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Response of Yellow Maize Yield to Preceding Crop Effect and NP Fertilization Level

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THIS STUDY was conducted in the Experimental Farm, Ghazala Village, Faculty of Agriculture, Zagazig University, El-Sharkia Governorate, Egypt, during two successive seasons (2014 and 2015). The study aimed to find out the effect of preceding crop (berseem and wheat), phosphorus "P" (0, 15.5 and 31 kg P_2O_5/ fad*) and nitrogen "N" (40, 80 and 120 kg N/ fad) levels on yellow maize yield and its attributes. The results clearly clarified the possibility of saving N additions when maize was preceded by berseem than when preceded by wheat. Though ear length and diameter and the grain set per ear as expressed in the number of rows per ear, number of grains per row, number of grains per ear and total yield/ fad were not significantly increased, however, grain filling as expressed in seed index and grain weight per ear were significantly increased due to growing maize after berseem and hence the grain and ears yields per fad, shelling percentage and harvest index were increased compared with growing maize after wheat. Regarding P levels effect, the first increment (15.5 P_2O_5/ fad) was quite enough for increasing grain yield per fad and almost all of its attributes, where the further increase in P level did not add any significant increase in this respect. Finally, the grain yield, ears yield and hence the total yield per fad responded to each N increment up to 120 kg N/ fad, but, the stover yield responded to only 80 kg N/ fad and hence the harvest index was the highest (41.30 %) at the lowest N level (40 kg N/ fad). The most frequent first order interaction between factors under study was that between the preceding crop and N levels which indicated the need of lower N level in order to maximize the grain yield per fad when maize was preceded by berseem compared with after wheat. The grain yield response to N level was diminishing where 50.8 kg N/ fad were needed to maximize the grain yield to 3.03 ton/ fad compared with 105.7 kg N/ fad needed to maximize the grain yield to only 2.89 ton/ fad when maize was preceded by berseem and wheat, respectively.

Keywords: Maize, Preceding crop, P, N, Grain yield.

In Egypt, attempts are being devoted to optimize the use of irrigation water through reducing the rice cultivated area to about one million faddan instead of twice of this area. Accordingly, the maize (*Zea mays* L.) cultivated area is expected to be extended to more than 1.79 million faddan (FAOSTAT, 2014). This extension dictates growing some of the maize area after wheat and mainly after berseem. Therefore, studies should focus on the response of maize to the effects of the preceding crop, *i.e.* wheat and berseem which occupy most of the cultivated area during winter. The favourable effects of legumes in enriching soil

*fad = faddan = 4200 m^2 and ha = 2.4 fad fertility from physical, chemical and biological points of view cannot be denied and are extensively reported in the literature (Chan & Heenan, 1996; Bagayako *et al*., 2000; and Yusuf *et al*., 2009 and Zivorad *et al*., 2013). The extensive use of mineral fertilizers has masked most of the beneficial effects of crop rotation. Karlen *et al*. (1994) stated that no amount of mineral fertilizer can be fully compensated for crop rotation beneficial effects. Grain yield response of maize to applied P was greater when the preceding crop was maize compared with soybean. This may have been because of greater net release of P from soil organic matter and crop residues when the previous crop was soybean (Wortmann *et al*., 2009). Succession of grasses in the crop rotation needs enriching soil fertility from plant nutrients and in particular from N and P.

Several studies have been carried out to find out the response of maize to P fertilization. Saleem *et al*. (2003) showed that, maize grain yield was significantly affected by P levels where the highest yield average was produced at 29 kg P_2O_5 /fad followed by 25, 33, 21 P_2O_5 /fad and control. Also, Hegazy *et al.* (1996), Omar (2014), Salem, (2000), Hussein (2009), Masood *et al.* (2011) and Abd El-Rheem *et al*. (2015) showed that, the increase P levels up to 15, 25, 30, 38, 42 and 80 kg P_2O_5 /fad increased grain yield, biomass and its components. While, Skarlou & Nuhas (1981) and Mazengia (2011) showed that, application of mineral P was without any significant effect on maize yield and its attributes.

Mineral fertilization with nitrogen was also reported to increase yield of maize. Mahama *et al*. (2016), Shams (2000), El-Murshedy (2002) and Kandil (2013) reported that, the increase of N level up to 75, 120, 140 and 150 kg N/ fad increased grain yield and its components *i.e.* number of rows/ ear, number of grains/ row, 100 kernels weight and grain weight. These increases were attributed to the increase of yield attributes, *i.e*. plant height, ears/ plant, ear length and diameter (Ghazy, 2004; Abd-Alla, 2005; Atia & Mahmoud, 2006; Soliman & Gharib, 2011; El-Azab, 2012; Darwich, 2013 and Abd El-Rheem *et al*., 2015). Synergistic relationship between N and P may convert relatively unavailable native and residual P to available forms which are ready for uptake by plants (Ogunlela *et al*., 2005).

Therefore, the present study was devoted to find out the response of yellow maize to the effect of the preceding crop (berseem and wheat) under different levels from P (0, 15.5 and 31 kg P_2O_5/ fad[*]) and N (40, 80 and 120 kg N/ fad) and their interactions.

Materials and Methods

The present study was conducted in the Experimental Station at Ghazala Village, Fac. Agric., Zagazig Univ., Sharkia Governorate, Egypt (30.11 °N, 31.41 °E) during two successive summer seasons of 2014 and 2015. The study aimed to find out the effect of preceding crop treatments, phosphorus (P) and nitrogen (N) fertilization levels on maize yield.

Studied factors

Preceding crop treatments

1. Berseem (*Trifolium alexandrinum* L.) (Legume forage crop).
2. Wheat (*Triticum aestivum* L.) (Spring wheat, bread wheat).

Phosphorus fertilization levels

1. Check.
2. 15.5 kg P_2O_5/ fad.
3. 31 kg P_2O_5/ fad.

Nitrogen fertilization levels

1. 40 kg N/ fad.
2. 80 kg N/ fad.
3. 120 kg N/ fad.

Phosphorus as ordinary superphosphate (15.5 % P_2O_5) was band placed at planting. Ammonium nitrate (33.5 % N) was partly applied in two splits before the first and second irrigations at 20 and 34 days after planting (DAP). A split-split plot design with four replications was used, where the preceding crop treatments were allocated in the main plots, whereas, P and N levels were allocated in the first and second order sub plots (17.5 m^2), respectively.

Recorded data

Maize yield and yield attributes

At harvest, (120 DAP), the following yield attributes were recorded on ten maize plants and ears: ear diameter, ear length (cm), rows number per ear (No.), grains number per row (No.), grains number per ear (calculated), hundred grain weight (g), shelling percentage (%) and grain weight per ear (g). Also, the following final yield traits were recorded from the two central ridges: grain yield (ton/fad): at grain moisture content of 15.5 %, ears yield, total yield, stover yield (ton/fad) and harvest index (%) *i.e.,* grain to total yield in percentage.

General agronomic practices

Single cross 173 yellow maize cultivar was planted on May 20th in both seasons. Each sub plot (3.5m x 5m) included 5 ridges 70 cm apart. Seeds were hand sown on one side of the ridge in hills 25 cm apart. Planting was made after berseem and wheat as preceding using seeding rate of 10 kg/ fad. Plants were thinned to one plant per hill (24000 plant/ fad) before the first irrigation (20 DAP) and flood irrigation was practiced every 14 days. Soil samples were taken from the two preceding crop sites (berseem and wheat) at a depth of 0 -30 cm before planting to determine soil physical and chemical properties at the Central Laboratory of Faculty of Agriculture, Zagazig University, Zagazig, Egypt (Table 1-a).

Statistical analysis

Data were statistically analyzed according to Gomez & Gomez (1984) by using MSTAT-C (1991) where statistical program Version 2.1 was used for analysis of variance (ANOVA). A combined analysis was undertaken for the data of the two seasons after testing the homogeneity of the experimental errors. Duncan Multiple range test was used to compare statistical significant differences (Duncan, 1955). In interaction Tables, capital and small letters were used to denote significant differences among rows and columns means, respectively. Interaction Tables are provided with response equations to compare the response of maize yield and its attributes to the increase of N level at the two preceding crop treatments. The response equations were calculated according to Snedecor & Cochran (1967) using the orthogonal polynomial Tables. The significance of the linear and quadratic components of each of equation was tested, then the response could be described as linear (first order) or quadratic (second order). The predicted maximum averages ($\hat{Y}_{max}$) which could have been obtained due to the addition of the predicted maximum N level (X_{max}) were calculated according to Neter *et al.* (1990) as explained by Abdul Galil *et al.* (2003) using the following equations:

$\hat{Y}_{max} = \hat{Y}_0 + b^2 / 4c$ $X_{max} = X_0 + b / 2c$ (u)

where: $\hat{Y}_0$ = Grain yield at the lowest N level *i.e.* 40 kg N/ fad (ton/ fad).

b = Measures the linear component of the response equation.

c = Measures the quadratic component of the response equation.

u = unit of N = 40 kg N/ fad.

Climate conditions

Data in Table 1-b show the monthly mean minimum and maximum air temperatures, relative humidity, wind speed and precipitation during the two maize growing seasons.

TABLE1-a. Physical and chemical analyses of the experimental soil sites at 30 cm depth (average of two seasons).

Preceding crop	Organic matter (%)	Total N (%)	Available P (mg kg^{-1})	Available K (mg kg^{-1})	pH*	Texture
Berseem	2.0	0.15	17	140	7.9	Clay
Wheat	1.04	0.05	8.95	148	7.99	Clay

* Soil suspension

TABLE 1-b. Monthly mean minimum and maximum air temperatures, relative humidity, wind speed and precipitation during the two maize growing seasons*

Month	Temperature (°C)			Relative humidity (%)	Wind (km/h)	Precipitation (mm)
	Max.	Min.	Mean			
2014 season						
May	42	25	33.5	71	13	0.00
June	43	29	36	73	12	0.00
July	39	31	35	82	10	0.00
August	38	32	35	83	10	0.00
September	39	28	33.5	74	9	0.00
2015 season						
May	44	27	35.5	76.4	10	0.00
June	40	28	34	77.4	10	0.00
July	41	30	35.5	85.2	8	0.00
August	42	33	37.5	80.9	10	0.00
September	39	33	36	78.7	10	0.00

*http:// www.wunderground.com

Results and Discussion

Maize grain yield attributes

Ear length and diameter

Preceding crop effect: Ear length and diameter were not significantly affected by varying the preceding crop in both seasons. However, the combined analysis detected significant increase in ear diameter of maize grown after berseem (Table 2).

TABLE 2. Ear length and diameter of maize as affected by preceding crop treatments, phosphorus and nitrogen fertilization levels and their interactions in both seasons and their combined.

Main effects and interactions	Ear length (cm)			Ear diameter (cm)		
	2014	2015	Comb.	2014	2015	Comb.
Preceding crop treatments (C)						
Berseem	17.81	17.96	17.88	4.60	4.58	4.59
Wheat	17.68	17.75	17.71	4.35	4.36	4.36
F-test	N.S.	N.S.	N.S.	N.S.	N.S.	**
Phosphorus level (P):						
Check	17.46	17.48	17.47 b	4.41 b	4.41	4.41 b
15.5 kg P_2O_5/ fad	17.97	18.23	18.10 a	4.52 a	4.51	4.52 a
31 kg P_2O_5/ fad	17.80	17.84	17.82 a	4.50 a	4.49	4.50 a
F.test	N.S.	N.S.	*	**	N.S.	**
Nitrogen level (N):						
40 kg N/ fad	16.75 b	16.90 b	16.83 b	4.41 c	4.42 b	4.42 c
80 kg N/ fad	18.18 a	18.22 a	18.20 a	4.49 b	4.48 a	4.49 b
120 kg N/ fad	18.30 a	18.44 a	18.37 a	4.52 a	4.52 a	4.52 a
F.test	**	**	**	**	**	**
Interactions:						
C x P	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C x N	**	N.S.	**(2-a)	**	N.S.	**(2-c)
P x N	**	N.S.	**(2-b)	*	N.S.	N.S.

*,** and N.S. indicate statistically significant at 0.05 and 0.01 levels and insignificancy of differences, respectively.

Phosphorus level effect: Ear length was not significantly affected by P level in both seasons, however, the combined analysis detected significant increase due to addition of P at either levels which had at par averages. This significant effect was observed in ear diameter in the first season and the combined of both seasons (Table 2). These results refer to the need of maize plants to added P at only the lower level, *i.e.* 15.5 kg P_2O_5/ fad where the further increase in P level did not add a significant increase in either length or ear diameter. These results are in harmony with those obtained by Hegazy *et al.* (1996), Saleem *et al.* (2003) and Omar (2014), while, not in accordance with those reported by Hussein (2009), Masood *et al*. (2011) and Abd El-Rheem *et al*. (2015) as they reported more response to added P than that observed herein.

Nitrogen level effect: In both seasons and their combined, the increase of N level to 80 or 120 kg N/ fad produced at par significant increase in ear length, which was also observed in ear diameter in the second season. However, ear diameter in the first season and the combined analysis detected consistent significant increase with each increase in N level up to the addition of 120 kg N/ fad (Table 2). These results indicated that ear diameter was more affected by increasing N level than ear length. Similar findings were reported by Ghazy (2004), Abd-Alla (2005), Atia & Mahmoud (2006), Soliman & Gharib (2011), El-Azab (2012), Darwich (2013) and Abd El-Rheem *et al.* (2015).

Interaction effect: Significant interaction effects were observed to affect both ear length and ear diameter. According to the combined analysis, ear length was significantly affected by C x N and P x N interactions (Tables 2-a and 2-b). Ear diameter was significantly affected only by C x N interaction (Table 2-c). Regarding ear length (Table 2-a) it was significantly increased by adding 80 kg N/ fad when maize was grown after berseem, while the further increase in N level to 120 kg N/ fad brought significant increase in ear length of maize grown after wheat. The response equation predicated possible maximization of ear length to 18.49 and 18.79 cm due to predicated maximum additions of 50.73 and 100 kg N/ fad, respectively. These results are quite interesting as they clearly indicate the need of lower N level in order to maximize ear length after berseem than after wheat. These results refer to more availability of N in fields of berseem than fields of wheat (Table 1-a). This effect was observed in ear diameter (Table 2-c) but, further indicate more need of N up to 153.3 kg N/ fad after wheat compared with only 53.33 kg N/ fad after berseem. Ear length was also affected by the N x P interaction as shown in Table (2-b). In the check P plots, each N increment produced a significant increase in ear length, however, in the P fertilized plots with either P levels, no significant increase in ear length could be detected beyond the addition of 80 kg N/ fad. This effect was clearly indicted by the response equations, where the predicted N level which could have been used to maximize ear length was consistently decreased as the level of P fertilization was increased. It seems possible that added P and its level increase might have had made N more available to maize plants. This effect could be physiological effect due to the role of P in enhancing root multiplication and extension and hence more root ramification and thereby more N availability for uptake. Therefore, the higher the P level, the lower N level needed to maximize ear length.

TABLE 2-a. Ear length (cm) of maize as affected by preceding crop treatments and N level interaction (combined data).

Preceding crop treatments	N level			$\hat{Y} = a + bx - cx^2$	$\hat{Y}_{max}$ (cm)	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Berseem	B	A	A	$17.17 + 2.08x - 0.82x^2$	18.49	50.73
	17.17 a	18.43 a	18.05 b			
Wheat	C	B	A	$16.48 + 1.85x - 0.37x^2$	18.79	100.0
	16.48 b	17.96 b	18.70 a			

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

TABLE 2-b. Ear length (cm) of maize as affected by P level and N level interaction (combined data).

P level	N level			$\hat{Y} = a + bx - c\,x^2$	$\hat{Y}_{max}$ (cm)	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Check	C	B	A	$16.03 + 2.12\,x - 0.40\,x^2$	18.79	104.4
	16.03 b	17.74 b	18.64 a			
15.5 kg P_2O_5/ fad	B	A	A	$17.13 + 2.17\,x - 0.72\,x^2$	18.77	60.28
	17.13 a	18.58 a	18.59 ab			
31 kg P_2O_5/ fad	B	A	AB	$17.32 + 1.60\,x - 0.66\,x^2$	18.29	48.7
	17.32 a	18.26 ab	17.89 b			

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

TABLE 2-c . Ear diameter (cm) of maize as affected by preceding crop treatments and N level interaction (combined data).

Preceding crop treatments	N level			$\hat{Y} = a + bx - c\,x^2$	$\hat{Y}_{max}$ (cm)	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Berseem	A	A	A	$4.56 + 0.08\,x - 0.03\,x^2$	4.61	53.33
	4.56 a	4.61 a	4.60 a			
Wheat	C	B	A	$4.27 + 0.12\,x - 0.02\,x^2$	4.49	153.3
	4.27 b	4.37 b	4.44 b			

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

Number of grains per ear

Preceding crop effect: The preceding crop did not reflect any significant effect on number of rows per ear, number of grain per row and hence the number of grains per ear. This was observed in the two seasons and their combined (Table 3). These results refer to similar grain set per ear as ear length and ear diameter were not significantly affected by varying the preceding crop though ear diameter was significantly thicker after berseem than after wheat as was detected by the combined analysis (Table 2). These results are not in accordance with those reported by Bagayako *et al.* (2000) and Yusuf *et al.* (2009) and Zivorad *et al*. (2013) as they reported that, cropping sequence with legume crops might reduce mineral fertilizer requirements of succeeding non- legume crops and increase crop yield.

Phosphorus level effect: In both seasons and their combined analysis, the number of rows per ear was not significantly increased due to the increase of P level. However, the combined analysis detected significant increase in number of grains per row due to the addition of the first P increment. This was reflected in number of grains per ear was observed in the first season and the combined analysis (Table 3). These results indicate that, the increase of ear length and diameter due to the increase of P level (Table 2) was reflected in number of grains per row and hence number of grains per ear but only due to the addition of the first P increment, where the further increase of P level did not add any significant increase to the number of grains per row or per ear. Similar results were reported by Mazengia (2011), who showed that, mineral P fertilization was without any significant effect on maize yield attributes. But, these results are not in accordance with those reported by Hegazy *et al.* (1996), Salem (2000), Hussein (2009), Masood *et al*. (2011), Omar (2014) and Abd El-Rheem *et al*. (2015).

TABLE 3. Number of rows per ear, number of grains per row and number of grains per ear of maize as affected by preceding crop treatments, phosphorus and nitrogen fertilization levels and their interactions in both seasons and their combined.

Main effects and interactions	Number of rows / ear			Number of grains / row			Number of grains / ear		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Preceding crop treatments (C)									
Berseem	14.89	14.84	14.87	39.49	39.38	39.43	589.3	585.8	587.6
Wheat	14.41	14.47	14.44	39.20	39.31	39.26	565.0	569.2	567.1
F-test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Phosphorus level (P):									
Check	14.43	14.47	14.45	39.18	38.77	38.98 b	567.1 b	562.4	564.7 b
15.5 kg P_2O_5/ fad	14.82	14.83	14.83	40.16	40.18	40.17 a	595.2 a	596.2	595.7 a
31 kg P_2O_5/ fad	14.70	14.67	14.68	38.69	39.08	38.89 b	569.3 b	573.9	571.6 b
F.test	N.S.	N.S.	N.S.	N.S.	N.S.	*	**	N.S.	**
Nitrogen level (N):									
40 kg N/ fad	14.33 b	14.33	14.33	37.33 b	37.23 b	37.28 b	536.4 c	535.1 c	535.7 c
80 kg N/ fad	14.78 a	14.77	14.78	40.18 a	40.18 a	40.18 a	594.2 b	593.7 b	594.0 b
120 kg N/ fad	14.83 a	14.87	14.85	40.53 a	40.62 a	40.57 a	601.0 a	603.6 a	602.3 a
F.test	*	N.S.	N.S.	**	**	**	**	**	**
Interactions:									
C x P	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C x N	N.S.	N.S.	N.S.	N.S.	*	N.S.	*	N.S.	*(3-a)
P x N	N.S.	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.

*,** and N.S. indicate statistically significant at 0.05 and 0.01 levels and insignificancy of differences, respectively.

*Nitrogen level effect:*The first N increment resulted in a significant increase in each of rows number per ear and number of grains per row. However, number of grains per ear continued to increase significantly due to each N increase up to the addition of 120 kg N/ fad (Table 3). This could be attributed to the increase of ear diameter which was significantly increased with each increase in N level (Table 2). These results are in harmony with those obtained by Shams (2000), El-Murshedy (2002), Soliman & Gharib (2011), El-Azab (2012), Kandil (2013) and Mahama *et al*. (2016).

Interaction effect: The combined analysis detected significant C x N interaction in number of grains per ear as shown in Table (3-a). It is quite clear that number of grains per ear continued to increase significantly up to the addition of 120 kg N/ fad after wheat, but failed to increase significantly beyond the addition of 80 kg N/ fad after berseem. This effect was observed in the both ear length (Table 2-a) and as well as in ear diameter (Table 2-c) and hence could account for the results obtained herein regarding the number of grains per ear. These results were formerly discussed and obviously cleared that, the soil of the experiment site after berseem was more enriched by available soil N (Table 1-a) which in turn saved the use of mineral N as indicated by the response equations where only 51.13kg N/ fad were needed to maximize the number of grains of ear to 611.9 grain after berseem compared with 96.06 kg N/ fad needed to maximize this number to 612.5 grain after wheat.

TABLE 3-a. Number of grains per ear of maize as affected by preceding crop treatments and N level interaction (combined data).

Preceding crop treatments	N level			$\hat{Y} = a + bx - cx^2$	$\hat{Y}_{max}$ (No.)	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Berseem	B 558.5 a	A 609.4 a	A 594.9 a	$558.5 + 83.6x - 32.7x^2$	611.9	51.13
Wheat	C 513.0 b	B 578.6 a	A 609.7 a	$513.0 + 82.9x - 17.3x^2$	612.5	96.06

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

Grain weight and grain yield per fad

Preceding crop effect: In the first season and the combined analysis of both seasons, the seed index and shelling percentage were significantly increased after berseem compared with these traits averages after wheat. This was in turn reflected in the grain weight per ear and finally in the grain yield per fad as indicated by the combined analysis (Table 4). These results could be attributed to the increase of seed index and shelling percentage as neither the ear length and diameter (Table 2) or the number of grains per ear (Table 3) was increased significantly due to growing maize after berseem. The data further indicated that, the favorable effect of berseem was gained by maize during their grain filling rather than earlier during grain set where the number of grains per ear did not vary significantly due to varying the preceding crop. Similar results were reported by Yusuf *et al.* (2009) and Zivorad *et al*. (2013).

TABLE 4. 100- grain weight, grain weight per ear, shelling percentage and grain yield of maize as affected by preceding crop treatments, phosphorus and nitrogen fertilization levels and their interactions in both seasons and their combined.

Main effects and interactions	100- grain weight (g)			Grain weight per ear (g)			Shelling (%)			Grain yield (ton/ fad)		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Preceding crop treatments (C)												
Berseem	29.62	29.60	29.61	171.3	172.3	171.8	82.17	82.38	82.27	2.85	2.86	2.85
Wheat	27.15	26.98	27.07	144.9	144.8	144.9	77.71	77.60	77.66	2.56	2.52	2.54
F-test	*	N.S.	**	**	N.S.	**	*	N.S.	**	N.S.	N.S.	**
Phosphorus level (P):												
Check	28.17 b	28.0 b	28.08 b	150.8 c	152.5	151.6 c	79.52 b	79.75	79.64	2.66 b	2.68	2.67 b
15.5 kg P_2O_5/ fad	28.88 a	28.77 a	28.83 a	164.6 a	164.5	164.5 a	79.88 b	79.89	79.89	2.77 a	2.74	2.75 a
31 kg P_2O_5/ fad	28.11 b	28.11 b	28.11 b	159.0 b	158.7	158.8 b	80.42 a	80.32	80.37	2.68 b	2.65	2.67 b
F.test	**	*	**	**	N.S.	**	*	N.S.	N.S.	*	N.S.	*
Nitrogen level (N):												
40 kg N/ fad	27.89 b	27.8 b	27.85 b	148.3 c	147.3 b	147.8 b	81.01 a	80.98 a	80.99 a	2.41 c	2.40 b	2.40 c
80 kg N/ fad	29.26 a	29.0 a	29.13 a	162.5 b	164.3 a	163.4 a	79.93 b	80.21 b	80.07 b	2.80 b	2.82 a	2.81 b
120 kg N/ fad	28.01 b	28.08 b	28.04 b	163.5 a	164.0 a	163.8 a	78.88 c	78.78 c	78.83 c	2.90 a	2.85 a	2.88 a
F.test	**	**	**	**	**	**	**	**	**	**	**	**
Interactions:												
C x P	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**.	N.S.	N.S.
C x N	N.S.	**	**(4-a)	**	N.S.	**(4-c)	**	N.S.	N.S.	**	N.S.	**(4-d)
P x N	**	**	**(4-b)	**	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.

*,** and N.S. indicate statistically significant at 0.05 and 0.01 levels and insignificancy of differences, respectively.

Phosphorus level effect: Addition of the first P increment recorded the highest averages of grain yield per fad as well as 100-grain weight and grain weight per ear (Table 4). However, the highest shelling percentage was obtained due to the addition of the highest P level as indicated by a significant effect in only the first season. Similar significant effects were observed in all yield attributes as observed in Tables 2 and 3. These results are in harmony with those obtained by Salem (2000), Saleem *et al.* (2003), Hussein (2009), Masood *et al.* (2011), Omar (2014) and Abd El-Rheem *et al.* (2015).

Nitrogen level effect: The first N increment produced significant increase in grain yield attributes but, the combined analysis detected consistent significant increase in grain yield/ fad due to each N increment up to the addition of 120 kg N/ fad reflecting the trend observed in the first season (Table 4). Similar significant effects were reported by El-Murshedy (2002), Soliman & Gharib (2011), El-Azab (2012), Kandil (2013) and Mahama *et al.* (2016).

Interaction effect: Significant interaction effects were detected to affect the grain yield/ fad and some of its attributes in both seasons. The combined analysis indicated clear significant interaction effect between the preceding crop and N levels as observed in grain yield per fad and all of its attributes. As far as the effect of C x N interaction on grain yield per fad (Table 4-d) and Fig.1, the first N increment was quite enough to increase the yield average after berseem, but the second N increment was still badly needed to maximize this average after wheat. The response equations showed diminishing increase in grain yield with increasing N level after berseem or after wheat. However, these quadratic equations detected maximum N levels of 105.7 kg N/ fad after wheat compared with only 50.83 kg N/ fad after berseem in order to maximize yield averages to 2.89 and 3.03 ton/ fad, respectively.

These effects were also observed in seed index, grain weight per ear as shown in Tables (4-a) and (4-c), respectively. Seed index was significantly affected by the N x P interaction (Table 4-b) where no particular trend could be detected from these results as higher predicted N levels were needed when the level of P was increased in order to maximize seed index to lower averages. According to these results, and in particular the grain yield per fad the only significant interaction was that between the preceding crop and N level which clearly indicate an increase in soil fertility level, most probably from available N, where about 50 % of N level could be saved when maize was preceded by berseem than by wheat (Table 4-d). Veenstra *et al*. (2007) showed that, winter legume cover crops can improve physical soil properties, reduce soil erosion, conserve soil water, recycle plant nutrients, and increase crop yield potential and soil productivity.

TABLE 4-a. 100-grain weight (g) of maize as affected by preceding crop treatments and N level interaction (combined data).

Preceding crop treatments	N level			$\hat{Y} = a + bx - c x^2$	$\hat{Y}_{max}$ (g)	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Berseem	A	A	B	$29.93 + 1.48x - 1.08x^2$	30.44	27.44
	29.93 a	30.33 a	28.58 a			
Wheat	B	A	A	$25.77 + 3.45x - 1.29x^2$	28.08	53.49
	25.77 b	27.93 b	27.51 b			

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

TABLE 4-b. 100-grain weight (g) of maize as affected by P level and N level interaction (combined data).

P level	N level			$\hat{Y} = a + bx - c x^2$	$\hat{Y}_{max}$ (g)	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Check	B	A	B	$27.33 + 3.42x - 1.6x^2$	29.16	42.75
	27.33 b	29.15 b	27.77 a			
15.5 kg P_2O_5/ fad	B	A	B	$27.89 + 4.6x - 2.2x^2$	30.29	41.87
	27.89 ab	30.29 a	28.30 a			
31 kg P_2O_5/ fad	A	A	A	$28.32 + 0.61x - 0.24x^2$	27.93	50.83
	28.32 a	27.95 c	28.06 a			

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

TABLE 4-c. Grain weight per ear (g) of maize as affected by preceding crop treatments and N level interaction (combined data).

Preceding crop treatments	N level			$\hat{Y} = a + bx - c x^2$	$\hat{Y}_{max}$ (g)	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Berseem	B	A	AB	$166.7 + 19.8x - 8.8x^2$	177.8	45.0
	166.7 a	177.7 a	171.1 a			
Wheat	B	A	A	$129.0 + 26.7x - 6.5x^2$	156.4	82.15
	129.0 b	149.2 b	156.4 b			

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

TABLE 4-d. Grain yield (ton/ fad) of maize as affected by preceding crop treatments and N level interaction (combined data).

Preceding crop treatments	N level			$\hat{Y} = a + bx - c x^2$	$\hat{Y}_{max}$ ton/ fad	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Berseem	B	A	A	$2.64 + 0.61x - 0.24x^2$	3.03	50.83
	2.64 a	3.01 a	2.90 a			
Wheat	C	B	A	$2.16 + 0.56x - 0.11x^2$	2.89	105.7
	2.16 b	2.61 b	2.85 a			

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

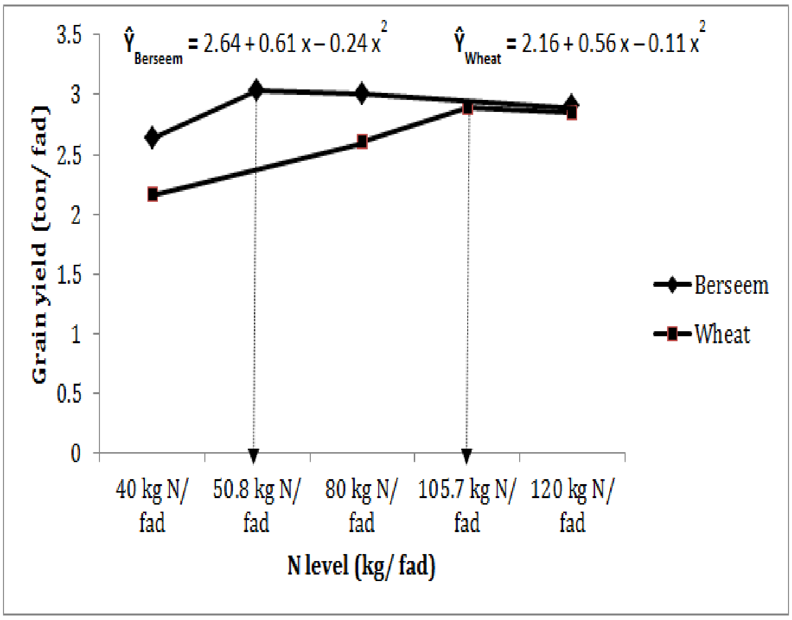

Fig. 1. Respone of maize yield (ton/ fad) to the interaction effect between preceding crop and N fertililzation level (combined data)

Ears, stover and total yields and harvest index

Preceding crop effect: The preceding crop was without significant effect on ears and total yields per fad, however, the combined analysis showed that, the ears yield per fad was significantly increased after berseem compared with that after wheat (Table 5). In the first season and the combined analysis, stover yield was higher after wheat compared with after berseem. Therefore, harvest index was higher after berseem compared with after wheat. These results are in accordance with those reported by Bagayako *et al.* (2000) and Yusuf *et al.* (2009) and Zivorad *et al.* (2013).

Phosphorus level effect: In the first season and the combined analysis of both seasons, ear and stover as well as total yield per fad were increased due to the addition of the first P increment, but, the second increment failed to add a further significant increase (Table 5). However, in both seasons and their combined analysis, harvest index was not significantly increased due to the increase of P level. The failure of the second P increment to increase either the grain or stover yield per fad was observed also in all yield attributes (Tables 2-4) and could be attributed to the high soil fertility level from P after berseem (Table 1-a). Similar significant effects were reported by Saleem *et al.* (2003), Hussein (2009), Masood *et al*. (2011), Omar (2014) and Abd El-Rheem *et al*. (2015).

TABLE 5. Ears, stover and total yields and harvest index of maize as affected by preceding crop treatments, phosphorus and nitrogen fertilization levels and their interactions in both seasons and their combined.

Main effects and interactions	Ears yield (ton/ fad)			Stover yield (ton/ fad)			Total yield (ton/ fad)			Harvest index (%)		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Preceding crop												
treatments (C)	3.47	3.47	3.47	3.30	3.35	3.32	6.77	6.82	6.79	42.36	42.20	42.28
Berseem	3.29	3.25	3.27	3.57	3.64	3.60	6.86	6.89	6.87	37.52	37.08	37.30
Wheat	N.S.	N.S.	*	*	N.S.	**	N.S.	N.S.	N.S.	*	N.S.	**
F-test												
Phosphorus level (P):	3.35 b	3.35	3.35 b	3.24 b	3.28	3.26 b	6.58 b	6.63	6.61 b	40.53	40.63	40.58
Check	3.46 a	3.43	3.45 a	3.58 a	3.71	3.64 a	7.04 a	7.14	7.09 a	39.56	38.73	39.14
15.5 kg P_2O_5/ fad	3.34 b	3.30	3.32 b	3.48 a	3.49	3.49 ab	6.82 b	6.79	6.80 b	39.73	39.56	39.65
31 kg P_2O_5/ fad	**	N.S.	**	**	N.S.	**	**	N.S.	**	N.S.	N.S.	N.S.
F.test												
Nitrogen level (N):	2.96 c	2.95 b	2.96 c	2.96 b	2.89 b	2.92 b	5.92 c	5.84 b	5.88 c	41.05	41.55	41.30 a
40 kg N/ fad	3.50 b	3.52 a	3.51 b	3.61 a	3.67 a	3.64 a	7.12 b	7.19 a	7.15 b	39.40	39.31	39.36 b
80 kg N/ fad	3.68 a	3.62 a	3.65 a	3.73 a	3.92 a	3.82 a	7.40 a	7.53 a	7.47 a	39.37	38.05	38.71 b
120 kg N/ fad	**	**	**	**	**	**	**	**	**	N.S.	N.S.	**
F.test												
Interactions:	**.	N.S.	N.S.	**.	N.S.	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.
C x P	**	N.S.	**(5-a)	**	N.S.	*(5-b)	**	N.S.	**(5-c)	**	N.S.	N.S.
C x N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
P x N												

*,** and N.S. indicate statistically significant at 0.05 and 0.01 levels and insignificancy of differences, respectively.

Nitrogen level effect: Each increase in N level was reflected in a significant increase in ears and total yields per fad up to the addition of 120 kg N/ fad in the first season and the combined analysis, but, the second N increment failed to increase stover yield significantly though it evidently increased the ears yield per fad, possibly due to increase of grain yield per fad (Table 5). However, the combined analysis detected significant decrease in harvest index due to the increase of N level to 80 or 120 kg N/ fad which produced at par significant decrease in harvest index. Similar results were reported by Shams (2000), El-Murshedy (2002), Abd-Alla (2005), Soliman & Gharib (2011), Darwich (2013), Abd El-Rheem *et al*. (2015) and Mahama *et al*. (2016).

Interaction effect: According to the combined analysis ears, stover and total yields per fad were significantly affected by C x N interaction (Tables 5-a, 5-b and 5-c). The ears yield (Table 5-a) and total yield (Table 5-c) continued to increase significantly due to each increase in N level when maize was preceded by wheat, but, the second N increment failed to increase it when maize was preceded by berseem. The response equations predicted maximum ears yield of 3.71 and 3.77 ton per fad due to predicted additions of 56.49 and 110.8 kg N/ fad, respectively. A look in Table 5-c regarding this interaction effect on total yield per fad showed linearity in the increase of total yield due to the increase of N level when maize was preceded by wheat, however, quadratic increase when maize was preceded by berseem. The response equations predicted maximum total yield of 7.49 ton per fad due to a predicted addition of 55.56 kg N/ fad.

Table 5-b shows the interaction effect of C x N on stover yield/ fad according to the combined analysis. The stover yield failed to increase significantly due to any increase in N level when maize preceded by berseem, but however, was significantly increased due to the increase of N level up to 120 kg N per fad when maize was preceded by wheat. Interestingly, the response of stover yield per fad was quadratic after berseem but however linear after wheat where 54.58 kg N/ fad were enough to maximize the stover yield to 3.80 ton/ fad after berseem but however, 120 kg N/ fad were not yet enough to maximize it after wheat.

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TABLE 5-a. Ears yield (ton/ fad) of maize as affected by preceding crop treatments and N level interaction (combined data).

Preceding crop treatments	N level			$\hat{Y} = a + bx - c\,x^2$	$\hat{Y}_{max}$ ton/ fad	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Berseem	B	A	A	$3.14 + 0.81\,x - 0.29\,x^2$	3.71	56.49
	3.14 a	3.66 a	3.61 a			
Wheat	C	B	A	$2.77 + 0.72\,x - 0.13\,x^2$	3.77	110.8
	2.77 b	3.36 b	3.69 a			

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

TABLE 5-b. Stover yield (ton/ fad) of maize as affected by preceding crop treatments and N level interaction (combined data).

Preceding crop treatments	N level			$\hat{Y} = a + bx - c\,x^2$	$\hat{Y}_{max}$ ton/ fad	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Berseem	A	A	A	$2.70 + 1.61\,x - 0.59\,x^2$	3.80	54.58
	2.70 a	3.72 a	3.56 b			
Wheat	B	AB	A	$3.15 + 0.38\,x$	Linear	Linear
	3.15 a	3.57 a	4.08 a			

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

TABLE 5-c. Total yield (ton/ fad) of maize as affected by preceding crop treatments and N level interaction (combined data).

Preceding crop treatments	N level			$\hat{Y}=a+bx-cx^2$	$\hat{Y}_{max}$ ton/ fad	X_{max} kg N/ fad
	40 kg N/ fad	80 kg N/ fad	120 kg N/ fad			
Berseem	B	A	A	$5.84 + 2.38\,x - 0.86\,x^2$	7.49	55.56
	5.84 a	7.36 a	7.17 b			
Wheat	C	B	A	$5.92 + 1.12\,x$	Linear	Linear
	5.92 a	6.94 a	7.77 a			

$\hat{Y}_{max}$: predicted maximum average X_{max}: predicted maximum N level

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إستجابة الذرة الشامية الصفراء لتأثير المحصول السابق ومستوي التسميد النيتروجيني والفوسفاتي

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أجريت هذه الدراسة في مركز بحوث التجارب التابع لكلية الزراعة جامعة الزقازيق بمنطقة غزالة محافظة الشرقية وذلك خلال الموسمين الزراعيين ٢٠١٤ – ٢٠١٥. بهدف دراسة تأثير كل من المحصول السابق (البرسيم والقمح) ومستوي التسميد الفوسفاتي (صفر ، ١٥,٥ و ٣١ كجم فـ٢أ٥/ فدان) والنيتروجيني (٤٠ ، ٨٠ و ١٢٠ كجم ن/ فدان) على محصول الذرة الشامية ومؤشرات المحصول. ويمكن تلخيص النتائج المتحصل عليها على النحو التالى:

١. كان للمحصول السابق تأثيراً معنوياً وايجابياً على محصول الذرة الشامية وبعض مؤشرات المحصول ، حيث لوحظ وجود زيادة في كل من دليل البذور، وزن حبوب الكوز، محصول الحبوب والكيزان/ فدان ودليل الحصاد عند زراعة الذرة الشامية عقب البرسيم مقارنة بزراعته عقب القمح.
٢. أدى زيادة معدل التسميد الفوسفاتي حتى ١٥,٥ كجم فـ٢أ٥/ فدان إلى زيادة معنوية في محصول الحبوب/ فدان وأغلب مؤشرات المحصول ، في حين لم يكن للمستوى الأعلى إي تأثير معنوى في ذلك.
٣. إستجاب كل من محصول الحبوب، ومحصول الكيزان والمحصول الكلي/ فدان لكل زيادة في مستوى التسميد النيتروجينى حتى ١٢٠ كجم ن/ فدان، في حين استجاب محصول الحطب لإضافة ٨٠ كجم ن/ فدان وتحقق أقصى دليل للحصاد (٤١,٣٠ %) عند أقل مستوي تسميد نيتروجينى (٤٠ كجم ن/ فدان).
٤. لوحظ تداخل فعل معنوي بين عوامل الدراسة على أغلب الصفات تحت الدراسة وكان التفاعل بين المحصول السابق ومستوي التسميد النيتروجيني هو الأكثر شيوعاً. والذي يشير إلى إمكانية إستخدام مستوى منخفض من التسميد النيتروجينى لمعظمة محصول الحبوب/ فدان عند زراعة الذرة الشامية عقب البرسيم مقارنة بزراعته عقب القمح. وأوضحت معادلات الاستجابة إمكانية تعظيم محصول الحبوب الذرة الشامية إلى ٣,٠٣ طن/ فدان بإضافة ٥٠,٨ كجم ن/ فدان فقط عقب البرسيم مقارنة بـ ٢,٨٩ طن/ فدان بإضافة ١٠٥,٧ كجم ن/ فدان عقب القمح.