are significantly different at 5% level of probability using LSD test.

Biological yield (Kg ha⁻¹)

Y, N, P, Zn, control vs rest, N x P, P x Zn and N x P x Zn interactions significantly affected biological yield. Higher biological yield (12223 kg ha^{-1}) was recorded in 2014 compared with 2013 (Table 5). Higher biological yield was recorded for fertilized plots compared with control.

Higher biological yield (12955 Kg ha^{-1}) was recorded for 250 kg N ha^{-1}. Highest level of P (175 kg ha^{-1}) which resulted in 12694 kg ha^{-1} higher biological yield. Higher biological yield was recorded for 15 kg Zn ha^{-1}.N x P interaction stated that higher biological yield was obtained with 250 kg N and 175 kg P ha^{-1}.

Table 6. Days to emergence of faba bean as affected by year, residual nitrogen, phosphorus and zinc levels.

Nitrogen (kg ha^{-1})	Year		Mean
	2013-2014	2014-2015	
150	10.9	7.4	9.2
200	10.9	7.4	9.2
250	10.9	7.3	9.1
Phosphorus (kg ha^{-1})			
75	11.0	7.3	9.1
125	10.7	7.6	9.1
175	11.0	7.3	9.2
Zinc (kg ha^{-1})			
5	10.8	7.4	9.1
10	10.9	7.4	9.1
15	11.0	7.4	9.2
Control	11	8	9
Rest	11	7	9
Mean	10.9 a	7.5 b	

LSD (0.05) for N = NS

LSD (0.05) for P = NS

LSD (0.05) for Zn = NS

Means followed by different letters in each category are significantly different at 5% level of probability using LSD test.

Table 7. Days to flowering of faba bean as affected by year, residual nitrogen, phosphorus and zinc levels.

Nitrogen (kg ha^{-1})	Year		Mean
	2013-2014	2014-2015	
150	60.7	111.9	86.3 c
200	64.9	117.1	91.0 b
250	70.3	122.1	96.2 a
Phosphorus (kg ha^{-1})			
75	63.6	115.4	89.5 c
125	65.2	116.9	91.1 b
175	67.0	118.8	92.9 a
Zinc (kg ha^{-1})			
5	64.6	116.4	90.5 c
10	65.2	117.1	91.1 b
15	66.0	117.6	91.8 a
Control	55	106	81 b
Rest	65	117	91 a
Mean	60.3 b	111.3 a	

LSD (0.05) for N = 0.5

LSD (0.05) for P = 0.5

LSD (0.05) for Zn = 0.5

Means followed by different letters in each category are significantly different at 5% level of probability using LSD test.

Biological yield increased with increase in each increment of N at 175 kg P ha^{-1}, while increasing N beyond 200 kg at 75 and 125 kg P ha^{-1} did not increased biological yield (Fig 3). P x Zn interaction stated that higher biological yield was obtained with 175 kg P and 15 kg Zn ha^{-1}. N x P x Zn interaction revealed that biological yield was higher with 10 kg Zn, 175 kg P and 250 kg N ha^{-1}. Biological yield was increased with each increment increase in Zn with 125 and 175 kg P and 250 kg N ha^{-1}, however biological yield decreased with increase in Zn up to 10 kg at 175 kg P and 200 kg N ha^{-1}, similarly increase in Zn level at 75 kg P did not increase the biological yield (Fig 4). Higher biological yield in case of higher N may be due to the fact that N increased the vegetative growth which resulted in more dry matter production and increased biomass yield.

Table 8. Biological yield (kg ha^{-1}) of faba bean as affected by year, residual nitrogen, phosphorus and zinc levels.

Nitrogen (kg ha^{-1})	Year		Mean
	2013-2014	2014-2015	
150	8711	10601	9656 b
200	9145	10883	10014 b
250	9637	11716	10677 a
Phosphorus (kg ha^{-1})			
75	8770	10633	9701 b
125	9222	11085	10153 ab
175	9502	11483	10492 a
Zinc (kg ha^{-1})			
5	8774	10658	9716 b
10	9058	10905	9982 b
15	9661	11637	10649 a
Control	4604	6417	5510 b
Rest	9165	11067	10116 a
Mean	6884 b	8742 a	

LSD (0.05) for N = 474

LSD (0.05) for P = 474

LSD (0.05) for Zn = 47

Means followed by different letters in each category are significantly different at 5% level of probability using LSD test.

The results are in agreement with Zubair *et al.*, (2009) who stated that higher N levels increased vegetative growth, which enhanced biological yield. Ortiz Monasterio *et al.*, (1997) who concluded that biomass and grain yield of the crop increased with N application. Efficient utilization of solar radiation, assimilates production and conversion to starches resulted in more number of grains and heavier grains, thus resulting in more biomass and seed yield (Derby *et al.*, 2004). Similarly El-sheikh, 1998 and Samira *et al.*, 1998 reported significant results of N on biological yield of maize. Higher biological yield in case of higher P may be due to it is needed for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division, fat and albumen formation. Similar results were reported by (Hussain *et al.* 2011).

These results agree with Kaleem *et al.* (2009). Who reported that biological yield significantly increase with application of phosphorus up to 120 kg P ha^{-1}. Higher biological yield in case of higher Zn may be due to Zn plays an important role in the biomass production.

These results are in line with Kaya, Higgs (2002) and Cakmak (2008) reported that biological yield increases with increasing Zn level. Similarly Kenbaev and Sade (2002) and Hosseini (2006) have reported that increase in yield components for application of zinc.

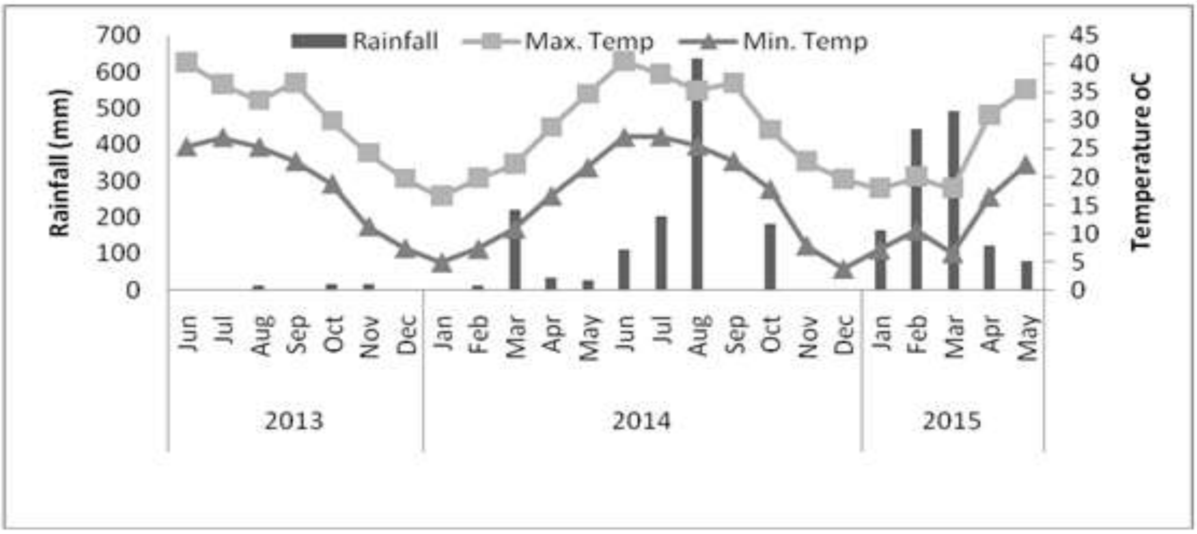

Fig. 1. Maximum, minimum temperature and rainfall during growing season June-2013 to May-2015 of maize and faba bean.

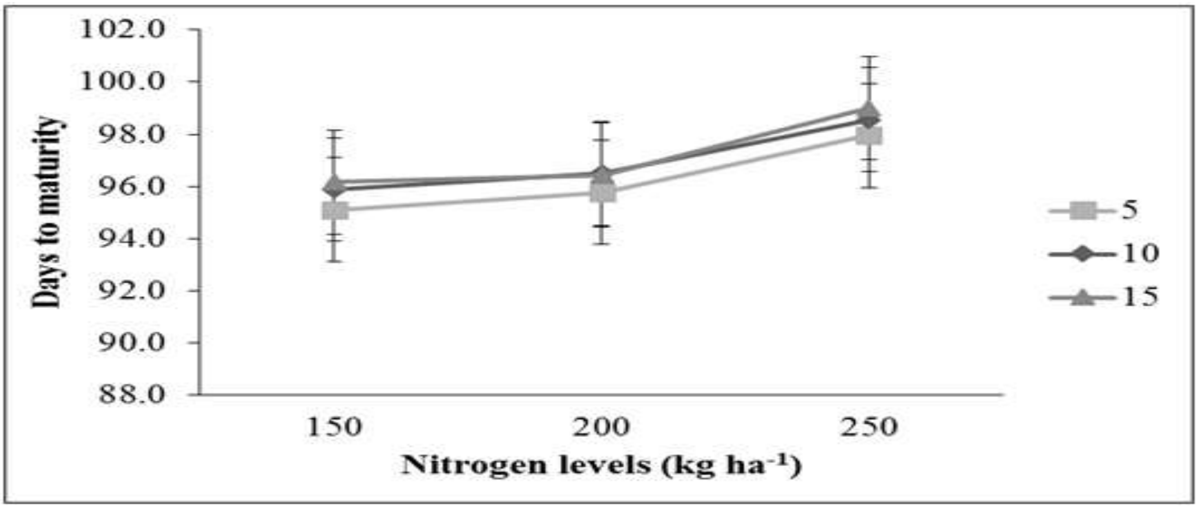

Fig. 2. Days to maturity of maize as affected by N x Zn interaction.

Faba bean parameters

Days to emergence

Days to emergence were significantly affected by year, while effect of residual N, P, Zn, control vs rest and interactions were non-significant (Table 6). Days to emergence were higher (10.9) in 2013 as compared to 2014.The higher days to emergence due to the year effect might be attributed to the environmental conditions such as temperature which was low in 2013 compared to 2014 (Fig.1).

Days to flowering

Y, N, P, Zn and control vs rest significantly affected days to flowering and interactions were non-significant (Table 7).

Higher days to flowering (117.3) were recorded in 2014-2015 compared with 2013-2014. Higher days to flowering (91) were recorded for fertilized plots compared with control. Higher days to flowering (96.2) were recorded at 250 kg N ha^{-1}. Highest level of P (175 kg ha^{-1}) resulted in 92.9 days to flowering. 15 kg Zn ha^{-1} resulted 91.8 days to flowering.

The delay in flowering due to nitrogen might be attributed to the fact that N increased the vegetative growth and thus delayed the reproductive growth. Similar results were earlier reported by Deldon (2001). Increasing P delayed the flowering might be attributed to efficiently utilize the nutrient and thus prolonging the vegetative growth.

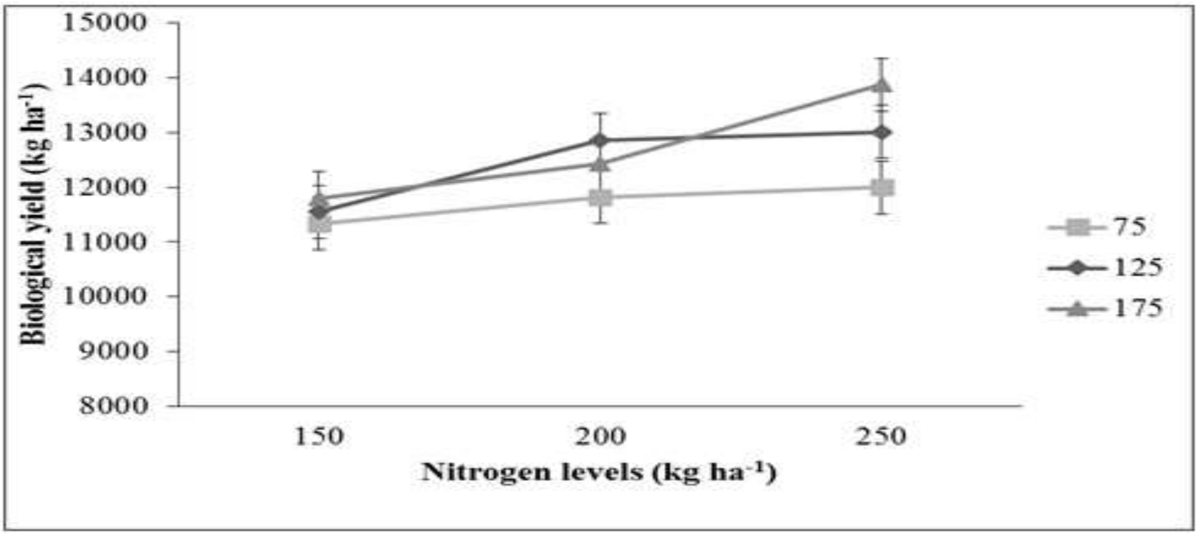

Fig. 3. Biological yield of maize as affected by N x P interaction.

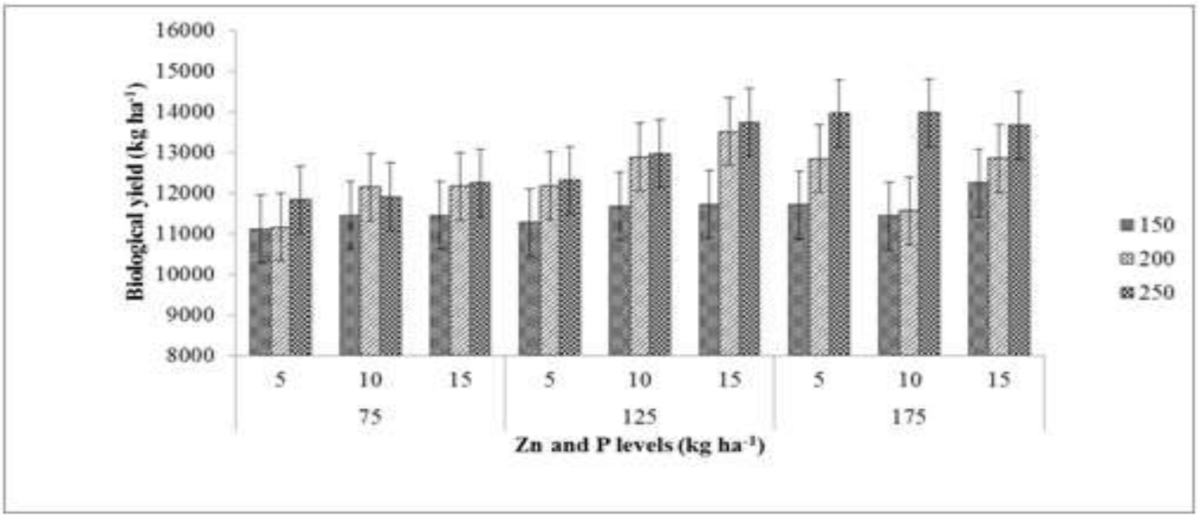

Fig. 4. Biological yield of maize as affected by N x P x Zn interaction. Standard error = (┬) when these bars cross each other than it shows non-significant and vice versa.

These results are in contrast with those suggested by Khalil *et al.* (2010) who reported earlier flowering with application of P at higher levels. Similarly the Zn delayed flowering due to its role in growth and thus delaying flowering. Similar results were earlier reported by Kaya and Higgs (2002) and Cakmak (2008) who concluded that Zn plays important role in phenology of crop.

Biological yield (Kg ha^{-1})

Y residual N, P, Zn, control vs rest, N x P, P x Zn and N x P x Zn interactions significantly affected biological yield (Table 8). Higher biological yield (8742 kg ha^{-1}) was recorded in 2014-2015 compared to 2013-214. Higher biological yield (10116 kg ha^{-1}) was recorded for fertilized plots compared with control plots. Higher biological yield (10677 Kg ha^{-1}) was recorded at 250 kg N ha^{-1}. Highest level of P (175 kg ha^{-1}) resulted in 10492 kg ha^{-1} higher biological yield. 15 kg Zn ha^{-1} produced 10649 kg ha^{-1} higher biological yield. N x P interaction indicated that biological yield was higher with 250 kg N and 175 kg P ha^{-1}. Increasing N level up to 200 kg ha^{-1} increased biological yield at 75 and 125 kg P ha^{-1} while biological yield was decreased with increase in N up to 200 kg at 175 kg P ha^{-1}, however biological yield was increased with increase in N beyond 200 kg at 175 kg P ha^{-1} (Fig 5).

P x Zn interaction revealed that biological yield was higher with 15 kg Zn and 175 kg P ha^{-1}. Biological yield was increased with each increment of Zn at 175 kg P, while at 125 kg P increasing Zn decreased biological yield (Fig 6). N x P x Zn interaction indicated that biological yield was higher with 250 kg N 175 kg P and 15 kg Zn ha^{-1}. Increasing N and Zn at 175 kg P increased biological yield while at lower of P increasing Zn level decreased biological yield regardless of N (Fig 7). Higher biological yield in case of higher N may be due to the fact that vegetative growth was increased with addition of the nitrogen and thus crop producing more dry matter as nitrogen is the constituent of the plant parts.

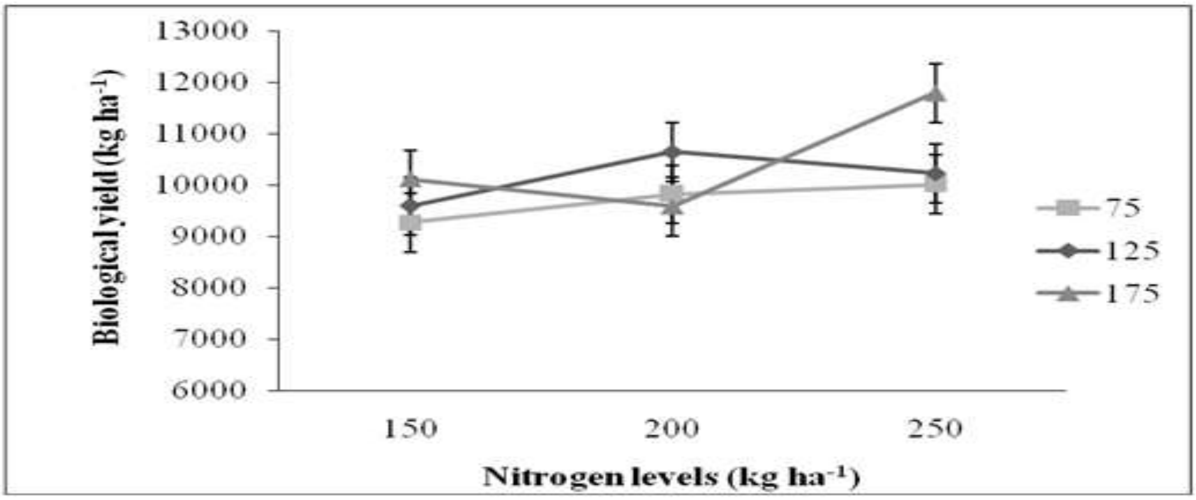

Fig. 5. Biological yield of faba bean as affected by N x P interaction.

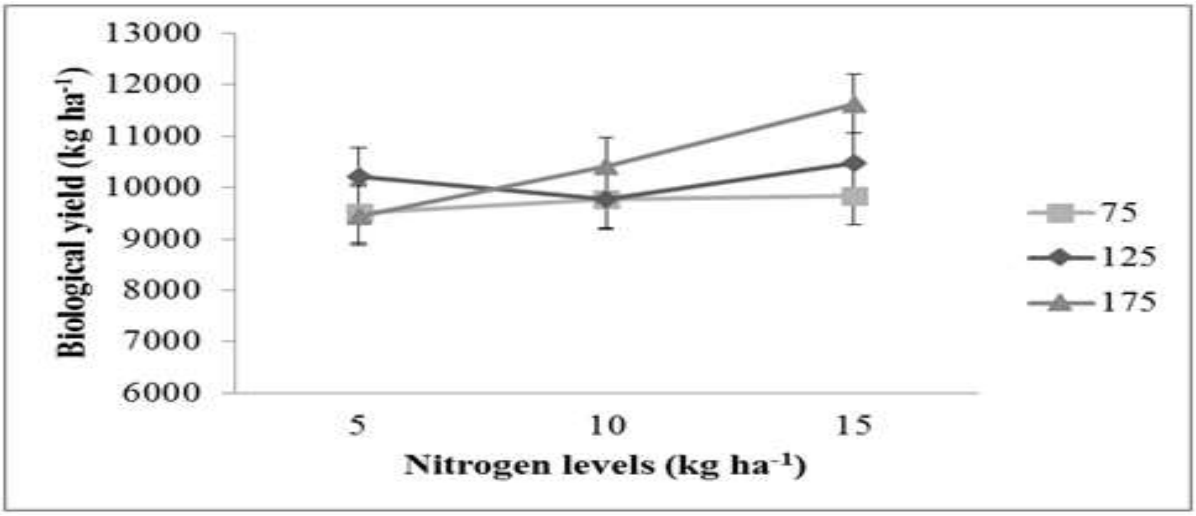

Fig. 6. Biological yield of faba bean as affected by P x Zn interaction.

The results are in agreement with Zubair *et al*., (2009) who stated that higher N levels increased vegetative growth, which enhanced biological yield. Ortiz Monasterio *et al*. (1997) also reported an increase in biomass and grain yield of the crop with increasing N level. El-sheikh (1998) and Samira *et al*. (1998) also reported a significant effect of N on yield and yield components of maize. Nitrogen was significantly enhanced biological yield of subsequent crop when nitrogen was applied from organic source (Khan and Khalil, 2014). Higher biological yield in case of higher P may be due to it is needed for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division, fat and albumen formation. Similar results were reported by (Hussain *et al*.,2011).

These results agree with Kaleem *et al.* (2009). Who reported that biological yield significantly increase with application of phosphorus up to 120 kg P ha-1. Residual effect of phosphorus increases plant height, biomass and yield and yield components of sorghum (Daba and Zewedie, 2001 and Sahrawat, 2000). Higher biological yield in case of higher Zn may be due to Zn plays an important role in the biomass production. These results are in line to Kaya, Higgs (2002) and Cakmak (2008) reported that biological yield increases with increasing Zn level. Similarly Kenbaev and Sade (2002) and Hosseini (2006) have reported that increase in yield components for application of zinc.

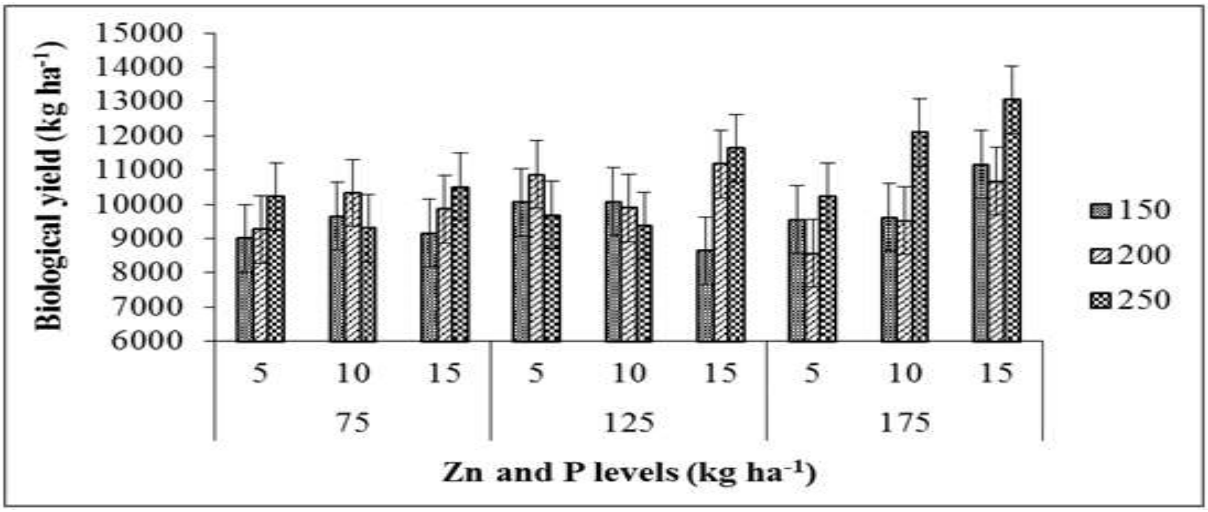

Fig. 7. Biological yield of faba bean as affected by N x P x Zn interaction.

Conclusion

Nitrogen applied at the rate of 250 kg ha-1 increased soil fertility and crop productivity.

Phosphorus applied at the rate of 175 kg ha-1 increased soil fertility and crop productivity.

Zinc applied at the rate of 15 kg ha-1 increased soil fertility and crop productivity.

Residual nitrogen applied at the rate of 250 kg, P @ 175 kg and Zn @ 15 kg ha-1 improved the yield and yield components of faba bean.

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