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PHYSIOLOGICAL RESPONSE OF MAIZE HYBRIDS TO NITROGEN AND PHOSPHORUS FERTILIZATION

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ABSTRACT: Two field experiments were conducted at the Experimental Farm, Gemmeiza Agriculture Research station, Agricultural Research Center white maize (ARC), Egypt during two growing seasons (2014 and 2015), to study the response of two maize hybrids *i.e.,* white maize single cross 128 and yellow maize single cross 176 to four nitrogen fertilizer levels *i.e.* 0, 45, 90 and 135 kg N/fad., and three phosphorus fertilizer levels *i.e.* 0, 15.5 and 31 kg P_2O_5/fad. Concerning the obtained results, SC 128 outyielded SC 176 in grain and biological yields (combined data) due to superiority in days to 50% tassiling and silking, leaf chlorophyll content, ear leaf area, leaf area index, relative photosynthetic potential for stover yield/plant, ear length and diameter, stem diameter, number of grains/row, hundred grain weight as well as grain and stover yields/plant, while SC. 176 gave the highest mean for each of plant height and relative photosynthetic potential for grain yield/plant. No significant differences among maize hybrid could be detected in relative photosynthetic potential for biological yield/plant, number of rows/ear, ear leaf efficiency and migration coefficient. Data of combined analysis revealed that addition of nitrogen (N) fertilizer and raising its rate up to 135 kg N/fad., was accompanied by asignificant increase in each of leaf chlorophyll content (mg m^{-2}), plant height, leaf area index (LAI), ear length and diameter, stem diameter, number of rows/ear, number of grains/row, hundred grain weight, grain and stover yields/plant, ear leaf efficacy and migration coefficient, but relative photosynthetic potential for both stover and biological yields/plant were decreased. Increase of phosphorus (P) level up to 31 kg P_2O_5/fad., was followed by a significant increase in grain yield/fad., and almost all their attributes, but relative photosynthetic potential for both stover and biological yields/plant were decreased. Meantime, ear diameter responded to phosphorus addition up to 15.5 kg P_2O_5/fad., however, days to 50% tassling and silking were not significantly affected by varying phosphorus levels according to combined analysis. In almost cases, maize hybrid SC. 128 was more efficient and more responsive than SC. 176, where the former was is need to 135 kg N/fad., and 31 kg P_2O_5/fad., in order to maximize the grain yield to only 42.8 ardab/fad.

Key words: *Zea mays* L., hybrids, nitrogen fertilizer, phosphate fertilizer, agronomic characters; Egypt.

INTRODUCTION

Maize (*Zea mays* L.) is the world's widely grown highland cereal and primary staple food crop in many developing countries. It is the third most important staple food crop in both area and production after wheat and rice in Egypt. Total area under cultivation of maize in Egypt is 857329 hectare which is about 25.00% of the total cultivated agricultural land while average yield is 8.40 ton ha^{-1}. (FAOSTAT, 2015). The rapidly increasing demand of maize is driven by the increased demand for direct human consumption in the hills as a staple food crop (Ghimire *et al*., 2007). The Egyptian government aims to decrease the gap between consumption and production *via* increasing grain yield per unit area. There are several approaches

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to increase crop productivity, improving farming practices, employing merging technology, using new and high yielding maize hybrids which have more efficiently for using nitrogen and more response to high rate of nitrogenous fertilizer to create more grain.

The hybrid maize gave higher yields and using N and P more efficiently than the open pollinated one at both trial locations and hybrid varieties responding up to 200 kg N ha^{-1} (Kogbe and Adediran, 2003). Also, (El-Sheikh, 1998) reported that application of 160 kg N ha^{-1} significantly increased grain yield of maize. On the contrary, nitrogen deficiency decreased grain yield for all hybrids, especially the older hybrids. However, there were no significant differences regarding harvest index, leaf area or plant weight at flowering stage between the N-deficient and control plants of all hybrids. Dry matter production after flowering of the nitrogen deficient plants was, significantly, lower than that of the control plants in all hybrids, also, N deficiency accelerated senescence, *i.e.* decreased chlorophyll and protein contents, after anthesis more for the earlier released hybrids than for the later ones (Ding *et al*., 2005).

However, nitrogenous fertilizere is one of the most important factors for crop growth, high yield, yield components and grain quality. Where, nitrogen element plays an essential role in many compounds essential for plant growth, chlorophyll and many enzymes. It is considered the key element in increasing crops productivity, also, helps in the use of P, K and other elements in plants.

Additionally, (Bader and Othman, 2006) find out that increasing level of nitrogenous fertilization led to increase grain yield and its components. Increasing nitrogen fertilizer rate from zero up to 250 kg N ha^{-1}, significantly increased the studied maize growth, yield and yield components characters where maximum number of leaves/plant, number of cobs/plant, number of grains/cob, taller plants, grain and biological yields were recorded in ridge planting and application of 200 kg N ha^{-1} when compared with other treatments (Bakht *et al*., 2006). Considering soil fertility status and cropping system, the 150 kg N ha^{-1} application to maize variety Jalal in Peshawar was required for maximum biological and seed production (Akmal *et al*., 2010). Ears m^{-2}, grains/ear, 1000 grain weight, grain yield, biological yield and harvest index were higher at the highest level of nitrogen (Arif *et al.*, 2010).

Phosphorus plays a key role in energy transfer and is essential for photosynthesis and other chemo-physiological processes in plants. The different NP combinations significantly affected plant height, cob bearing plants, number of grains/cob, 1000-grain weight and grain yield, therefore the proper management of these two nutrient elements is very important for good crop production.

In this connection several research workers get significant response to phosphorus fertilization up to 35 kg P_2O_5 ha^{-1} (Diab *et al*., 1990; El-Far, 1996; Hegazy *et al*., 1996). However, other got higher response when they added 71 kg P_2O_5 ha^{-1} (Badawi and El-Moursy, 1997; Salem, 2000; Hussein, 2009; Amanullah and Khalil, 2010). Furthermore, (Masood *et al*., 2011) get more higher response when they added 100 kg P_2O_5 ha^{-1}. Yosefi *et al*. (2011) reported that application of 50 kg P ha^{-1} with 100 g bio-phosphate gave the highest yield in Iran.

In order to achieve maximum attainable yield from the existing corn varieties in a given environment, it is essential to improve crop fertilizer management practices. The present study objective to determine a suitable combination of nitrogen and phosphorus fertilizers for maximizing grain yield of maize under Egyptian conditions.

MATERIALS AND METHODS

The current investigation was carried out at the Experimental Farm, Gemmeiza Agriculture Research Station, Gharbiya Governorate, Agricultural Research Center (ARC), Egypt during 2014 and 2015 summer growing seasons.

The Studied Factors

Factors under the study included two maize hybrids (H) *i.e.* white single cross (S.C.) 128 and yellow single cross (SC) 176, four nitrogen (N) fertilizer levels which were 0, 45, 90 and 135 kg N/fad., as well as three phosphorus (P) levels *i.e.* 0, 15.5 and 31 kg P_2O_5/fad.

Cultural Practices

Each plot consisted of five ridges, each ridge was 6 m long, 80 cm in width, 25 cm between hills and one blank ridge was left between plots. The outer two ridges (1st and 5th) were considered as borders. The previous crop was wheat in both years. Planting was done on June 3rd in 2014 season, and June 9th in 2015 season. Ordinary super phosphate (15.5% P_2O_5), was applied before planting. Three grains were hand planted in each hill. Thinning to one plant per hill was done before the first irrigation. Hoeing twice was done for controlling weeds before the first and second irrigations. Nitrogen fertilizer in the form of urea (46.6% N), was applied in two equal doses before the first and the second irrigations, respectively. Recommended pest control was applied when necessary.

Experimental Design

A split-split plot design with four replications was conducted where maize hybrids were distributed in main plots, nitrogen fertilizer levels were allocated in sub-plots, while phosphorus fertilizer levels were kept in sub sub–plots according to Steel and Torrie (1980).

Soil Sampling and Analysis

Soil samples from the experimental locations were obtained from the upper 30 cm soil surface during land preparation in both 2014 and 2015 seasons. The soil had normal percentage of salinity and its drainage was naturally well. Both physical and chemical analyses of the soil were carried out by the methods described by Jackson (1958). Whereas N, P and K elements as well as some micronutrients were determined by applying the procedure documented by Lindsay and Norvell (1978). The soil of the experimental site was clay in texture where it had a particle size distribution of 21.98, 31.85 and 46.17% for sand, silt and clay, respectively. The soil had an average pH of 8.05. The average available N,P and K contents were 30.79, 6.01 and 121.0 ppm respectively (average of the two seasons).

Studied Characters

1. Days to 50 % tasseling.
2. Days to 50 % silking.
3. Chlorophyll content.

Five SPAD-503 readings were measured at 70 days after planting on ear-bearing leaves of five plants by the portable chlorophyll meter (SPAD-503, Minolta, Japan). Mean of five SPAD-503 readings were recorded. Chlorophyll content was determined as SPAD unit, these units were transformed to mg m^{-2} as described by Monje and Bugbee (1992) as follows: (Chlorophyll content = 80.05 + 10.4 [SPAD 503]).

4. Plant height (cm).
5. Ear height (cm).
6. Ear leaf area: It was measured as described by Mckee, 1964. ELA= $\text{Leaf}_{\text{Length}} \times \text{Leaf}_{\text{width}} \times 0.75$.
7. Leaf area index (LAI): It was measured as described by Watson (1952). LAI = leaf area/ plant/ land area (at 70 days after planting).
8. Relative photosynthetic potential for grain yield/ plant. = Grain yield (g./plant) / LAI.
9. Relative photosynthetic potential for stover yield/ plant. = Stover yield (g./plant) / LAI.
10. Relative photosynthetic potential for biological yield (g./plant). = [Grain yield (g./plant) + Stover yield (g./ plant)] / LAI.
11. Ear length (cm).
12. Ear diameter (cm).
13. Stem diameter (cm.).
14. Number of rows/ear.
15. Number of grains/row.
16. 100– grain weight (g).
17. Grain yield (g./plant).
18. Stover yield (g./plant).
19. Biological yield (g./plant).
20. Grain yield (ardab /fad.).
21. Biological yield (ton /fad.).
22. Ear leaf efficiency = Grain yield (g./plant) / Ear leaf area.
23. Migration coefficient = Ear dry weight at harvest / total plant dry weight at harvest.

Statistical Analysis

Data were statically analyzed according to Gomez and Gomez (1984), using the computer MSTAT-C statistical analysis package Freed *et al.* (1989). Treatment means were compared according to the LSD test. In the tables of the analysis of variance *,** indicate significant at 0.05 and 0.01 levels of probability, respectively as described by Waller and Duncan (1969).

RESULTS AND DISCUSSION

Days to 50% Tasseling, Days to 50% Silking and Chlorophyll Content

Maize hybrid differences

The results confirmed highly significant differences between the two maize hybrids concerning days to 50 % tasseling, days to 50% silking and chlorophyll content in both seasons and their consolidated data with the exception to the first season of chlorophyll content (Table 1). The results indicated clearly that the maize cultivar hybrid SC. 128 was always superior in each the aforementioned characters. This was completely true in both seasons and their combined analysis. The differences in these characters between the two maize hybrids might be attributed to the genetically variation. These results are in line with those reported by Mahgoub and El-Shenawy (2006), Attia *et al.* (2009) and Mukhtar *et al*. (2012).

Nitrogen level effect

It is quite clear from Table 1 that application of N fertilizer was without significant effect on days to 50% tasseling and days to 50% silking in the second season. But, in the first season and combined data, the differences had no clear trend for these characters. Regarding chlorophyll content, each increase of N level up to 135 kg N/fad., reflected significant increase in both seasons and their combined. These results suggest that nitrogen favored growth of maize plant. These results are in harmony with the findings of El-Murshedy (2002), El-Azab (2012), Darwich (2013) and El-Sobky (2014) as they found that maize reached tassling and silking later when well nitrogen fertilization took place compared with the low nitrogen fertilized ones.

Phosphorus level effect

Application of P fertilizer was without significant effect on both days to 50% tasseling and days to 50% silking in both seasons and their consolidated data. Regarding chlorophyll content, each increase of P level up to 31 kg P_2O_5/fad., reflected as significant increase in both seasons and their combined, but the first P increment was quite enough to increase the chlorophyll content significantly in the first season.

Interaction Effect

Although the days to 50% tassling was not significantly affected by P application, yet it had a significant affect to P through the N and P interaction (Table 1-b). In general, under checks or 31 kg P_2O_5/fad., the check of N fertilizer had higher days to 50% tasseling, but under 15.5 kg P_2O_5/fad., the four N levels had the same days to 50% tasseling. Under check of N and P fertilizer, days to 50% tasseling had the highest value (57.38 days). This was also observed in days to 50% silking. Therefor, the highest days to 50% silking (58.33 days) was recorded when N and P didn't added to maize plants.

Under checks or 15.5 kg P_2O_5/fad., any increment in N level up to 90 kg N/fad., was acompanied with significant increase in chlorophyll content while under 31 kg P_2O_5/fad., the high N level continued to increase significantly chlorophyll content up to 135 kg N/fad. Under any N level chlorophyll content significantly increased with P application of 31 kg P_2O_5/fad.

It is evident from Table 1-a that under N level of 90 kg N/fad., chlorophyll content of maize hybrid SC.128 was higher than that of SC.176 hybrids. Under the other N levels both maize hybrids SC.128 and SC. 176 had the same chlorophyll content.

Table 1. Days to 50% tasseling, days to 50% silking and Chlorophyll content (mg m^{-2}) of the two maize hybrids as affected by nitrogen, phosphorus fertilizer levels and their interactions in 2014, 2015 seasons and their combined data

Main effects and interactions	Days to 50% tasseling			Days to 50% silking			Chlorophyll content (mg m^{-2})		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Maize hybrid (H)									
SC 128	56. 96 a	57.19 a	57.07 a	58.21 a	57.98 a	58.09 a	570.03	605.66 a	587.84 a
SC 176	55.08 b	56.15 b	55.62 b	56.19 b	57.13 b	56.66 b	557.70	587.01 b	572.35 b
F. test	**	**	**	**	**	**	NS	**	**
Nitrogen level (kg N/fad) N									
0	56.46 a	57.17	56.81 a	57.58 a	58.08	57.83 a	434.08 d	469.21 d	451.64 d
45	56.29 a	56.54	56.42 a	57.58 a	57.46	57.52 a	559.18 c	587.54 c	573.36 c
90	55.58 b	56.25	55.92 b	56.71 b	57.08	56.90 b	622.15 b	647.81 b	634.98 b
135	55.75 b	56.71	56.23 ab	56.92 b	57.58	57.25 a	640.04 a	680.77 a	660.41 a
F. test	**	NS	**	**	NS	**	**	**	**
Phosphorus level (kg. P_2O_5/ fad.) P									
0	56.25	56.63	56.44	57.38	57.53	57.45	542.38 b	567.78 c	555.08 c
15.5	55.88	56.75	56.31	57.13	57.56	57.34	572.50 a	599.58 b	586.04 b
31	55.94	56.63	56.28	57.09	57.56	57.33	576.71 a	621.65 a	599.18 a
F. test	NS	NS	NS	NS	NS	NS	**	**	**
`Interactions									
H × N	*	NS	NS	*	NS	NS	*	*	**
H × P	NS	NS	NS	NS	NS	NS	**	NS	NS
N × P	**	NS	**	*	NS	*	**	*	**

*,** indicate significant at 0.05 and 0.01 levels of probability, respectively. NS = Not significant.

Table 1-a. Effect of interaction between maize hybrids and nitrogen fertilizer levels on chlorophyll content (mg m^{-2}) (combined)

Maize hybrid (H)	Chlorophyll (mg m^{-2}) N level (kg N/ fad.)			
	0	45	90	135
	C	B	A	A
SC 128	446.82 a	583.76 a	654.29 a	666.50 a
	D	C	B	A
SC 176	456.47 a	562.96 a	615.67 b	654.32 a

Table 1-b. Effect of interaction between nitrogen fertilizer levels and phosphorus fertilizer levels on days to 50% tasseling, days to 50% silking and chlorophyll content (mg m^{-2}) (combined)

N level (kg N/fad.)	Days to 50% tasseling			Days to 50% silking			Chlorophyll (mg m^{-2})		
	P level (kg P_2O_5/ fad.)								
	0	15.5	31	0	15.5	31	0	15.5	31
	A	B	AB	A	B	AB	C	B	A
0	57.38 a	56.20 a	56.83 a	58.33 a	57.44 a	57.75 a	426.17 c	453.14 c	475.62 d
	A	A	A	A	A	A	B	A	A
45	56.53 ab	56.38 a	56.33 ab	57.63 a	57.44 a	57.50 ab	531.77 b	601.78 b	586.55 c
	A	A	A	A	A	A	B	AB	A
90	55.88 b	56.19 a	55.69 b	56.83 b	57.19 a	56.69 b	622.54 a	633.67 a	648.74 b
	A	A	A	A	A	A	B	B	A
135	55.94 ab	56.44 a	56.33 ab	57.03 ab	57.31 a	57.38 ab	639.85 a	655.56 a	685.81 a

Plant and Ear heights and Ear Leaf Area

Maize hybrid differences

Table 2 shows plant and ear heights and ear leaf area of the two maize hybrids as affected by N and P fertilizer levels in the two seasons and their combined.

It is evident from Table 2 that plant height of the two maize hybrids under study significantly varied in the two seasons and their combined while ear height varied in the combined only. According to the combined of the two seasons, SC.176 had taller plants (246.5cm^2) with smaller ear leaf area (598.6 cm^2) than SC. 128 which had shorter plants (241.1 cm) with larger ear leaf area (668.9 cm^2).

Significant hybrid differences were reported in the literature regarding plant height and ear height by Khalil (2001) and Mowafy (2003) as well as Mahgoub and El-Shenawy (2006) and ear leaf area Oraby *et al.* (2005). These variation were attributed to differences in the genetic back ground of the studied hybrids.

Nitrogen level effect

Results in Table 2 reveal that increasing nitrogen levels significantly increased maize plant height in the two seasons and their combined analysis. Based on the combined, adding 45, 90 and 135 kg N/fad., increased plant height by 10.01, 14.70, 19.40%, respectively. Regarding both ear height and ear leaf area, they were significantly increased due to the addition of 90 kg N/fad. The increased of N levels from 90 to 135 kg/fad., failed to reflect significant increase in both characters.

The elongating effect of N is well crown and is documented in maize by Toaima and Saleh (2003), Abd-Alla (2005), Soliman and Gharib (2011), Darwich (2013), El-Sobky (2014), Olusegun (2015) and Seadh *et al.* (2015) reported significant increase in plant height and ear height of maize due to addition 90 and 140 kg N/fad., respectively. Similar results were reported regarding ear leaf area by Darwich (2013) and El-Sobky (2014) when they added 60 and 120 kg N/fad., respectively.

Phosphors level effect

It is evident from Table 2 that each P increment up to 31 kg P_2O_5/fad., produced significant increase in each of plant height, ear height and ear leaf area in both seasons and their combined. Based on the combined data, adding 15.5 and 31 kg P_2O_5/ fed., increased ear leaf area by 11.08 and 17.89%, receptively. These results are similar to those proved by Mukhtar *et al.* (2011), Khan *et al.* (2014) and Olusegun (2015).

Interaction effect

Generally, maize plant height exhibited more response to phosphorus fertilizer when N fertilizer was added by either 90 or 135 kg N/fad. Under check or 45 kg N/fad., plant height was only increased by 15.5 kg P_2O_5/ fad. While

Table 2. Plant height (cm), ear height (cm) and ear leaf area (cm^2) of the two maize hybrids as affected by nitrogen fertilizer levels, phosphorus fertilizer levels and their interactions in 2014, 2015 seasons and their combined data

Main effects and interactions	Plant height (cm)			Ear height (cm)			Ear leaf area		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Maize hybrid (H)									
SC 128	233.77b	248.51 b	241.14 b	117.83	131.29	124.56 b	658.41 a	679.47 a	668.94 a
SC 176	242.40a	250.69 a	246.54 a	125.35	133.26	129.31 a	596.54 b	600.65 b	598.59 b
F. test	**	**	**	NS	NS	**	**	**	**
Nitrogen level (kg N/fad.) N									
0	217.17d	221.98 d	219.58 d	112.54 b	119.28 c	115.91 c	486.52 c	491.07 c	488.79 c
45	235.92c	247.33 c	241.62 c	118.88 b	130.91 b	124.89 b	610.49 b	611.63 b	611.06 b
90	244.33b	259.33 b	251.83 b	126.50 a	140.03 a	133.27 a	699.64 a	716.30 a	707.97 a
135	254.90a	269.77 a	262.34 a	128.46 a	138.87 a	133.66 a	713.24 a	741.23 a	727.23 a
F. test	**	**	**	**	**	**	**	**	**
Phosphorus level (kg. P_2O_5/fad.) P									
0	226.56c	234.29 c	230.43 c	118.19 c	126.99 c	122.59 c	572.46 c	584.07 c	578.27 c
15.5	238.84b	251.45 b	245.15 b	121.00 b	131.64 b	126.32 b	634.57 b	650.31 b	642.44 b
31	248.84a	263.06 a	255.95 a	125.59 a	138.19 a	131.89 a	675.39 a	685.79 a	680.59 a
F. test	**	**	**		**	**	**	**	**
Interactions									
H × N	NS	**	*	NS	NS	**	*	NS	**
H × P	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × P	**	*	**	NS	*	**	NS	*	**

*,** indicate significant at 0.05 and 0.01 levels of probability, respectively. NS = Not significant.

under the two high levels of N (90 and 135 kg/fad.), plant height increased with increased P up to 31 kg P_2O_5/fad., (Table 2-b).

Under unfertilized plants with of P, ear height was slightly affected by N level up to application of 135 kg N/fad. However under both 15.5 and 31 kg P_2O_5/fad., that height increased by increasing N level up to 90 kg N/fad. Under 45 kg N/fad., there were no significant differences between the three P levels.

In general, maize ear leaf area reported more response to phosphors fertilizer when plants were fertilized by 135 kg N/fad., whereas under the other three N levels ear leaf area increased up to 15.5 kg P_2O_5/fad. Therefore, the largest ear leaf area (780.83) was recorded when maize was fertilized by 31 kg P_2O_5/fad., and 135 kg N/fad.

It is evident from Table 2-a that under fertilizing maize plant by either 45 or 90 kg N/fad., plant height of SC. 176 was higher than that of SC. 128 hybrids. In this respect it is noticed that plant height of SC. 128 maize variety responded to N more than maize variety SC. 176 as plant height value increased consistently with N in the first case but only increased till 45 kg N/fad., in SC. 176. Also ear leaf area of both SC. 128 and SC. 176 responded to N up to 90 kg N/fad., whereas SC. 128 had higher ear leaf area than SC. 176 under different nitrogen levels.

Table 2-a. Effect of interaction between maize hybrids and nitrogen fertilizer levels on plant height (cm), ear height (cm) and ear leaf area (combined)

Maize hybrid (H)	Plant height (cm)				Ear height (cm)				Ear leaf area			
	N level (kg N/ fad.)											
	0	45	90	135	0	45	90	135	0	45	90	135
	D	C	B	A	B	AB	AB	A	C	B	A	A
SC 128	221.95a	234.43b	246.91b	261.28a	114.34 a	121.41a	127.68 b	134.83 a	539.19 a	657.72 a	730.58 a	748.26 a
	C	AB	A	A	B	AB	A	AB	C	B	A	A
SC 176	217.20a	248.81a	256.75a	263.41 a	117.50 a	128.38a	138.86 a	132.49 a	438.40 b	564.40 b	685.36 b	706.21 b

Table 2-b. Effect of interaction between nitrogen fertilizer levels and phosphorus fertilizer levels on plant height (cm), ear height (cm) and ear leaf area (combined)

N level (kg N/fad.)	Plant height (cm)			Ear height (cm)			Ear leaf area		
	P level (kg P_2O_5/ fad.)								
	0	15.5	31	0	15.5	31	0	15.5	31
	B	A	A	B	B	A	B	A	A
0	210.78 b	220.14 c	227.81 d	109.91 b	115.38 b	122.45 b	407.13 c	512.98 c	546.27 c
	B	A	A	A	A	A	B	A	A
45	232.66 ab	242.79 b	249.41 c	124.68 a	122.38 b	127.63 b	577.28 b	609.21 b	646.69 b
	C	B	A	AB	B	A	B	A	A
90	238.23 a	251.35 b	265.91 b	131.18 a	131.05 a	137.58 a	663.92 a	711.43 a	748.56 a
	C	B	A	B	A	A	C	B	A
135	240.04 a	266.31 a	280.68 a	124.60 a	136.48 a	139.91 a	664.73 a	736.14 a	780.83 a

Maize photosynthetic attributes

Effects of nitrogen and phosphorus levels on each of leaf area index (LAI), relative photosynthetic for grain yield/plant, relative photosynthetic for stover yield/plant and relative photosynthetic for biological yield/plant of two maize hybrids are given in Table 3.

Maize hybrids differences

The results in Table 3 shows that the two maize hybrids under study significantly varied in each of LAI and relative photosynthetic potential for grain and stover yields/ plant as indicated from the combined analysis. Insignificant differences between the two maize hybrids on relative photosynthetic potential for biological yield/plant in the two seasons and their combined were detected. In the both seasons and their combined SC.128 had larger LAI and higher relative photosynthetic potential of stover yield/plant than SC.176 which had higher relative photosynthetic potential for grain yield/plant in combined analysis.

In the literature several author, reported significant cultivar differences in leaf area index and photosynthetic attributes such as Khalil (2001), El-Nagar (2002) and Atia (2006).

Table 3. Leaf area index (LAI), Relative photosynthetic potential for grain yield/ plant, stover yield/ plant and biological yield/ plant of the two maize hybrids as affected by nitrogen and phosphorus fertilizer levels and their interactions in 2014, 2015 seasons and their combined data

Main effects and interactions	Leaf area index (LAI)			Relative photosynthetic potential for Grain yield/ plant			Stover yield/ plant			Biological yield/ plant		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Maize hybrid (H)												
SC 128	4.30 a	4.52 a	4.41 a	31.61b	33.02	32.32b	73.41a	71.26a	72.34a	105.03	104.28	104.65
SC 176	3.64 b	3.81 b	3.72 b	34.08a	35.83	34.95a	70.12b	66.68b	68.40b	104.20	102.51	103.35
F. test	**	**	**	**	NS	**	*	**	**	NS	NS	NS
Nitrogen level (kg N/fad.) N												
0	1.93 d	2.08 d	2.00 d	32.82	32.90	32.86	104.65a	96.04a	100.35a	137.47a	128.94a	133.20a
45	3.77 c	4.05 c	3.91 c	32.68	34.05	33.36	68.06b	65.01b	66.53b	100.73b	99.05b	99.89 b
90	4.73 b	4.94 b	4.83 b	32.20	34.81	33.50	58.54c	58.87c	58.71c	90.74c	93.68bc	92.21 c
135	5.45 a	5.59 a	5.52 a	33.70	35.94	34.82	55.80c	55.98c	55.89d	89.50c	91.91c	90.71 c
F. test	**	**	**	NS	NS	NS	**	**	**	**	**	**
Phosphorus level (kg. P_2O_5/fad.) P												
0	3.48 c	3.55 c	3.52 c	27.43c	30.32c	28.87c	77.80a	78.17a	77.99a	105.22	108.49a	106.86a
15.5	4.09 b	4.26 b	4.17 b	33.29b	34.91b	34.10b	69.65b	65.15b	67.40b	102.95	100.07b	101.51b
31	4.35 a	4.69 a	4.52 a	37.82a	38.03a	37.93a	67.84b	63.59 b	65.72b	105.66	101.62b	103.64b
F. test	**	**	**	**	**	**	**	**	**	NS	*	*
Interactions												
H × N	**	**	**	*	*	**	*	**	**	**	**	**
H × P	**	**	**	**	**	**	NS	**	**	NS	**	**
N × P	**	**	**	**	*	**	**	NS	**	*	NS	NS

*,** indicate significant at 0.05 and 0.01 levels of probability, respectively. NS = Not significant.

Nitrogen level effect

The increase of N level up to 135 kg N/fad., was accompanied by a significant increase in leaf area index, the opposite was completely true for both relative photosynthetic potential for stover yield/ plant and relative photosynthetic potential for biological yield/ plant. But this addition of N fertilizer was without significant effect on relative photosynthetic potential for grain yield/plant as indicated from the two seasons and their combined (Table 3).

Again, the results of LAI (Table 3) concerning the effect of N fertilizer level are identical with those of plant height (Table 2). The increase in LAI due to application of nitrogen was obtained by Kandil (2013), El-Sobky (2014) and El-Kholy (2015).

Phosphors level effect

Results in Table 3 shows that increasing P level from zero to 15.5 and to 31 kg P_2O_5/fad., caused a gradually increase in both leaf area index and relative photosynthetic potential for grain yield/ plant, but photosynthetic potential for both stover and biological yields/ plant were decreased as indicated from the two seasons and their combined with exception the for first season of relative photosynthetic potential for biological yield/plant which was not affected by P level. According to the combined analysis first P increment (15.5 P_2O_5 kg/fad.), produced a significant increase of 18.46%, whereas the seconded P increment (31 P_2O_5 kg/fad.), gave an increase of 28.41% in LAI. Also relative photosynthetic potential for grain yield/plant produced asignificant increase of 18.11% due to the first P increment, whereas the second P increment gave an increase of 31.38% only. These results are in line with those reported by Plenet *et al*. (2000).

Interaction effect

The two maize hybrids *i.e.* SC. 128 and SC.176 had the same LAI when maize was grown without applying nitrogen. SC.128 hybrid had larger LAI compared with SC.176 under the different nitrogen levels. Both maize hybrids responded to nitrogen fertilizer up to 135 kg N/fad., Table 3-a.

Maize hybrids SC. 128 and SC. 176 had the same relative photosynthetic potential (RPP) for grain yield/plant when maize was grown either without applying nitrogen or under both 90 and 135 kg N/fad. While SC. 176 hybrid had higher relative photosynthetic potential for grain yield/ plant compared with SC. 128 under 45 kg N/fad.

Maize hybrid SC. 128 responded to phosphorus fertilizer up to 15.5 kg P_2O_5/fad., only, while SC. 176 hybrid responded up to 31 kg P_2O_5/fad. Maize hybrid SC. 128 had higher LAI under the different P fertilizer levels. Under the highest P level used (31 kg P_2O_5/fad.), both maize cultivars produced their highest photosynthetic potential for grain yield/plant. Also SC. 128 and SC. 176 had the same relative photosynthetic potential for grain yield/plant when maize was grow under without P fertilizer addition and under application of 31 kg P_2O_5/ fad., however SC. 176 had higher RPP for grain yield/ plant under 15.5 kg P_2O_5/fad. The opposite was true for relative photosynthetic potential for stover yield/plant whereas increasing P fertilizer decreased relative photosynthetic potential for stover/plant of the two hybrids. The two maize hybrids had the same relative photosynthetic potential for both stover and biological yields/plant under 15.5 and 31 kg P_2O_5/fad., but SC. 128 had the higher value when maize was grow under without addition P fertilizer while the same trend was observed in SC. 128 for relative photosynthetic potential biological yield/ plant, but P fertilizer appeared to have no effect on relative photosynthetic potential for biological yield/ plant for maize hybrid SC. 176.

It is evident from Table 3-c that each P increment was effective to increase significantly leaf area index under the two high N levels *i.e.* 90 and 135 kg N/fad., but under both without addition of N and addition 45 kg N/ fad., the second P increment failed to increase LAI while each N increment was effective to increase significantly LAI at the three P fertilizer levels.

In general, relative photosynthetic potential for grain yield/plant was affected by the two P fertilizer increments for both check and 135 kg N/fad., whereas under 45 kg N/fad., the second P increment failed to increase relative photosynthetic potential for grain, while under 90 kg N/fad., this character responded to P up to 31 kg P_2O_5/fad. Under plants unfertilized with P, relative photosynthetic potential for grain yield/plant was affected by N level up to 45 kg N/fad., however, under both 15.5 and 31 kg P_2O_5/fad., that relative photosynthetic potential did not affected by varying N levels. But relative photosynthetic potential for stover decreased by increasing N level up to 90 kg N/fad., under the three P levels. This was also true under both without addition of N and 45 kg N/fad., but, under both the two high N levels, that relative photosynthetic potential did not affected by varying P levels.

Ear Length and Diameter of Ear and Stem

The results of ear length, ear diameter and stem diameter of the two maize hybrids as affected by N and P levels are presented in Table 4.

Maize hybrid differences

In both seasons and their combined maize hybrid SC.128 had higher ear length and stem diameter than SC.176, the increase valued 12.76% and 28.64% for the same respective order. This was also observed in ear diameter in combined data, but the difference did not reach the level of significance in the two seasons. Cultivar differences were reported by others in the literature such as Mohamed (2004), Abdou *et al.* (2012), Golezani and Tajbakhsh (2012) and Mukhtar *et al*. (2012).

Table 3-a. Effect of interaction between maize hybrids and nitrogen fertilizer levels on leaf area index (LAI), relative photosynthetic potential for grain yield/ plant, stover yield/ plant and biological yield/ plant (combined)

Maize hybrid (H)	Leaf area index (LAI)				Relative photosynthetic potential for Grain yield/ plant				Stover yield/ plant				Biological yield/ plant			
	N level (kg N/ fad.)															
	0	45	90	135	0	45	90	135	0	45	90	135	0	45	90	135
SC 128	D	C	B	A	AB	B	AB	A	A	B	B	B	A	B	B	B
	2.03a	4.54a	5.13a	5.95a	32.576a	29.97b	32.93a	33.79a	106.30a	62.56b	61.38a	59.11a	138.86a	92.53b	94.30a	92.90 a
SC 176	D	C	B	A	B	A	AB	AB	A	B	C	C	A	B	C	C
	1.98a	3.28b	4.54b	5.10b	33.136a	36.75a	34.08a	35.85a	94.39b	70.51 a	56.03a	52.67a	127.53b	107.26a	90.11a	88.51a

Table 3-b. Effect of interaction between maize hybrids and phosphorus fertilizer levels on leaf area index (LAI), relative photosynthetic potential for grain yield/ plant, stover yield/ plant and biological yield/ plant (combined)

Maize hybrid (H)	Leaf area index (LAI)			Relative photosynthetic potential for Grain yield/ plant			Stover yield/ plant			Biological yield/ plant		
	P level (kg P_2O_5/ fad.)											
	0	15.5	31	0	15.5	31	0	15.5	31	0	15.5	31
SC 128	B	A	A	B	B	A	A	B	B	A	B	B
	3.70a	4.68a	4.85a	29.33a	30.85b	36.76a	82.74a	67.27 a	66.97 a	112.0 a	98.14a	103.75 a
SC 176	C	B	A	B	B	A	A	B	B	A	A	A
	3.33b	3.66b	4.18b	28.42a	37.36a	39.09a	73.23 b	67.52 a	64.45 a	101.64b	104.88a	103.54 a

Table 3-c. Effect of interaction between nitrogen fertilizer levels and phosphorus fertilizer levels on leaf area index (LAI), relative photosynthetic potential for grain yield/ plant and stover yield/ plant (combined)

N level (kg N/fad.)	Leaf area index (LAI)			Relative photosynthetic potential for Grain yield/ plant			Stover yield/ plant		
	P level (kg P_2O_5/ fad.)								
	0	15.5	31	0	15.5	31	0	15.5	31
	B	A	A	C	B	A	A	B	B
0	1.55 d	2.21 d	2.25 d	23.43 b	35.06 a	40.07 a	116.82 a	92.80 a	91.41 a
	B	A	A	B	A	A	A	AB	B
45	3.51 c	4.07 c	4.14 c	30.56 a	34.72 a	34.81 b	72.91 b	65.50 b	61.18 b
	C	B	A	B	B	A	A	A	A
90	4.26 b	4.97 b	5.27 b	31.70 a	31.91 a	36.90 a	62.46 c	56.24 c	57.42 bc
	C	B	A	C	B	A	A	A	A
135	4.74 a	5.43 a	6.40 a	29.80 a	34.72 a	39.92 a	59.75 c	55.07 c	52.85 c

Table 4. Ear length (cm), ear diameter (cm) and stem diameter (cm) of the two maize hybrids as affected by nitrogen fertilizer levels, phosphorus fertilizer levels and their interactions in 2014, 2015 seasons and their combined data

Main effects and interactions	Ear length (cm)			Ear diameter (cm)			Stem diameter (cm)		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Maize hybrid (H)									
SC 128	20.19 a	23.20 a	21.69 a	4.35	4.56	4.46 a	2.13 a	2.99 a	2.56 a
SC 176	18.31 b	20.10 b	19.20 b	4.18	4.45	4.31 b	1.91 b	2.07 b	1.99 b
F. test	**	**	**	NS	NS	*	**	**	**
Nitrogen level (kg N/fad.) N									
0	15.90 d	16.30 d	16.10 d	3.44 c	3.91 b	3.68 d	1.33 d	1.79 b	1.56 c
45	19.04 c	21.68 c	20.36 c	4.10 b	4.48 a	4.29 c	2.16 c	2.71 a	2.43 b
90	20.22 b	22.93 b	21.58 b	4.60 a	4.75 a	4.67 b	2.23 b	2.75 a	2.49 b
135	21.84 a	25.68 a	23.76 a	4.92 a	4.88 a	4.90 a	2.34 a	2.87 a	2.61 a
F. test	**	**	**	**	**	**	**	**	**
Phosphorus level (kg. P_2O_5/fad.) P									
0	18.30 c	19.96 c	19.13 c	4.02 b	4.39 b	4.21 b	1.80 c	2.29 c	2.04 c
15.5	19.13 b	21.53 b	20.33 b	4.35 a	4.51 a	4.43 a	2.02 b	2.56 b	2.29 b
31	20.31 a	23.46 a	21.88 a	4.42 a	4.61 a	4.52 a	2.23 a	2.74 a	2.49 a
F. test	**	**	**	**	*	**	**	**	**
Interactions									
H × N	**	NS	**	NS	NS	NS	NS	NS	**
H × P	NS	NS	NS	**	NS	NS	**	**	**
N × P	NS	**	**	NS	**	**	**	*	**

*,** indicate significant at 0.05 and 0.01 levels of probability, respectively. NS = Not significant.

Nitrogen level effect

The results in Table 4 shows that applying N fertilizer up to 135 kg N/fad., reflected significant effects on maize ear length, ear diameter and stem diameter according to the combined analysis, but 45 kg N/fad., was quite enough to produce the highest averages of ear diameter and stem diameter in the second season. Based on the combined data, adding 45, 90 and 135 kg N/ fad., increased ear length by 26.45, 34.04 and 47.58% and ear diameter increased by 16.57, 26.90 and 33.15%, respectively. These results are in accordance with Vania *et al.* (2010), Soliman and Gharib (2011), El-Moursy (2013), Seadh *et al.* (2015) and Matusso and Materusse (2016).

Phosphors level effect

Results in Table 4 shows that increasing P level from zero to 15.5 and up to31 kg P_2O_5/fad., caused significant increase in ear length and stem diameter. However addition of the first P increment (15.5 kg P_2O_5/fad.), reflected significant increase in ear diameter, whereas the second P increment failed to add further significant increase. This trend was true in both seasons and their combined. Basing on the combined data, increasing P levels up to 15.5 and 31 kg P_2O_5/fad., increased ear length by 6.27 and 14.38% and stem diameter by 12.25 and 22.06%, respectively compared with the control. These results were in agreement with those of Olusegun (2015).

Interaction effect

In general, each N increment was effective to increase significantly ear length for SC. 128 hybrids, however the second N increment failed to increase ear length of maize hybrid SC 176. Maize hybrids SC. 128 had the higher ear length under the different N level. This was observed also in stem diameter, but maize stem diameter of SC. 128 responded up to 135 kg N/fad., while stem diameter of SC. 176 responded only to 90 kg N/fad. (Table 4-a).

It is evident from Table 4-b that each P increment was effective to increase significantly stem diameter of SC. 176, but stem diameter of SC. 128 responded to 15.5 kg P_2O_5/fad., only while the second P increment failed to increase that diameter.

Generally, maize ear length was responded to phosphors fertilizer more when plants were fertilized by 45 kg N/fad. But at both without addition of N and 90 kg N/fad., ear length was only increased under P level of 15.5 kg P_2O_5/fad., when maize was fertilized by 135 kg N/fad., the results indicated that ear length consistently increased due to any P fertilizer increase. Under the P levels, ear length was affected by N fertilizer up to 90 kg N/fad., further increase in N *i.e.* 135 did not effect ear length (Table 4-b).

Ear diameter of maize was affected by the second increment of P under N level of 135 kg/ fad., whereas under control and 90 kg N/fad., this increment failed to increase ear diameter. Under unfertilized plants with P or adding 15.5 kg P_2O_5/fad., ear diameter was affected by N levels up to 45 kg N/fad., when maize fertilized by 31 kg P_2O_5/fad., that diameter responded only to 90 kg N/fad.

The results indicated that in general, for the two low N levels *i.e.* checks and 45 kg N/fad., any increase in phosphorus was followed by a significant increase in stem diameter while under 90 kg N/fad., stem diameter significantly increased by P application up to 15.5 kg P_2O_5/fad., but under 135 kg N/ fad., the response observed was with 31 kg P_2O_5/fad. Under either without additional P or adding 31 kg P_2O_5/fad., stem diameter significantly increased by N application up to 135 kg N/fad., while under 15.5 kg P_2O_5/fad., that diameter responsed up to 45 kg N/fad.

Number of Rows/Ear, Number of Grains/ Row and Hundred Grain Weight

Table 5 shows number of rows/ear and number of grains/row as well as hundred grain weight of two maize hybrids as affected by N and P levels in the two seasons and their combined.

Maize hybrid differences

It is seen in Table 5 that the two maize hybrids varied significantly regarding each of number of grains/row and hundred grain weight while number of rows/ear was insignificantly affected. SC. 128 had more number of grains/ row (44.42) than SC. 176 (40.07) and also gave heavier hundred grain weight (37.89) than SC. 176 (33.76). The two hybrids had almost similar number of rows/ear. This was true in the two seasons and was ascertained by the combined analysis.

Significant hybrid differences were reported in the literature regarding number of grains/row Attia *et al.* (2009), Sharifi *et al*. (2009), Mukhtar *et al*. (2012) and Hejazi and Soleymani (2014). and hundred grain weight Attia *et al.* (2009), Abdou *et al.* (2012), Modhej *et al*. (2014) and Sorkhi and Fateh (2014).

Nitrogen level effect

Each N increment up to the highest N level under study (135 kg N/fad.), was accompanied by a significant increase in each of number of rows/row, number of grains/row and hundred grain weight in the two seasons and their combined with the exception of the second season of number of rows/ear (Table 5) Based on the combined data adding 45, 90 and 135 kg N/fad., increased number of grains/row by 22.13, 36.27 and 46.46% and hundred grain weight by 32.15, 39.32 and 47.43%, respectively.

Similar increases were observed in chlorophyll content (Table 1), plant height (Table 2) and LAI (Table 3). These results clearly indicated that the increase of ear diameter due to the increase of N levels was significantly effected on number of rows/ear and these N increments increased each of ear length (Table 4) which resulted in a significant increase in the number of grains/row and finally the number of grains/ear. These results followed the same patterns of the most yield attributes former discussed indicating the promotion effect of N on vegetative growth which inturn favored metabolic processes and increased growth and yield attributes, of corn. In the literature, several authors found that addition of N was effective to increase each of number of rows/ear and number

Table 4-a. Effect of interaction between maize hybrids and nitrogen fertilizer levels on ear length (cm) and stem diameter (cm) (combined)

Maize hybrid (H)	Ear length (cm)				Stem diameter (cm)			
	N level (kg N/ fad.)							
	0	45	90	135	0	45	90	135
	D	C	B	A	C	B	B	A
SC 128	16.82 a	21.47 a	22.93 a	25.55 a	1.79 a	2.77 a	2.76 a	2.91 a
	C	B	B	A	C	B	AB	A
SC 176	15.38 b	19.24 b	20.23 b	21.96 b	1.33 b	2.09 b	2.22 b	2.30 b

Table 4-b. Effect of interaction between maize hybrids and phosphorus fertilizer levels on stem diameter (cm) (combined)

Maize hybrid (H)	Stem diameter (cm)		
	P level (kg P_2O_5/ fad.)		
	0	15.5	31
	B	**A**	**A**
SC 128	**2.29 a**	**2.64 a**	**2.74 a**
	C	**B**	**A**
SC 176	**1.80 b**	**1.93 b**	**2.23 b**

Table 4-c. Effect of interaction between nitrogen fertilizer levels and phosphorus fertilizer levels on ear length (cm) , ear diameter (cm) and stem diameter (cm) (combined)

N level (kg N/fad.)	Ear length (cm)			Ear diameter (cm)			Stem diameter (cm)		
	P level (kg P_2O_5/ fad.)								
	0	15.5	31	0	15.5	31	0	15.5	31
	B	A	A	A	A	A	C	B	A
0	19.41 b	20.08 b	21.07 b	3.53 b	3.82 b	3.68 c	1.20 c	1.59 b	1.89 c
	B	B	A	A	A	B	C	B	A
45	17.19 c	18.18 c	19.56 c	4.37 a	4.36 a	4.13 b	2.23 b	2.46 a	2.62 b
	B	A	A	B	A	A	B	A	A
90	21.56 a	23.35 a	24.68 a	4.27 ab	4.79 a	4.96 a	2.30 b	2.56 a	2.60 b
	C	B	A	B	B	A	B	B	A
135	18.35 b	19.71 b	22.24 b	4.66 a	4.76 a	5.29 a	2.45 a	2.538 a	2.83 a

Table 5. Number of rows/ear, number of grains/row and 100-grain weight (g) of the two maize hybrids as affected by nitrogen fertilizer levels, phosphorus fertilizer levels and their interactions in 2014, 2015 seasons and their combined data.

Main effects and interactions	Number of rows/ear			Number of grains/row			100-grain weight (g)		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Maize Hybrid (H)									
SC 128	15.26	14.95	15.11	43.10 a	45.73 a	44.42 a	37.02 a	38.77 a	37.89 a
SC 176	14.85	15.00	14.92	38.64 b	41.50 b	40.07 b	32.77 b	34.76 b	33.76 b
F. test	NS	NS	NS	**	**	**	**	**	**
Nitrogen level (kg N/fad.) N									
0	13.46 d	14.10 b	13.78 d	32.97 d	33.96 d	33.47 d	28.26 d	26.98 d	27.62 d
45	14.42 c	14.67ab	14.54 c	39.06 c	42.71 c	40.88 c	35.12 c	37.88 c	36.50 c
90	15.59 b	15.22 a	15.41 b	43.68 b	47.54 b	45.61 b	36.99 b	39.97 b	38.48 b
135	16.74 a	15.92 a	16.33 a	47.78 a	50.26 a	49.02 a	39.21 a	42.23 a	40.72 a
F. test	**	*	**	**	**	**	**	**	**
Phosphorus level (kg. P_2O_5/fad.) P									
0	14.41 c	14.68 b	14.54 c	38.63 c	41.38 c	40.00 c	32.93 c	34.00 c	33.46 c
15.5	15.06 b	14.82 b	14.94 b	40.46 b	43.09 b	41.77 b	35.23 b	37.10 b	36.16 b
31	15.69 a	15.43 a	15.56 a	43.53 a	46.38 a	44.95 a	36.53 a	39.19 a	37.86 a
F. test	**	*	**	**	**	**	**	**	**
Interactions									
H × N	NS	NS	*	**	**	**	**	**	**
H × P	*	*	**	NS	NS	NS	NS	NS	NS
N × P	NS	NS	**	**	**	**	**	**	**

*,** indicate significant at 0.05 and 0.01 levels of probability, respectively. NS = Not significant.

of grains/row and hundred grain weight such as Sharifi and Taghizadeh (2009), Kandil (2013), Seadh *et al*. (2015) and Matusso and Materusse (2016).

Phosphors level effect

It is evident from Table 5 that each P increment up to 31 kg P_2O_5/fad., produced significant increase in each of row number/ear, grain number/row and hundred grain weight in both seasons and their combined. Also, the addition of 31 kg P_2O_5/fad., was followed by a significant increase in row number/ear, but the first P increment failed to add a significant increase in this number in the first season. Basing on the combined data, increasing P level up to 31 kg P_2O_5/fad., increased row number/ear by 2.75 and 7.02% and grain number/row by 4.42 and 12.38% as well as hundred grain weight by 8.07 and 13.15%, respectively compared with the control. Similar results were reported by Khan *et al*. (2005), Ahmad *et al*. (2007) and Mukhtar *et al.* (2011).

Interaction effect

The two maize hybrids used had the same number of rows/ear under each of check, 45 and 135 kg N/fad. It seemed that SC. 128 hybrid had higher No. of rows/ear than SC. 176 when 90 kg N/fad., was applied. Regarding to SC. 128, any increase in nitrogen fertilizer up to 90 kg N/fad., caused a significant increase in number of rows/ ear, (Table 5-a).

It seemed that SC. 128 hybrid always had higher number of grains/row and hundred grain weight than SC. 176 hybrid under the different N level. For the two maize hybrids used, any increase in nitrogen fertilizer caused a significant increase in both number of grains/ row and hundred grain weight (Table 5-a).

The maize hybrids used had the same number of rows/ear under the check P treatment. It seemed that SC. 128 hybrid always had higher number of rows/ear than SC. 176 when either 15.5 or 31 kg P_2O_5/fad., was applied. For SC. 128 hybrid any increase in phosphors fertilizer caused a significant increase in number of rows/ ear, however, this was always observed for the second P increment in SC. 176 case Table (5-b).

Under growing maize without applying P fertilizer or 15.5 kg P_2O_5/fad., the number of rows/ear responded to nitrogen fertilizer up to 135 kg N/fad.. In general, number of rows/ear was affected by the first and second P increment under both 90 and 135 kg N/fad., but it only increased due to applying 90 kg N/fad., under 31 kg P_2O_5/fad. Thus, under 45 kg N/fad., there was no significant different between the three P levels, where the first P increment increased that number only when maize unfertilized by nitrogen.

Under any phosphorus treatment, increasing nitrogen fertilizer from check to 45 or from 45 to 90 or from 90 to 135 was accompanied with significant increase in number of grains/row. In general, number of grains/row was affected by the first and second P increment for the different N levels. Also the same trend was observed in hundred grain weight, but under 45 kg N/fad., that weight was affected only by the first P increment (Table 5-c).

Grain, Stover and Biological Yields/Plant

Table 6 shows grain, stover and biological yields/plant of the two maize hybrids as affected by N and P levels and their interaction in both seasons and their combined.

Maize hybrid differences

Single cross 128 maize hybrid surpassed noticeably SC. 176 one for grain and stover as well as biological yields/plant, since the former had 9.10, 23.26 and 18.15% more yields than the latter and this was clearly valid in both growing seasons and across their pooled data (Table 6). The increase in grain yield/plant of SC. 128 could be attributed to larger number of grains/row and greater weight of hundred grains if compared with the other tested SC. 176. Cultivar and hybrids differences in yield/plant were reported by other investigators of than Ghanem *et al.* (2006), Sharifi *et al*. (2009), Abdou *et al.* (2012), Golezani and Tajbakhsh (2012), Kandil (2013) and Modhej *et al.* (2014).

Nitrogen level effect

Each N increment produced a significant increase in each of grain yield/plant, stover yield/ plant and biological yield/plant. This was valid in the two seasons and their combined. According to the combined analysis, the percentage increase due to addition of 135 kg N/fad., were 186.6, 57.25 and 90.52% for grain yield/plant, stover yield/plant and biological yield/plant. Similar effects were observed in plant height (Table 2), ear length and diameter (Table 4), row number/ear and grain number/ row as well as hundred grain weight (Table 5). It is worthy noticed that, N added to maize plants enhanced photosynthesis and photosynthetic partitioning to the grains as a results of raising enzymatic activity and other biological processes inside maize plant. These results are in accordance with those given by Azeez *et al.* (2006), El-Moursy (2013), Hejazi and Soleymani (2014), Seadh *et al.* (2015) and Matusso and Materusse (2016).

Phosphors level effect

Results in Table 6 shows that increasing P levels from zero to 15.5 and 31 kg P_2O_5/fad., caused significant increase in grain yield/plant and stover yield/plant as well as biological yield/ plant. This trend was true in both seasons and their combined. Basing on the combined data increasing P levels up to 15.5 and 31 kg P_2O_5/ fad., increased grain yield/plant by 33.09 and 63.22% and stover yield/plant by 6.23 and 11.63% as well as biological yield by 14.24 and 27.03%, respectively compared with the control. These results are in consistent with those reported on other yield attributes namely plant height, ear leaf area, leaf area index, relative photosynthetic potential for grain, ear length, number of rows/ear, number of grains/ row and hundred grain weight (Tables 2 , 3 , 4 and 5).

Table 5-a. Effect of interaction between maize hybrids and nitrogen fertilizer levels on number of rows/ear, number of grains/ row and 100-grain weight (g) (combined)

Maize hybrid (H)	Number of rows/ ear				Number of grains/row				100-grain weight (g)			
	N level (kg N/fad.)											
	0	45	90	135	0	45	90	135	0	45	90	135
	C	B	A	A	D	C	B	A	D	C	B	A
SC 128	13.66a	14.55a	15.82a	16.39a	35.71a	44.27a	47.66a	50.03a	28.29a	38.85a	41.37a	43.07a
	B	B	B	A	D	C	B	A	D	C	B	A
SC 176	13.90a	14.54a	14.99b	16.26a	31.22b	37.50b	43.56b	48.01b	26.95b	34.14b	35.59b	38.37b

Table 5-b. Effect of interaction between maize hybrids and phosphorus fertilization levels on number of rows/ear (combined)

Maize hybrid (H)	Number of rows/ ear		
	P level (kg P_2O_5/ fad.)		
	0	15.5	31
	C	B	A
SC 128	14.40 a	15.07 a	15.85 a
	B	B	A
SC 176	14.69 a	14.81 b	15.28 b

Table 5-c. Effect of interaction between nitrogen fertilizer levels and phosphorus fertilizer levels on number of rows/ear, number of grains/row and 100-grain weight (g) (combined)

N level (kg N/fad.)	Number of rows/ ear			Number of grains/row			100 – grain weight (g)		
	P level (kg P_2O_5/fad.)								
	0	15.5	31	0	15.5	31	0	15.5	31
	B	AB	A	C	B	A	C	B	A
0	13.42 c	13.72 c	14.22 b	31.81 d	33.52 d	35.07 d	22.56 d	28.61 d	31.69 d
	A	A	A	C	B	A	B	A	A
45	14.37 b	14.45 c	14.83 b	38.41 c	41.28 c	42.97 c	35.18 c	36.83 c	37.48 c
	C	B	A	C	B	A	C	B	A
90	14.50 b	15.41 b	16.31 a	42.45 b	43.78 b	50.59 b	37.32 b	38.29 b	39.83 b
	C	B	A	C	B	A	C	B	A
135	15.90 a	16.18 a	16.90 a	47.35 a	48.52 a	51.188 a	38.78 a	40.93 a	42.44 a

Table 6. Grain yield (g./plant), stover yield (g./plant) and biological yield (g./plant) of the two maize hybrids as affected by nitrogen, phosphorus fertilizer levels and their interactions in 2014, 2015 seasons and their combined data

Main effects and interactions	Grain yield (g./plant)			Stover yield (g./plant)			Biological yield (g./plant)		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Maize hybrid (H)									
SC 128	136.21a	151.08a	143.65a	285.25a	288.16a	286.70a	421.46a	439.24a	430.35a
SC 176	125.08b	138.24b	131.66b	229.09b	236.10b	232.59b	354.17b	374.33b	364.25b
F. test	**	**	**	**	**	**	**	**	**
Nitrogen level (kg N/fad.) N									
0	65.97d	69.69d	67.45d	197.88d	191.94d	194.91d	263.08d	261.63d	262.36d
45	120.65c	135.66c	128.16c	251.69c	257.60c	254.64c	372.34c	393.26c	382.80c
90	151.49b	171.78b	161.63b	275.40b	289.70b	282.55b	426.88b	461.48b	444.18b
135	185.24a	201.50a	193.37a	303.71a	309.28a	306.50a	488.95a	510.78a	499.87a
F. test	**	**	**	**	**	**	**	**	**
Phosphorus level (kg. P_2O_5/fad.) P									
0	98.59c	109.80c	104.20c	239.20c	250.91c	245.06c	337.79c	360.71c	349.25c
15.5	130.23b	147.12b	138.68b	261.22b	259.42b	260.32b	391.45b	406.54b	398.99b
31	163.11a	177.06a	170.08a	271.09a	276.06a	273.57a	434.20a	453.11a	443.66a
F. test	**	**	**	**	**	**	**	**	**
Interactions									
H × N	*	*	**	**	**	**	**	**	**
H × P	**	NS	**	NS	NS	NS	NS	NS	NS
N × P	**	**	**	**	**	**	**	**	**

In this regard Khan *et al*. (2005), Hussein (2009) and Popoola *et al*. (2015) obtained similar results.

Interaction effect

In general, each N increment was effective to increase both grain and biological yields/plant for the two maize hybrids *i.e.* SC. 128 and SC.176. It seemed that SC. 128 hybrid always had higher yield/plant than SC.176 under the different N levels, but the maize hybrids had the same grain yield under check N treatment.

For SC. 176 hybrid the second N increment failed to increase stover yield/plant, but any N increment increased stover yields/plant for SC. 128. In general SC. 128 hybrid always had higher stover and biological yields/plant than SC. 176 under the different N levels (Table 6-a). It is evident from Table 6-b that each P increment was effective to increase grain yield/plant of the two maize hybrids *i.e.* SC. 128 and SC. 176 significantly. SC. 128 hybrid had the higher grain yield/plant under both check P and 31 kg P_2O_5/fad., but both SC. 128 and SC. 176 had the same grain yield/plant under 15.5 kg P_2O_5/fad.

It is evident from Table 6-c that each N increment produced a significant increase in the grain yield/plant under the two high levels of phosphorus *i.e.* 15.5 and 31 kg P_2O_5/fad. Where, no further significant increase could be obtained due to the increase of N level beyond 90 kg N/fad., under the check P treatment. Also grain yield/plant was affected by the first and second P increment for each of unfertilized by N, 90 and 135 kg N/fad. But no further significant could be obtained due to the increase of P level beyond 15.5 kg P_2O_5/fad., under the 45 kg N/fad., treatment.

Table 6-a. Effect of interaction between maize hybrids and nitrogen fertilizer levels on grain yield (g/plant), stover yield (g/plant) and biological yield (g/plant) (combined)

Maize hybrid (H)	Grain yield (g/plant)				Stover yield (g/plant)				Biological yield (g/plant)			
	N level (kg N/fad.)											
	0	45	90	135	0	45	90	135	0	45	90	135
	D	C	B	A	D	C	B	A	D	C	B	A
SC 128	66.85a	135.89a	169.21a	202.63a	207.44a	279.02a	313.54a	346.82a	274.29a	414.91a	482.75a	549.44a
	D	C	B	A	C	B	A	A	D	C	B	A
SC 176	68.04a	120.42b	154.05b	184.11b	182.38b	230.27b	251.58b	266.18b	250.42b	350.69b	405.61b	450.29b

Table 6-b. Effect of interaction between maize hybrids and phosphorus fertilizer levels on grain yield (g/plant) (combined)

Maize hybrid (H)	Grain yield (g/plant)		
	P level (kg P_2O_5/ fad.)		
	0	15.5	31
	C	B	A
SC 128	111.27 a	141.30 a	178.37 a
	C	B	A
SC 176	97.12 b	136.05 a	161.79 b

Under growing maize without applying P fertilizer or 31 kg P_2O_5/fad., stover yield/plant responded to nitrogen fertilizer up to 135 kg N/fad., but only increased till 90 kg/fad., under 15.5 kg P_2O_5/fad.. In general, each P increment produced a significant increase in stover yield/ plant under the check N fertilizer, whereas, no further significant increase could be obtained due to the increase of P level beyond 15.5 kg P_2O_5/fad., at both 90 and 135 kg N/fad.. But at 45 kg N/fad., the stover yield did not affected by various P levels, each N increment produced a significant increase in the biological/plant. Also biological yield/plant was affected by the first and second P increment under both 90 and 135 kg/fad., whereas the last P increment failed to add a significant increase under both check N and 45 kg N/fad.

Grain and Biological Yields/fad.

Grain and biological yields/fad., as affected by the different N and P levels and their interactions in the two seasons and their combined is given in Table 7 for two maize hybrids.

Maize hybrid differences

The two maize hybrids exerted significant variation in both grain and biological yields/fad., where SC. 128 had greater grain and biological yields than the other corresponding SC. 176 one. This inclination was fairly virtual in both growing seasons and affirmed when their data were statistically combined. Basing on the combined data, the grain and biological yields obtained from SC. 128 was about 10.19 and 27.83% greater than the other tested SC. 176, respectively. The hybrid differences in such trait could be explained by the fact that the photosynthetic translocate from the source to the sink were great enough to fill all the grains of SC. 128 hybrid or to increase the final grain yield/ fad., relative to SC. 176 one. On the other

Table 6-c. Effect of interaction between nitrogen fertilizer levels and phosphorus fertilizer levels on grain yield (g/plant), stover yield (g/plant) and biological yield (g/plant) (combined)

N level (kg N/fad.)	Grain yield (g/plant)			Stover yield (g/plant)			Biological yield (g/plant)		
	P level (kg P_2O_5/ fad.)								
	0	15.5	31	0	15.5	31	0	15.5	31
	C	B	A	C	B	A	B	A	A
0	35.10 c	77.31 d	89.94 d	175.11 c	204.45 c	205.17 d	210.20 d	281.76 d	295.11 d
	B	A	A	A	A	A	B	A	A
45	105.86 b	136.95 c	141.66 c	256.13 b	259.99 b	247.81 c	361.99 c	396.93 c	389.47 c
	C	B	A	B	B	A	C	B	A
90	134.87 a	156.59 b	193.44 b	266.12 b	279.38 a	302.14 b	400.99 b	435.96 b	495.59 b
	C	B	A	B	B	A	C	B	A
135	140.96 a	183.86 a	255.30 a	282.87 a	297.46 a	339.16 a	423.82 a	481.32 a	594.45 a

Table 7. Grain yield (ardab/fad.) and biological (ton /fad.) of the two maize hybrids as affected by nitrogen fertilizer levels, phosphorus fertilizer levels and their interactions in 2014, 2015 seasons and their combined data

Main effects and interactions	Grain yield (ardab /fad.)			Biological (ton /fad.)		
	2014	2015	Comb.	2014	2015	Comb.
Maize hybrid (H)						
SC 128	27.17 a	30.99 a	29.08 a	7.00 a	8.79 a	7.90 a
SC 176	25.48 b	27.30 b	26.39 b	6.35 b	6.00 b	6.18 b
F. test	*	**	**	**	**	**
Nitrogen level (kg N/fad.) N						
0	16.99 d	17.54 d	17.27 d	4.25 d	4.39 d	4.32 d
45	24.70 c	28.26 c	26.48 c	6.36 c	7.13 c	6.74 c
90	30.30 b	33.52 b	31.91 b	7.66 b	8.43 b	8.04 b
135	33.31 a	37.25 a	35.28 a	8.44 a	9.64 a	9.04 a
F. test	**	**	**	**	**	**
Phosphorus level (kg. P_2O_5/fad.) P						
0	21.42 c	23.58 c	22.50 c	5.69 c	6.20 c	5.94 c
15.5	26.45 b	29.52 b	27.99 b	6.71 b	7.46 b	7.08 b
31	31.11 a	34.33 a	32.72 a	7.64 a	8.53 a	8.09 a
F. test	**	**	**	**	**	**
Interactions						
H × N	NS	**	**	*	**	**
H × P	NS	**	**	NS	NS	NS
N × P	**	**	**	**	**	**

*,** indicate significant at 0.05 and 0.01 levels of probability, respectively. NS = Not significant.

meaning, the growth and yield parameters behavior found between the two hybrids could interpret much the high productivity of SC. 128 hybrid than SC. 176 one. These results are in conformity with those given by Golezani and Tajbakhsh (2012), Kandil (2013), and Modhej *et al.* (2014) as they recorded significant cultivar variations in final grain and biological yields/ unit area.

Nitrogen level effect

It is evident from Table 7 that each N increment up to 135 kg N/fad., produced a significant increase in both grain and biological yields/fad., in both seasons and their combined. According the combined analysis, adding 45, 90 and 135 kg N/fad., increased grain yield fad., by 53.33, 84.77 and 104.10% and biological yield by 65.01, 86.11 and 109.30%, respectively. The response of grain and biological yields to the increase of N level reflected that observed in each of chlorophyll content, plant height, ear leaf area, leaf area index, ear length, stem diameter, row number /ear, grain number/row, hundred grain weight and grain and stover yields/plant as well as biological yield/plant Tables (1, 2, 3, 4, 5 and 6). Noval and Silem (2003) working on maize fertilization, stated that increasing N level up to 135 kg N/fad., decreased markedly number of days to 50% tasseling and silking if compared with both 45 and 90 kg N rates/fad., On the other hand, number of green leaves/plant showed marked increase by raising N levels/up to 135 kg N/fad., several authors reported significant increase in grain yield due to the increase of N up to 125 kg N/fad. El-Naggar *et al.* (2012) and El-Kholy (2015) also other got yield response due to adding 135 and 118 kg N/fad.

Phosphors level effect

It was previously mentioned that phosphorus fertilizer could control maize yield components. Increasing the P fertilizer rate reflected in a significant increase in grain and biological yields/fad., and this was true in both seasons and their combined. According to the combined data, adding 15.5 and 31 kg P_2O_5/fad., increased grain yield with abut 24.4 and 45.42% compared with unfertilized (control) since, grain yield was about 22.5, 27.99 and 32.72 ardab/fad. Due to adding zero, 15.5 and 31 kg P_2O_5/fad., respectively for biological yield, when the field was fertilized with 15.5 and 31 kg P_2O_5/fad., biological yield increased with about 19.19 and 36.19% compared to control, since, biological yield was about 5.99. 7.08 and 8.09% due to adding 15.5 and 31 kg P_2O_5/fad., respectively. Similar results were observed regarding chlorophyll content (Table 1), LAI and relative photosynthetic potential for grain yield/plant (Table 3), Plant height and ear leaf area (Table 2), ear length and stem diameter (Table 4), row number/ear and grain number/row as well as hundred grain weight (Table 5) and grain yield/ plant and biological yield/ plant. These results are in agreement with those reported by Khan *et al*. (2005), Ahmad *et al*. (2007), Hussein (2009) and Khan *et al.* (2014) as they reported significant increase in grain and biological yields/ fad., due to addition of P up to level of (60, 90 , 120 kg P_2O_5 ha^{-1}), respectively.

Interaction effect

In general, each N increment was effective to increase both grain and biological yields/fad., for the maize hybrids *i.e.* SC. 128 and SC. 176. It seemed that SC. 128 hybrid always had higher grain and biological yields/fad., than SC. 176 under the different levels, however the two maize hybrids had the same grain yield under check N treatment (Table 7-a).

It is evident from Table 7-b that any increase in phosphors fertilizer caused a significant increase in grain yield/fad., up to 31 kg P_2O_5/fad., for the two maize hybrids. In general SC. 128 hybrid always had higher grain yield/fad., than SC 176 under the different P levels (Table 6-b).

It is evident from Table 7-c that each N increment produced a significant increase in both grain and biological yields/fad., when maize plant fertilized by 15.5 or 31 kg P_2O_5/fad., whereas, no further significant increase could be obtained due to the increase of N level beyond 90 kg N/fad., at the check P treatment. Under all

Table 7-a. Effect of interaction between maize hybrids and nitrogen fertilizer levels on grain yield (ardab/fad.) and biological (ton /fad.) (combined)

Maize hybrid (H)	Grain yield (ardab /fad.)				Biological yield (ton/fad.)			
	N level (kg N/ fad.)							
	0	45	90	135	0	45	90	135
SC 128	D 17.58 a	C 28.56 a	B 33.55 a	A 36.64 a	D 4.84 a	C 7.60 a	B 8.96 a	A 10.19 a
SC 176	D 16.96 a	C 24.40 b	B 30.27 b	A 33.99 b	D 3.81 b	C 5.88 b	B 7.13 b	A 7.89 b

Table 7-b. Effect of interaction between maize hybrids and phosphorus fertilizer levels on grain yield (ardab /fad.) (combined)

Maize hybrid (H)	Grain yield (ardab/fad.)		
	P level (kg P_2O_5/fad.)		
	0	15.5	31
SC 128	C 23.81 a	B 28.88 a	A 34.56 a
SC 176	C 21.19 b	B 27.09 b	A 30.87 b

Table 7-c. Effect of interaction between nitrogen fertilizer levels and phosphorus fertilizer levels on grain yield (ardab/fad.) and biological (ton /fad.) (combined)

N level (kg N/fad.)	Grain yield (ardab /fad.)			Biological yield (ton /fad.)		
	P level (kg P_2O_5/ fad.)					
	0	15.5	31	0	15.5	31
0	C 11.87 c	B 18.46 d	A 21.47 d	C 2.89 c	B 4.71 d	A 5.38 d
45	C 23.03 b	B 26.80 c	A 29.61 c	C 6.13 b	B 6.72 c	A 7.38 c
90	C 27.37 a	B 31.38 b	A 36.98 b	C 7.14 a	B 7.91 b	A 9.08 b
135	C 27.75 a	B 35.30 a	A 42.81 a	C 7.61 a	B 9.01 a	A 10.51 a

the four N levels, each P increment produced a significant increase in both grain and biological yields/fad.

Ear Leaf Efficiency and Migration Coefficient

The average effects of nitrogen and phosphorus levels on ear leaf efficiency and migration coefficient of the maize hybrids are shown in Table 8.

Maize hybrid differences

The two maize hybrids *i.e.* SC. 128 and SC. 176 had statistically the same ear leaf efficiency and migration coefficient in both seasons and their combined.

Nitrogen level effect

It is evident from Table 8 that each N increment up to 135 kg N/fad., produced a significant increase in both ear leaf efficiency and migration coefficient in both seasons and their combined. According to the combined analysis, adding 45, 90 and 135 kg N/fad., increased ear leaf efficiency by 50.00, 64.28 and 85.71% and migration coefficient by 30.77, 4615 and 50.00%, respectively. These result are in consistent with those reported on other yield attributes and yield component. Ogola *et al.* (2002), Ghanem *et al.* (2006) and Khan *et al.* (2014).

Phosphors level effect

Results in Table 8 show that increasing P level from zero to 15 and 31 kg P_2O_5/fad., caused significant increase in both ear leaf efficiency and migration coefficient. This was true in both seasons and their combined however, the second P increment failed to add a further significant increase in migration coefficient. Basing on the combined data, increasing P levels up to 31 kg P_2O_5/fad., increased ear leaf efficiency by 23.53 and 41.17% and migration coefficient by 24.13 and 31.03%, respectively compared with the control. Similar findings were reported by Hussein (2009) and Zafar *et al.* (2011).

Interaction effect

It is evident from Table 8-a that growing under unfertilized with N, ear leaf efficiency of SC. 176 was higher than that of SC. 128 hybrid, whereas, under the different levels of N both SC. 128 and SC. 176 had the same ear leaf efficiency and migration coefficient with the exception under 135 kg N/fad., where the latter had higher migration coefficient than the former hybrid. In this respect it is noticed that ear leaf efficiency value of both hybrids increased consistently by any increase in N fertilizer. This was always observed for migration coefficient in SC. 176 hybrid, but no further significant increase could be obtained due to the increase of N level beyond 45 kg N/fad., in maize hybrid SC. 128 (Table 8-b).

In general, any increase in phosphorus fertilizer caused a significant increase in ear leaf efficiency up to 31 kg P_2O_5/fad., for the two maize hybrids. SC. 176 hybrid had higher ear leaf efficiency than SC. 128 under 15.5 kg P_2O_5/fad., but the two maize hybrids had the same ear leaf efficiency under the other P level *i.e.* check and 31 kg P_2O_5/fad.

In general, under growing maize with 15.5 and 31 kg P_2O_5/fad., ear leaf efficiency responded to nitrogen fertilizer up to 135 kg N/fad., but only increased till 90 kg N/fad., under without P treatment. Under all the four N levels, each P increment produced a significant increase in the ear leaf efficiency.

Each N increment produced a significant increase in migration coefficient under the high level of phosphors 31 kg P_2O_5/fad., where, no farther significant increase could be obtained due to the increase of N level beyond 45 kg N/fad., under 15.5 kg P_2O_5/fad., treatment, but only increased till 90 kg N/fad., under without P application. Also, each P increment produced a significant increase in migration coefficient when maize plant fertilized by 135 kg N/fad., whereas migration coefficient was affected by the first P increment under the other N treatment *i.e.* check 45 and 90 kg N/fad., (Table 8-c).

Table 8. Ear leaf efficiency and migration coefficient of the two maize hybrids as affected by nitrogen, phosphorus fertilizer levels and their interactions in 2014, 2015 seasons and their combined data

Main effects and interactions	Ear leaf efficiency			Migration coefficient		
	2014	2015	Comb.	2014	2015	Comb.
Maize hybrid (H)						
SC 128	0.20	0.21	0.21	0.33	0.35	0.34
SC 176	0.20	0.22	0.21	0.33	0.36	0.35
F. test	NS	NS	NS	NS	NS	NS
Nitrogen level (kg N/fad.) N						
0	0.13 d	0.14 d	0.14 d	0.25 d	0.27 d	0.26 d
45	0.20 c	0.22 c	0.21 c	0.34 c	0.35 c	0.34 c
90	0.22 b	0.24 b	0.23 b	0.36 b	0.39 b	0.38 b
135	0.26 a	0.27 a	0.26 a	0.38 a	0.41 a	0.39 a
F. test	**	**	**	**	**	**
Phosphorus level (kg. P_2O_5/fad.) P						
0	0.16 c	0.18 c	0.17 c	0.29 c	0.30 c	0.29 c
15.5	0.20 b	0.22 b	0.21 b	0.35 a	0.37 b	0.36 b
31	0.24 a	0.25 a	0.24 a	0.36 a	0.40 a	0.38 a
F. test	**	**	**	**	**	**
`Interactions						
H × N	*	NS	*	**	NS	**
H × P	NS	NS	*	**	NS	NS
N × P	**	**	**	**	**	**

*,** indicate significant at 0.05 and 0.01 levels of probability, respectively. NS = Not significant.

Table 8-a. Effect of interaction between maize hybrids and nitrogen fertilizer levels on ear leaf efficiency and migration coefficient (combined)

Maize hybrid (H)	Ear leaf efficiency				Migration coefficient			
	N level (kg N/ fad.)							
	0	45	90	135	0	45	90	135
	D	C	B	A	B	A	A	A
SC 128	0.12 b	0.21 a	0.23 a	0.27 a	0.25 a	0.35 a	0.37 a	0.38 b
	D	C	B	A	D	C	B	A
SC 176	0.15 a	0.21 a	0.23 a	0.26 a	0.27 a	0.34 a	0.38 a	0.41 a

Table 8-b. Effect of interaction between maize hybrids and phosphorus fertilizer levels on ear leaf efficiency (combined)

Maize hybrid (H)	Ear leaf efficiency		
	P level (kg P_2O_5/ fad.)		
	0	15.5	31
	C	B	A
SC 128	0.17 a	0.21 b	0.24 a
	C	B	A
SC 176	0.17 a	0.22 a	0.25 a

Table 8-c. Effect of interaction between nitrogen fertilizer levels and phosphorus fertilizer levels on ear leaf efficiency and mgration coefficient (combined)

N level (kg N/fad.)	Ear leaf efficiency			Migration coefficient		
	P level (kg P_2O_5/ fad.)					
	0	15.5	31	0	15.5	31
	C	B	A	B	A	A
0	0.09 c	0.16 c	0.17 d	0.18 c	0.29 b	0.31 d
	C	B	A	B	A	A
45	0.18 b	0.23 b	0.22 c	0.30 b	0.36 a	0.37 c
	C	B	A	B	A	A
90	0.20 a	0.22 b	0.26 b	0.34 a	0.38 a	0.40 b
	C	B	A	C	B	A
135	0.21 a	0.25 a	0.33 a	0.34 a	0.40 a	0.44 a

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الاستجابة الفسيولوجية لهجن الذرة الشامية للتسميد النيتروجيني والفوسفاتي

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أقيمت تجربتان حقليتان بالمزرعة التجريبية بالجميزة التابعة لمركز البحوث الزراعية خلال الموسمين (٢٠١٤ ، ٢٠١٥) وذلك لدراسة استجابة اثنان من الهجن الفردية للذرة هما الهجين الفردي ١٢٨ (أبيض الحبوب)، الهجين الفردي ١٧٦ (أصفر الحبوب) لأربع مستويات من التسميد النيتروجيني (بدون إضافة ، ٤٥ ، ٩٠ ، ١٣٥) كجم ن/ فدان وثلاثة مستويات من التسميد الفوسفاتي (بدون إضافة ، ١٥,٥ ، ٣١) فو٢أ٥/ فدان ويمكن تلخيص النتائج كما يلي: تفوق صنف الذرة الهجين الفردي ١٢٨ على الهجين الفردي ١٧٦ في محصولي الحبوب والبيولوجي للفدان بفضل تفوقه في كل من عدد الأيام حتى ظهور ٥٠% من النورات المذكرة والمؤنثة، محتوى الأوراق من الكلوروفيل، مساحة ورقة الكوز، دليل مساحة الأوراق، الجهد التمثيلي النسبي لمحصول القش للنبات، طول الكوز ، قطر الكوز، قطر الساق، عدد الحبوب بالسطر، وزن الـ ١٠٠ حبة ومحصول الحبوب والقش للنبات، بينما تفوق الهجين الفردي ١٧٦ في كل من ارتفاع النبات والجهد التمثيل الضوئي لمحصول الحبوب للنبات في حين لم يختلف الصنفان في كل من الجهد التمثيلي الضوئي للنبات، عدد السطور بالكوز، كفاءة ورقة الكوز، معامل الهجرة، أوضح التحليل التجميعي للموسمين أن إضافة التسميد النيتروجيني وزيادة معدل الإضافة حتى ١٣٥ كجم نيتروجين /الفدان أدى إلى زيادة معنوية في محصول الحبوب/الفدان بفضل زيادة كل من محتوى الأوراق بالكلوروفيل، ارتفاع النبات، دليل مساحة الأوراق ، طول الكوز، قطر الكوز، قطر الساق، عدد السطور بالكوز وعدد الحبوب بالسطر، وزن الـ ١٠٠ حبة، محصول القش للنبات، وكفاءة ورقة الكوز، معامل الهجرة، لكن انخفض معنويا كل من الجهد التمثيل الضوئي لمحصول القش والمحصول البيولوجي للنبات، أدى إضافة الفوسفور وزيادة معدل الإضافة حتى ٣١ كجم فو٢أ٥/فدان لزيادة معنوية في محصول الحبوب/فدان ومعظم مساهماته ولكن انخفض معنويا كل من الجهد التمثيلي لمحصولي القش والبيولوجي للنبات كما استجاب قطر الكوز حتى ١٥,٥ كجم فو٢أ٥/فدان في حين لم يتأثر كل من عدد الأيام حتى ظهور ٥٠% من النوارات المذكرة والمؤنثة بإضافة الفوسفور، أوضحت الدراسة وجود تفاعل معنوي بين عوامل الدراسة حيث تم الحصول على أفضل محصول حبوب بمساهماته باستخدام الصنف هجين فردي ١٢٨ عند تسميده بمعدل ١٣٥ كجم نتروجين/الفدان، ٣١ كجم فو٢أ٥/فدان حيث أمكن معظمة محصول الحبوب إلى ٣٣,٩٩ ، ٤٢,٨ أردب/فدان على الترتيب.

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