7

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Nitrogen Use Efficiency and Grain Protein of Corn Affected by Low Nitrogen Application

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NITROGEN use efficiency (NUE) is one of the most important physiological traits related to low N tolerance. The present investigation was carried out during 2016 and 2017 seasons at the Agricultural Research and Experiment Station, Faculty of Agriculture, Cairo University, Giza, Egypt. The objectives were to study the effect of low N level on NUE, yield and grain composition as well as to determine the relationship between physiological traits (N accumulated in grain, Ng; NUE and grain produced per unit of grain N, Gw/Ng) and grain yield/plant (Gw). Two single cross hybrids were evaluated under three N levels, namely low N level (216kg N/ha), control (288kg N/ha) and high N level (360kg N/ha). Therefore, the amounts of applied nitrogen in the soil were 3.75, 5.0 and 6.25g/plant under low N, medium N (control) and high N, respectively. A split-plot design in a randomized complete block arrangement was used with four replications. The percent change relative to control showed that high N level caused a significant increase in grain yield/plant, grain yield/ha, kernels/row, ear length, N% in grain, Ng and grain protein % by 13.8, 14.53, 9.12, 6.99, 8.25, 22.85 and 7.2%, respectively. On the other hand, low N level caused a significant increase in NUE by 27.53% and Gw/Ng by 3.70%. Results of the simple regression analyses revealed that the superior traits in their contributions to Gw were NUE where R^2 values were 0.99, 0.98 and 0.96 along with Ng where R^2 values were 0.95, 0.66 and 0.94 under low N, medium N and high N, respectively.

Keywords: Maize, NUE, N accumulation, Protein, Oil, Simple regression.

Introduction

Corn (*Zea mays* L.) is the third important cereal crop after wheat and rice worldwide. It is used for several purposes such as human nutrition, livestock and poultry feed as well as manufacturing starch and cooking oils, corn is also grown for fodder and silage. Nitrogen is the most important nutritive element for the worldwide production of cereals and it is one of the most important factors that determine crop production (Parry et al., 2005). In addition, it is the most important plant macronutrient because it is an essential component of plant cell compounds such as chlorophyll and proteins (Srivastava & Singh, 1999), that are closely associated with leaf color, crop growth status and yield (Fageria et al., 2011). Therefore, increasing maize yield in the worldwide production was accompanied by increasing use of N fertilization.

Negative impacts of the increased N fertilization on environment could be summarized as misuse and over application of N in the developed countries created growing environmental concerns from increased nitrate leaching that may lead to ground water contamination (Akintoye et al., 1999 and Raun & Johnson, 1999). In addition, Rejesus & Hornbaker (1999) reported that a lot of the applied mineral nitrogen is lost through gaseous emissions, erosion and leaching. In contrast, in many developing countries such as Egypt the rates of N fertilizers are considerably low because of the limited access to fertilizers and low purchasing power of small farmers.

Moll et al. (1982) defined NUE as grain production per unit of N available in the soil. Furthermore, Grohan (1984) defined NUE as the ability of a genotype to produce superior grain yield under low soil-N conditions in comparison with other genotypes. Several researchers (Moll et al., 1982; Anderson et al., 1984; Pandey et al., 2001; Atta, 2009 and Al-Naggar et al., 2009, 2015)

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reported that NUE increased as soil-N decreased. Differences in NUE among corn genotypes have been reported by several researchers (Chevalier & Schrader, 1977; Moll et al., 1982; Van & Smith, 1996; El-Moselhy, 2000; Omoigui et al., 2006; Atta, 2009 and Al-Naggar et al., 2009, 2015), indicating that NUE trait could be improved via conventional breeding methods. Al-Naggar et al., (2009) found that NUE had positive correlation coefficients (r) with grain yield, 100 kernel weight, kernels/row, ears/plant, rows/ear and plant height under low and high-N conditions.

In order to increase maize yield under limited access to fertilizers in developing countries such as Egypt, it should be screened the available maize genotypes to low-N tolerance. Therefore, the objectives of the present investigation were to study the effect of low N level on NUE, yield and grain composition as well as to determine the relationship between physiological traits (N accumulated in grain, Ng; NUE and grain produced per unit of grain N, Gw/Ng) and grain yield/plant (Gw).

Materials and Methods

Two field experiments were carried out at the Agricultural Research and Experiment Station, Fac. Agric., Cairo Uni., Giza, Cairo, Egypt (30°02’ N and 31°13’ E, with an altitude of 30 meter) during 2016 and 2017 seasons. The climatic variables in the two successive seasons are presented in Table 1. Soil properties of 2016 and 2017 seasons (Table 2) were analyzed at Reclamation and Development Center Desert Soils, Faculty of Agriculture Research Park, Cairo University.

TABLE 1. Some climatic variables recorded at Giza location in 2016 and 2017 seasons.

Month	2016		2017	
	Temperature (°C)	Relative humidity (%)	Temperature (°C)	Relative humidity (%)
June	29.9	47.4	29.3	35.3
July	28.9	57.5	31.4	42.5
August	29.3	57.9	30.9	46.2
September	27.8	56.2	28.6	46.0

Data obtained from the Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC), Egypt.

Precipitation was not detected in both seasons.

TABLE 2. Some physical and chemical properties of soil at the experimental site in 2016 and 2017 seasons.

Soil analysis	2016	2017
Physical properties		
Sand (%)	33.3	33.2
Silt (%)	30.2	31.5
Clay (%)	36.5	35.3
Texture class	Clay loam	Clay loam
Chemical properties		
$pH_{(1:1)}$	7.61	7.73
$Ec_{(1:1)}$ (dS m^{-1})	1.9	1.9
Organic matter (%)	2.3	2.2
Total Ca Co_3 (%)	3.4	3.5
Available N (mg kg^{-1})	37.4	34.9
Available P (mg kg^{-1})	9.23	9.9
Available K (mg kg^{-1})	223.0	234.0
Irrigation water analysis		
Ec of irrigation water (ds/m)	0.78	0.86
pH of irrigation water	7.02	7.50
Irrigation system	Flooding	Flooding

Plant material

Two commercial hybrids of corn, namely single cross hybrid SC-P3444 and single cross hybrid SC-P3733 (both of them have yellow endosperm) were tested. The two single crosses were purchased from Pioneer International Company (Egypt).

Experimental design and treatments

The studied corn hybrids were evaluated under three N levels, namely low N level by applying 216kg N/ha, control by applying 288kg N/ha (as recommended by the Agricultural Research Center, ARC) and high N level by applying 360kg N/ha. Therefore, the amount of applied nitrogen in the soil was 3.75g/plant under low N level, 5.0g/plant under control and 6.25g/plant under high N level. All N-treatments were added in two equal doses before the first and the second irrigations. A split-plot design in a randomized complete block arrangement was used with four replications. The main plots were allotted to the three levels of nitrogen [low-N 3.75, control 5.00 and high-N 6.25g/plant] and the two hybrids were devoted to sub-plots. Each sub-plot consisted of 15 ridges of 0.70m in width and 4.0m in length, i.e. the experimental plot area was 42m^2. Therefore, plant density in each sub-plot was 242 plants, i.e. 57600 plants/ha. Each main plot was surrounded with a wide ridge (1.5m) to avoid interference of the three N-treatments.

Cultural practices

The preceding crop was barley (*Hordeum vulgare* L.) in both seasons. Sowing dates were on June 5 and 9 in 2016 and 2017 seasons, respectively. Seeds were sown in hills at 25cm apart by hand, thereafter (before the 1st irrigation) plants were thinned to one plant per hill. Calcium super phosphate fertilizer (15.5% P_2O_5) at the rate of 60kg P_2O_5/ha was applied uniformly before sowing. The weed management was carried out during the growing season by hoeing twice, before the 1st and the 2nd irrigations. The other cultural practices were applied as recommended by the Agricultural Research Center (ARC), Giza, Egypt.

Data collection

At harvest, 25 guarded plants were randomly sampled from each plot to determine grain yield/plant in gram (Gw). Grain yield in kg was weighed from the whole area of each experimental unit (sub-plot) and then adjusted into ton/hectare (ton/ha). The grain yield/plant and per hectare were adjusted on the basis of 15.5% grain moisture content. Kernels/row, ear length, rows/ear, shelling % and 100 kernel weight (g) were determined on 40 random ears from each plot. Shelling % was calculated by dividing grain weight on ear weight and multiplied by 100. Nitrogen percentage (N %) in grain was determined according to A.O.A.C. (2000). Nitrogen accumulated in grain (Ng) was calculated by multiplying grain yield/plant in gram (Gw) by N% in grain. Nitrogen use efficiency (NUE) was calculated as follows: NUE= Gw/Ns, where Ns is applied N/plant (g). Grain produced per unit of grain N was calculated as follows: Grain produced per unit of grain N= Gw/Ng. Grain protein percentage and oil percentage were determined according to A.O.A.C. (2000).

Analyses of N % in grain, grain protein % and grain oil % were done at Faculty of Agriculture Research Park, Faculty of Agriculture, Cairo University. Traits of Ng, NUE and Gw/Ng were calculated according to Moll et al. (1982)

Statistical analysis

Test of normality distribution was carried out according to Shapiro and Wilk method (Shapiro & Wilk, 1965), by using SPSS v. 17.0 (2008) software package. Also, data were tested for violation of assumptions underlying the combined analysis of variance by separately analyzing of each season and then combined analysis across the two seasons was performed if homogeneity (Bartlet test) was insignificant. Estimates of LSD were calculated to test the significance of differences among means according to Snedecor & Cochran (1994). Also, the regression analysis was done to determine the relationship between the causal effect and significance of the three independent physiological variables (Ng, NUE and Gw/Ng) on grain yield per plant (Gw). SPSS software package of v. 17.0 (2008) was used to calculate simple, regression and coefficient of determination (R^2) across years.

Results and Discussion

Analysis of variance

The combined analysis of variance for all traits under three N levels across years is presented in Table 3. Mean squares due to years were highly significant for all studied traits, except ear length and rows/ear, indicating the effect of climatic conditions on most studied traits. Mean squares due to N levels were significant for all traits, except rows/ear and oil percentage, suggesting that the studied N levels had a significant effect on most studied traits. Mean squares due to hybrids were significant for all traits, except ear length and rows/ear. Also, mean squares due to years x N levels interaction were significant or highly significant only for kernels/row and ear length. Significant mean squares were also detected for years x genotypes interaction for grain yield/plant, nitrogen accumulated in grain (Ng) and nitrogen use efficiency (NUE). Furthermore, mean squares due to N levels x genotypes were significant for grain yield/ha, shelling % and oil %. Mean squares due to years x N levels x genotypes were significant only for grain yield/plant, shelling % and Ng.

Several authors (Chevalier & Schrader, 1977; Moll et al., 1982; Van & Smith, 1996; El-Moselhy, 2000; Omoigui et al., 2006; Atta, 2009 and Al-Naggar et al., 2009, 2015) reported that performance of maize genotypes varied with N levels for most studied traits. However, mean squares due to N levels x hybrids interaction were significant only for three traits namely grain yield/ha, shelling % and oil %.

Effect of N levels

Effect of N levels on the studied traits is presented in Fig. 1. The change percent in traits due to apply different N levels is presented in Table 4. Under high N level, the highest mean values was observed for grain yield/plant (Gw), grain yield/ha, ear length, N% in grain, N accumulated in grain (Ng) and protein %. On the other hand, under low N level the highest mean values was observed for nitrogen use efficiency (NUE) and grain produced per unit of grain N (Gw/Ng).

The change percent (Table 4) relative to control showed that high N level caused significant increase in grain yield/plant, grain yield/ha, kernels/row, ear length, N% in grain, Ng and protein % by 13.8, 14.53, 9.12, 6.99, 8.25, 22.85 and 7.2%, respectively. On the other hand, low N level caused significant increase in NUE by 27.53% and Gw/Ng by 3.70%. On the contrary, low N level caused significant reduction, relative to control, in grain yield/plant (4.26%), yield/ha (4.3%), N% in grain (3.61%), Ng (7.53%) and protein % (3.45).

It is worthy to note that high N level caused a significant increase in most studied traits confirming that nitrogen is one of the most important factors determine crop production (Parry et al., 2005). In addition, it is the most important plant macronutrient because it is an essential component of plant cell compounds such as chlorophyll and proteins (Srivastava & Singh, 1999), that are closely associated with leaf color, crop growth status and yield (Fageria et al., 2011).

Therefore, increasing maize yield in the worldwide production was accompanied by increasing use of N fertilization. However, over application of N in the developed countries created growing environmental concerns from increased nitrate leaching that may lead to ground water contamination (Akintoye et al., 1999 and Raun & Johnson, 1999). In addition, a lot of the applied N is lost through gaseous emission, erosion and leaching (Rejesus & Hornbaker, 1999). In contrast, in many developing countries such as Egypt the rates of N fertilizers are considerably low because of the limited access to fertilizers and low purchasing power of small farmers.

It is worth noting that, nitrogen use efficiency (NUE) and grain produced per unit of grain N (Gw/Ng) significantly increased due to low N level by 27.53 and 3.7 %, respectively. It could be concluded that under low N level maize plants are forced to improve their N uptake and N translocation efficiencies. In this aspect, Moll et al. (1982), Anderson et al. (1984), Pandy et al. (2001), Atta (2009) and Al-Naggar et al. (2009, 2015) reported that NUE increased as soli N decreased.

Corn hybrids responses

Mean performance of the studied hybrids across N levels is presented in Table 5. The single cross (SC) P3444 had the highest mean values across N levels for grain yield/plant (Gw), yield/ha, kernels/row, N % in grain, Ng, NUE and protein %. On the other hand, the single cross P3433 had the highest mean values for 100 kernel weight, shelling %, Gw/Ng and oil %.

Effect of N levels x hybrids interaction

The studied hybrids of maize showed a significant variation in their absolute means under low and high N levels relative to those under control for three studied traits, namely yield/ha, shelling % and oil % (Table 6). The highest means under low and high N were achieved by SC P3444 for yield/ha and shelling %. On the other hand, SC P3433 had the highest mean values for oil % under low and high N levels.

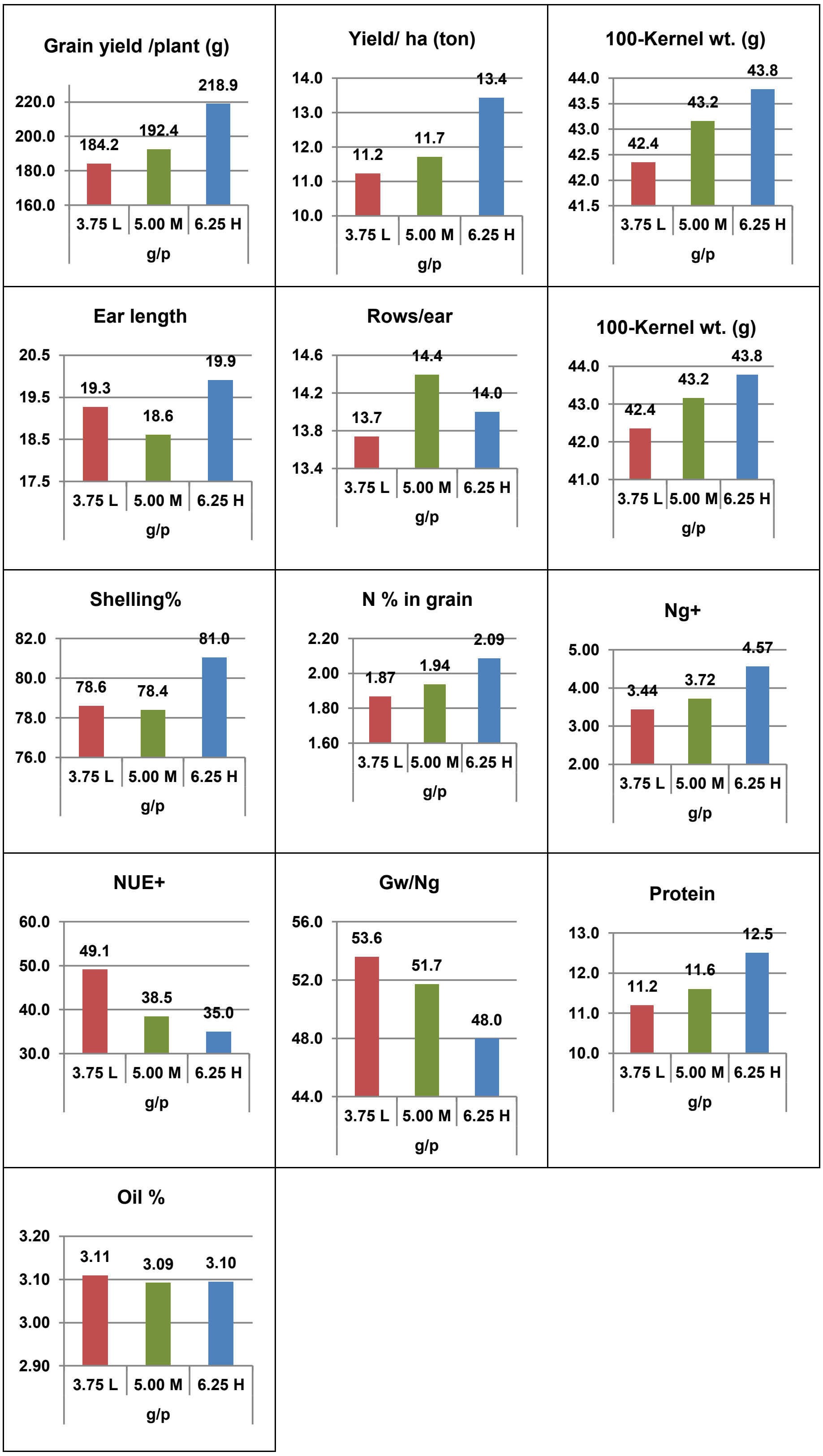

Fig. 1. Means of studied traits for N levels across hybrids and across 2016 and 2017 seasons [Ng= Nitrogen accumulated in grain, NUE= Nitrogen use efficiency and Gw/Ng= Grain produced per unit of grain N. L, C and H indicate to low N, control and high-N levels, respectively].

TABLE 3. Mean squares from combined analysis of variance of split plot design for two hybrids evaluated under three N levels across 2016 and 2017 seasons.

S.O.V	d.f	Grain yield/ plant	Grain yield/ ha	Kernels/ row	Ear length	Rows/ ear	100 kernel wt.	Shelling %
Years (Y)	1	4186.6**	3.40**	83.58**	3.87	0.093	7.93**	123.9**
R (Y)	6	72.0	0.05	0.58	2.06	0.306	0.31	7.5
N levels (A)	2	5281.7**	21.41**	70.29**	6.82*	1.749	8.19**	34.9*
YA	2	48.5	0.01	5.36**	6.93*	0.494	0.38	8.7
Error	12	27.8	0.06	0.65	1.07	1.461	0.64	8.8
Hybrids (B)	1	2055.1**	19.71**	23.58**	5.78	0.391	8.51*	41.5*
YB	1	3064.3**	0.13	0.00	0.84	0.281	1.02	0.7
AB	2	397.4	0.25*	2.68	2.21	1.112	3.39	43.2**
YAB	2	942.6*	0.07	7.17	0.13	0.017	2.94	30.9*
Error	18	161.1	0.07	2.38	1.60	0.692	1.11	8.6

		N % in grain	Ng+	NUE+	Gw/Ng+	Protein %	Oil %
Years (Y)	1	0.027**	0.85**	178.3**	17.69**	0.99**	0.77**
R (Y)	6	0.001	0.04	3.2	0.36	0.03	0.125
N-levels (A)	2	0.199**	5.51**	862.4**	129.83**	7.13**	0.001
YA	2	0.001	0.01	3.3	0.25	0.02	0.01
Error	12	0.002	0.02	1.2	1.15	0.07	0.069
Hybrids (B)	1	0.072**	2.08**	88.5**	48.76**	2.68**	1.43**
YB	1	0.002	1.45**	111.1**	1.38	0.10	0.033
AB	2	0.001	0.15	18.1	0.70	0.03	0.35*
YAB	2	0.001	0.39**	22.7	0.26	0.02	0.026
Error	18	0.001	0.06	8.2	0.82	0.04	0.06

*and** indicate significant at 0.05 and 0.01 levels of probability, respectively.

+Ng= Nitrogen accumulated in grain, NUE= Nitrogen use efficiency and Gw/Ng= Weight of grain produced per unit of grain N.

TABLE 4. Change % relative to medium-N (control) due to applying different N levels across 2016 and 2017 seasons.

Comparison	Grain yield/plant (g)	Grain yield/ ha (ton)	Kernels/row	Ear length (cm)	Rows/ear	100 kernel wt. (g)
Control vs. low N level	4.26**	4.30**	1.10	-3.80	4. 86	1.9
Control vs. high N level	-13.8**	-14.53**	-9.12**	-6.99*	2.80	-1.4
LSD$_{0.05}$	5.76	0.27	0.88	1.13	ns	0.87

	Shelling%	N % in grain	Ng (g)	NUE	Gw/Ng	Protein%	Oil %
Control vs. low N level	-0.26	3.61*	7.53**	-27.53**	-3.70**	3.45**	-0.32
Control vs. high N level	-3.44	-8.25**	-22.85**	9.1**	7.20**	-7.20**	0.00
LSD$_{0.05}$	3.23	0.05	0.16	1.20	1.18	0.28	N.S

*and** indicate significant at 0.05 and 0.01 levels of probability, respectively.

+Ng= Nitrogen accumulated in grain, NUE= Nitrogen use efficiency and Gw/Ng= Weight of grain produced per unit of grain N.

Change%= 100 [(control – low or high N level)/control].

TABLE 5. Means of all traits for studied hybrids across N levels and across 2016 and 2017 seasons.

Hybrids	Grain yield/ plant (g)	Grain yield/ha (ton)	Kernels/ row	Ear length (cm)	Rows/ear	100 kernel wt. (g)	Shelling %
P3433	192.0^{b}	11.48^{b}	37.61^{b}	19.61^{a}	13.95^{a}	43.52^{a}	78.41^{a}
P3444	205.0^{a}	12.76^{a}	39.01^{a}	18.92^{a}	14.13^{a}	42.68^{b}	80.27^{b}

	N % in grain	Ng+ (g)	NUE+	GW/Ng+	Protein%	Oil %
P3433	1.92^{b}	3.70^{b}	39.51^{b}	52.10^{a}	11.54^{b}	3.27^{a}
P3444	2.00^{a}	4.12^{a}	42.23^{a}	50.09^{b}	12.01^{a}	2.93^{b}

Means in the same column followed by the same latter not statistically different at 0.05 level of probability.

+Ng= Nitrogen accumulated in grain, NUE= Nitrogen use efficiency and Gw/Ng= Weight of grain produced per unit of grain N.

TABLE 6. Means and changes % of studied traits for N levels × genotypes interaction across 2016 and 2017 seasons.

Applied Nitrogen (Ns)	Hybrid	Grain yield/ plant (g)	Grain yield/ ha (ton)	Kernels/row	Ear length (cm)	Rows/ear	100 kernel wt. (g)
Low level 3.75g/p	P3433	175.75	10.66	36.69	19.29	13.34	42.37
	Change %	8.22	4.31**	-1.21	0.36	7.87	2.60
	P3444	192.59	11.80	37.17	19.25	14.13	42.33
	Change %	0.36	3.83**	2.93	-7.78	1.26	1.17
Control 5.00g/p	P3433	191.49	11.14	36.25	19.36	14.48	43.48
	P3444	193.28	12.27	38.29	17.86	14.31	42.83
High level 6.25g/p	P3433	208.62	12.65	39.88	20.18	14.04	44.70
	Change %	-8.95	-13.55**	-10.01	-4.24	3.04	-2.81
	P3444	229.25	14.21	41.56	19.64	13.96	42.86
	Change %	-18.61	-15.81**	-8.54	-9.97	2.45	-0.07
$LSD_{0.05}$		N.S	0.27	N.S	N.S	N.S	N.S

Applied Nitrogen (Ns)	Hybrid	Shelling%	N % in grain	Ng (g)	NUE	Gw/Ng	Protein %	Oil %
Low level 3.75g/p	P3433	77.00	1.84	3.22	46.87	54.52	11.00	3.29
	Change %	2.94	2.65	11.10	-22.40	-2.97	2.83	-5.59*
	P3444	80.19	1.90	3.66	51.36	52.65	11.40	2.93
	Change %	-3.54	4.04	4.44	-32.88	-4.34	4.12	4.56
Control 5.00g/p	P3433	79.33	1.89	3.62	38.30	52.95	11.32	3.11
	P3444	77.45	1.98	3.83	38.65	50.46	11.89	3.07
High level 6.25g/p	P3433	78.91	2.05	4.27	33.38	48.83	12.28	3.41
	Change %	0.53	-8.47	-17.96	12.85	7.78	-8.48	-9.65*
	P3444	83.18	2.12	4.87	36.68	47.14	12.73	2.78
	Change %	-7.40**	-7.10	-27.15	5.10	6.60	-7.10	9.45
$LSD_{0.05}$		3.08	N.S	N.S	N.S	N.S	N.S	0.26

*and** indicate significant at 0.05 and 0.01 levels of probability, respectively.

+Ng= Nitrogen accumulated in grain, NUE= Nitrogen use efficiency and Gw/Ng= Weight of grain produced per unit of grain N.

Change%= 100 [(control – low or high N level)/control].

In respect N accumulated in grain (Ng), the studied hybrids showed an increase in such trait and consequently increase in protein % under high N level. In contrast, the studied hybrids showed high mean values under low N level for NUE and Gw/Ng, indicating that NUE and Gw/Ng are the most physiological traits related to low N tolerance. The single cross P3433 improved its performance under low N level by 22.40 and 2.97% and the single cross P3444 improved its performance by 32.88 and 4.34% for NUE and Gw/Ng, respectively. Several authors (Chevalier & Schrader, 1977; Moll et al., 1982; Van & Smith, 1996; El-Moselhy, 2000; Omoigui et al., 2006; Atta, 2009 and Al-Naggar et al., 2009, 2015) reported genotypic differences in NUE among maize genotypes and they were able to determine the most tolerant genotypes to low N for future utilization in plant breeding programs. The studied hybrid P3444 could be considered as low N tolerant and could be used for future utilization in plant breeding programs as tolerant genotypes to low N requirements.

Simple regression analysis

The regression analysis method is used to determine the contribution role of some independent traits to the yield and selection efficiency by means of a few traits as the effective indicators to satisfy breeding aims (Farshadfar, 2004). Results of the simple regression analysis revealed that the superior traits in their contribution to grain yield per plant (Gw) were NUE where R^2 values were 0.99, 0.98 and 0.96, along with Ng, where R^2 values were 0.95, 0.66 and 0.94 under low N, control and high N, respectively. Grain produced per unit of grain N (Gw/Ng) was in the second order in the contribution to the grain yield per plant across all nitrogen levels (Table7). Similar results were reported by Abd El-Mohsen & Abd El-Shafi (2014) and Fouad (2018).

Conclusion

The studied hybrids showed high mean values under low-N level for nitrogen use efficiency (NUE) and grain produced per unit of grain N (Gw/Ng), indicating that NUE and Gw/Ng are the most important physiological traits related to low N tolerance.

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Author contributions

This work was carried out in collaboration between all authors. Author M.M.M. Atta wrote the protocol and wrote the first draft of the manuscript. Authors H.M. Abdel-Lattif designed and performed data analyses and M. H. Taha managed the literature searches. All authors designed the study, managed the experimental process, read and approved the final manuscript

TABLE 7. Variables selected by the model of Simple linear regression with their corresponding equation and significance level.

Nitrogen levels	Independent variables	R^2	Regression equation
Low N 3.75 g/p	Ng	0.95	$\hat{Y}$= 41.0+ 41.6 Ng**
	NUE	0.99	$\hat{Y}$= 0.01+ 3.75 NUE**
	Gw/Ng	0.39	$\hat{Y}$= 513– 6.13 Gw/Ng
Control 5.00g/p	Ng	0.66	$\hat{Y}$= 80.7+ 30.03 Ng*
	NUE	0.98	$\hat{Y}$= 0.33+ 4.99 NUE**
	Gw/Ng	0.03	$\hat{Y}$= 233– 0.79 Gw/Ng
High N 6.25g/p	Ng	0.94	$\hat{Y}$= 62.3+ 34.3 Ng**
	NUE	0.96	$\hat{Y}$= -0.02+ 6.25 NUE**
	Gw/Ng	0.40	$\hat{Y}$= 534– 6.57 Gw/Ng

*and** indicate the model significant at 0.05 and 0.01 levels of probability, respectively.

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كفاءة إستخدام النيتروجين وبروتين حبة الذرة الشامية المتأثرة من إضافة النيتروجين المنخفض

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تعتبر كفاءة إستخدام النيتروجين من أهم الصفات الفسيولوجية ذات الصلة بتحمل نقص النيتروجين. أجريت الدراسة خلال موسمى 2016 و 2017 فى محطة البحوث والتجارب الزراعية بكلية الزراعة جامعة القاهرة بالجيزة. كانت الأهداف تتضمن دراسة تأثير مستوى النيتروجين المنخفض على كفاءة إستخدام النيتروجين والمحصول ومكونات الحبة وكذلك لتحديد العلاقة بين الصفات الفسيولوجية (النيتروجين المتراكم فى الحبة، كفاءة إستخدام النيتروجين والحبة المنتجة من كل وحدة من وحدات النيتروجين) ومحصول النبات الفردى. تم تقييم أثنين من الهجن الفردية تحت ثلاث مستويات من النيتروجين وهى المستوى المنخفض (216 كجم نيتروجين/هكتار)، الكنترول (288 كجم نيتروجين/هكتار) والمستوى العالى (360 كجم نيتروجين/هكتار). وعليه فأن النيتروجين المضاف للتربة والمتاح للنبات هو 3.75، 5.0 و6.25 جرام/نبات وذلك تحت مستويات النيتروجين المنخفض و الكنترول والمستوى العالى، على التوالى. أستخدم تصميم القطع المنشقة مره واحدة موزعا طبقا للقطاعات الكاملة العشوائية فى أربع مكررات. أظهرت النسبة المئوية للتغير بالمقارنة بالكنترول أن المستوى العالى من النيتروجين تسبب فى زيادة معنوية لمحصول النبات الفردى، محصول الحبوب/هكتار، عدد الحبوب/الصف، طول الكوز، نسبة النيتروجين فى الحبة، النيتروجين المتراكم فى الحبة و نسبة البروتين بـ 13.8، 14.53، 9.12، 6.99، 8.25، 22.85 و 7.2%، على التوالى. وعلى الجانب الآخر تسبب مستوى النيتروجين المنخفض فى زيادة معنوية فى كفاءة إستخدام النيتروجين بـ 27.53% والحبة المنتجة لكل وحدة من وحدات النيتروجين بـ 3.7%. أظهرت نتائج تحليل الإنحدار البسيط أن أفضل الصفات من حيث مساهمتها فى محصول النبات الفردى هى صفة كفاءة إستخدام النيتروجين حيث كان معامل التقدير 0.99، 0.98 و 0.96 وكذلك صفة النيتروجين المتراكم فى الحبة حيث كان معامل التقدير 0.95، 0.66 و 0.94 تحت مستويات النيتروجين المنخفص والمتوسط والعالى، على التوالى.