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Response of white maize hybrids to various nitrogen fertilizer rates in Qalyubia, Egypt

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Two field experiments were conducted during the two successive summer growing seasons of 2016 and 2017 to study the effect of three nitrogen fertilizer rates, on the growth traits, yield components, yield and some kernels chemical properties of three white single cross hybrids of maize. Almost traits of maize under study, were significantly increased by increasing nitrogen fertilizer rates in the both seasons, application of 150 kg N/fed significantly gave the maximum values of studied traits except, No. of days to 50 % tasseling and tasseling as well as No. of barren plants/fed which were significantly decreased with increasing nitrogen rates in the both seasons. White single cross (S.C.) hybrids of maize were significantly differed in all maize traits under study in the both seasons. S.C. 30K8 was significantly surpassed S.C. 7071 and S.C. 2031 in mean values of No. of plants carried two ears/fed, No. of ears/fed, No. of rows/ear, No. of kernels/row, No. of kernels/ear, grain yield/fed, grain yield/plant and harvest index as well as gave the lowest mean values of No. of barren plants/fed and the shortest period from planting to 50 % tasseling or silking in the both seasons. Moreover, S.C. 2031 surpassed the other two maize hybrids in mean values of leaf area/plant, ear weight, 100-kernel weight, ear yield/fed, biological yield/fed, kernels nitrogen content, kernels crude protein content, kernels nitrogen uptake/fed and protein yield/fed in the two seasons. Meanwhile, S.C. 7071 recorded the highest mean values of No. of green leaves/plant, plant height, ear height, shelling % and stover yield/fed in the two seasons. Planting S.C. 30K8 and fertilized by 150 kg N/fed recorded significantly the highest mean values of No. of plants carried two ears/fed, No. of ears/fed, No. of kernels/row, No. of kernels/ear, grain yield/fed, grain yield/plant and harvest index as well as gave the lowest mean values of No. of barren plants/fed during the both seasons. Meanwhile, growing maize hybrid of S.C. 2031 under the same nitrogen fertilizer rate surpassed the other treatments in mean values of leaf area/plant, ear weight, 100-kernel weight, ear yield/fed, biological yield/fed, kernels nitrogen uptake/fed and protein yield/fed during the two seasons. Whereas, the maximum mean values of plant height, ear height, shelling % and stover yield/fed in the two seasons were produced from maize hybrid of S.C. 7071 with the same rate of nitrogen fertilizer rate.

Keywords: White maize hybrids, S.C. 2031, S.C. 30K8, S.C. 7071, nitrogen fertilizer.

INTRODUCTION

Maize or corn (*Zea mays,* L.) is globally the top ranking cereal in potential grain productivity. It is considered as a 'King of cereals crops' because of its special characteristics that include its carbon pathway (C4), wider adaptability, higher multiplication ratio, desirable architecture, superior transpiration efficiency and high versatile use (EL-Hosary, et al., 2011). In Egypt, maize is considered as one of the main cereal crops, comes the third after wheat and rice. Maize is very essential either for the human food or animal feeding and a common ingredient for industrial products. It plays a vital source of daily human food because their flour mixed with wheat flour by 20 % for bread making. Also, maize is used as a feed for livestock whether fresh, silage or grains. Therefore, a great attention should be paid to raise maize productivity by maximizing yield per unit area in order to reduce the gap between its production and consumption. Where, maize is well known for its high demand for nutrients and other production inputs. Thereby, among factors that enhances maize productivity through growing high yielding hybrids and applying the optimum nitrogen fertilizer rate. World average cultivated area of maize in 2017 year (www.fao.org) reached 469.49 million fed one fed = 4200 m^2; the total production was 1134.75 million tons, with an average productivity of 2416.97 kg grain/fed. The growing area of maize in Egypt during 2017 year is about 2.192 million fed with a total grain yield of 7.10 million tons. The average grain yield production/fed was about 3239.19 kg. The total production supplies 80 % of the require consumption with a reduction gap of 20 % which has to be filled via importation.

Nitrogen is the component of protoplasm, proteins, nucleic acids, chlorophyll and plays a vital role both in vegetative and reproductive phase of crop growth. Maize has been recognized as a heavy feeder and uses more of nitrogen than any other nutrient element. Many reports indicated that nitrogen fertilizer has more influence on the growth and yield of maize than any other plant nutrient because it is the nutrient most often deficient in the Egyptian soils. Thus, increasing application of nitrogen fertilizer rates led to significant increases in growth, yield and its attributes and quality characters of maize crop (El-Gedwy 2007; Sallah et al., 2009; Szulc et al.,2009; Bamuaafa et al., 2010; Hokmalipour and Darbandi 2011; Dawadi and Sah 2012; Karasu 2012; Li et al., 2012; Kandil 2013; Radma and Dagash 2013; Adeniyan 2014; Ahmadu 2014; Delibaltova 2014; Khan et al., 2014; Rehman et al., 2014; Hafez and Abdelaal 2015; Kandil et al. 2016; Gharibi et al., 2016; Majid et al., 2017; Marković et al., 2017; Sapkota et al., 2017; Sharanabasappa et al., 2017; Takele et al., 2017; Ahmad et al., 2018 and Zeleke et al., 2018)

Several investigators showed that maize hybrids differed in growth, yield components, yield and some chemical properties (Sallah et al., 2009; Szulc et al., 2009; Bamuaafa et al., 2010; Hokmalipour and Darbandi 2011; Dawadi and Sah 2012; Karasu 2012; Li et al., 2012; Kandil 2013; Radma and Dagash 2013; Adeniyan 2014; Ahmadu 2014; Delibaltova 2014; Khan et al., 2014; Rehman et al., 2014; Hafez and Abdelaal 2015; Karki et al. 2015; Kinfe et al., 2016; Majid et al. 2017; Marković et al. 2017; Ahmad et al., 2018 , Eyasu et al., 2018 and Sidi et al., 2019).

The aim of this investigation was designed to study the effect of nitrogen fertilizer rates on growth, yield components, yield and kernels chemical properties in three white single cross hybrids of maize.

MATERIALS AND METHODS

Two field experiments were carried out during the two summer successive growing seasons of 2016 and 2017 seasons at the Farm of Agricultural Research and the Experimental Center of Faculty of Agriculture at Moshtohor, (Toukh Directorate, Qalyubia Governorate) Benha Univ. Egypt, to investigate the performance of some white single cross hybrids of maize to nitrogen fertilizer rates on the growth traits, yield components, yield and some kernels chemical properties.

Treatments were arranged in a randomized complete block design arranged as a split plot with three replications. The studied three nitrogen fertilizers rates, *i.e.* 90, 120 and 150 kg N/fed arranged in the main plots. Nitrogen fertilizer was applied in form of urea (46 % N), and divided into two equal parts and applied before the first and second irrigation in each season. The sub-plots were assigned three white single cross hybrids of maize, *i.e.* single cross 7071 for Tech Seed Company (S.C. 7071), single cross 30 K 08 for Pioneer hybrids (S.C. 30K8) and single cross hybrid 2031 for Misr Hytech Seed Int. (S.C. 2031) Soil texture of the experimental site was clay of pH nearly of 8.0 and 2.3 % organic matter content. The chemical and mechanical properties analysis of the experimental soil were determined according to the standard procedures described by Black and Evans (1965) and represented in Table 1 in each of the two growing seasons.

The preceding winter crop in the two seasons was wheat (*Triticum aestivum*, L.). The sub plot area was 10.5 m^2 and contained five ridges of 3 m long and 70 cm apart. Phosphorous fertilizer was applied in form of Calcium super phosphate (12.5 % P_2O_5) at a rate of 100 kg/fed during soil preparation in each season.

Table 1: Chemical and mechanical properties of the experimental soil units at planting maize during 2016 and 2017 seasons.

Properties	Seasons	
	2016	2017
Chemical analysis		
E.C.	2.28	2.31
pH (1 :2.5)	8.12	8.09
$CaCo_3$ %	3.21	2.94
O.M %	2.28	2.31
N % (total)	0.19	0.20
N (ppm) (available)	61.93	63.72
P % (total)	0.120	0.125
P (ppm) (available)	23.80	25.12
K % (total)	0.62	0.63
K (ppm) (available)	919.06	969.98
Particle size distribution (mechanical analysis)		
Course sand %	6.93	5.50
Find sand %	27.28	28.64
Silt %	13.23	11.60
Clay %	52.58	54.26
Texture grade	Clay	Clay

Maize kernels were hand sown in hills 25 cm apart at the rate of 2-3 kernels/hill using dry sowing method (Afir) on one side of the ridge during May 23th and 29th of in the first season (2016) and the second season (2017), respectively. Maize plants were thinned before the first irrigation to one plant/hill. The first irrigation was applied after 21 days from sowing and the following irrigations were applied at 12-15 days intervals during the growing seasons. Maize plants were harvested on 17th and 23th of September in the first and the second seasons, respectively. The other agricultural practices were kept the same as normally practiced in maize fields according to the recommendations of Ministry of Agriculture and Land Reclamation, except for the factors under study.

Studied parameters:

A- Growth characteristics:

1-Time of tasseling was determined as the No. of days from planting to 50 % tasseling.

2-Time of silking was determined as the No. of days from planting to 50 % silking.

3-Number of green leaves/plant at 80 days after planting.

4-Leaf area/plant (cm^2) at 80 days after planting. It was calculated from the following equation:

$$\textbf{Leaf area/plant} = \textbf{Area of topmost ear leaf X No. of green leaves/plant}.$$

Where, Area of topmost ear leaf (cm^2) at 80 days after planting was estimated as described by Stickler, 1964. It was calculated from the following equation:

$$\textbf{Area of topmost ear leaf} = \textbf{Ear leaf length X Greatest leaf width X 0.75}$$

5-Plant height (cm) at harvest, from the soil surface to the top of tassel.

6-Ear height (cm) at harvest, from the soil surface to the base of the topmost ear.

7-Number of plants carried two ears/fed at harvest.

8-Number of barren plants/fed at harvest.

9-Number of ears/fed at harvest.

Ten plants were chosen from the three center ridges at random from each sub plots to determine No. of green leaves/plant, area of topmost ear leaf (cm^2), leaf area/plant (cm^2), plant height (cm) and ear height (cm). Whereas, the tasseling and silking dates, No. of plants carried two ears/fed, No. of barren plants/fed and No. of ears/fed were estimated from the whole plants in the three center ridges.

B- Yield and yield components:

1-Number of rows/ear.

2-Number of kernels/row.

3-Number of kernels/ear. It was calculated from the following equation:

$$\textbf{No of kernels/ear} = \textbf{No. of rows/ear X No. of kernels/row}$$

4-Ear weight (g).

5-Shelling %. It was calculated by using the following formula:

$$\textbf{Shelling } (\%) = \frac{\textbf{Weight of kernels/ear (g)}}{\textbf{Ear weight (g)}} \boldsymbol{X\ 100}$$

6-Weight of 100-kernel (g).

7-Ear yield/fed (kg).

8-Stover yield/fed (kg).
9-Grain yield/fed (kg), adjusted to 15.5 % moisture content. It was calculated by using the following formula:

$$\textbf{Grain}\,\frac{\textbf{yield}}{\textbf{fed}}\,(\textbf{kg}) = \frac{\textbf{Ear yield/fed (kg) X Shelling \%}}{\textbf{100}}$$

10-Grain yield/plant (g). It was calculated by using the following formula:

$$\textbf{Grain yield/plant (g)} = \frac{\textbf{Grain yield/fed (kg)}}{\textbf{No. of plants/fed}}\,X\,1000$$

11-Biological yield/fed (kg). It was calculated by using the following formula:

$$\textbf{Biological}\,\frac{\textbf{yield}}{\textbf{fed}}\,(\textbf{kg}) = \textbf{Ear yield/fed (kg)} + \textbf{Stover yield/fed (kg)}$$

12-Harvest index (%). It was calculated by using the following formula:

$$\textbf{Harvest index}\,(\%) = \frac{\textbf{Grain yield/fed (kg)}}{\textbf{Biological yield/fed (kg)}}\,X\,100$$

Ten ears were chosen from the three center ridges at random from each sub plots to determine No. of rows/ear, No. of kernels/row, No. of kernels/ear, ear weight (g), kernels weight/ear (g), shelling % and 100-kernel weight. Whereas, ear yield/fed (kg), stover yield/fed (kg), grain yield/fed (kg), grain yield/plant (g), biological yield/fed (kg) and harvest index (%) were estimated from the whole plants in the three center ridges.

C- Chemical analysis

Maize kernels samples were taken after harvest at random from all kernels of ten ears to determine:
1-Kernels nitrogen content (%) was determinate according to the modified micro Kjeldahl method (A. O. A. C., 1990).
2-Kernels crude protein content (%) was calculated by multiplying nitrogen content (%) X 6.25 (A. O. A. C., 1990).
3-Nitrogen uptake/fed (kg) = grain yield (kg) x kernels nitrogen content (%).
4-Protein yield/fed (kg) = grain yield (kg) x kernels crude protein content (%).

Statistical analysis:

The analysis of variance was carried out according to the procedure described by Gomez and Gomez (1984). Data were statistically analyzed according to using the MSTAT-C Statistical Software Package (Michigan State University, 1983). Where the F-test showed significant differences among means L. S. D. test at 0.05 level was used to compare between means.

RESULTS AND DISCUSSION

Effect of nitrogen fertilizer rates:

Results in Tables 2, 3 and 4 indicated that increasing nitrogen fertilizer rates from 90 up to 150 kg N/fed caused significant increments in mean values of almost maize characteristics except, mean values of No. of days from planting to 50 % tasseling and silking as well as No. of barren plants/fed were significantly decreased with increasing nitrogen rates in 2016 and 2017 seasons. Meanwhile, mean values of No. of rows/ear was not significantly affected by nitrogen fertilizer rates under study during the both seasons.

Maize plants which fertilized by the highest nitrogen fertilizer rate (150 kg N/fed) gave significantly the greatest mean values of No. of green leaves/plant (13.47 and 13.17 leaves), leaf area/plant (8904.18 and 8646.69 cm^2), plant height (305.19 and 306.30 cm), ear height (150.00 and 150.56 cm), No. of plants carried two ears/fed (1540.74 and 1259.26 plants), No. of ears/fed (24637.04 and 23851.85 ears), No. of kernels/row (41.75 and 42.36 kernels), No. of kernels/ear (535.99 and 546.25 kernels), ear weight (193.24 and 192.25 g), shelling (81.23 and 80.59 %), 100-kernel weight (33.56 and 32.14 g), ear yield/fed (4037.04 and 3920.37 kg), stover yield/fed (4338.89 and 4129.63 kg), grain yield/fed (3270.76 and 3158.06 kg), grain yield/plant (144.59 and 142.56 g), biological yield/fed (8375.93 and 8050.00 kg), harvest index (39.19 and 39.32 %), kernels nitrogen content (1.693 and 1.704 %), kernels crude protein content (10.58 and 10.65 %), nitrogen uptake/fed (55.90 and 54.20 kg) and protein yield/fed (349.38 and 338.73 kg) as well as recorded significantly the shortest period from planting to 50 % tasseling (64.22 and 63.78 days) and silking (66.48 and 66.15 days) as well as gave the lowest mean values of No. of barren plants/fed (177.78 and 311.11 plants) in the first and second seasons, respectively.

Table 2: Mean values of No. of days to 50 % tasseling, No. of days to 50 % silking, No. of green leaves/plant, leaf area/plant (cm^2), plant height (cm), ear height (cm), No. of plants carried two ears/fed, No. of barren plants/fed and No. of ears/fed as affected by nitrogen fertilizer rates, white single hybrids of maize and their interaction during 2016 and 2017 seasons.

Treatment	Trait	No. of days to 50 % tasseling		No. of day s to 50 % silking		No. of green leaves/plant		Leaf area/plant (cm^2)		Plant height (cm)		Ear height (cm)		No. of plants carried two ears/fed		No. of barren plants/fed		No. of ears/fed	
	Season	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Nitrogen fertilizer rate (kg N/fed)																			
90		65.33	64.96	67.78	67.44	13.18	13.02	8370.07	8294.24	291.30	294.07	142.78	144.44	1051.85	977.78	518.52	711.11	23822.22	23125.93
120		64.78	64.30	67.11	66.74	13.36	13.10	8698.14	8496.87	300.19	301.11	146.67	147.04	1274.07	1111.11	281.48	518.52	24266.67	23466.67
150		64.22	63.78	66.48	66.15	13.47	13.17	8904.18	8646.69	305.19	306.30	150.00	150.56	1540.74	1259.26	177.78	311.11	24637.04	23851.85
L.S.D at 5%		0.26	0.33	0.31	0.42	0.06	0.04	48.10	42.18	2.35	1.89	1.84	2.42	117.88	87.42	103.77	95.03	229.02	302.83
Maize hybrid																			
S.C.7071		64.70	65.15	66.85	67.67	13.75	13.64	8423.12	8402.81	311.30	317.22	177.41	179.63	192.59	459.26	370.37	755.56	23155.56	22622.22
S.C. 30K8		64.04	62.93	66.37	65.19	12.66	12.24	7980.57	7732.50	281.67	279.44	128.89	128.33	2266.67	2029.63	207.41	355.56	25333.33	24503.70
S.C. 2031		65.59	64.96	68.15	67.48	13.60	13.41	9568.69	9302.48	303.70	304.81	133.15	134.07	1407.41	859.26	400.00	429.63	24237.04	23318.52
L.S.D at 5%		0.29	0.33	0.37	0.31	0.07	0.04	74.51	47.52	1.83	2.21	1.68	2.32	158.19	146.31	107.03	142.12	267.30	260.45
Interaction between nitrogen fertilizer rate and maize hybrid																			
90	S.C.7071	65.22	65.89	67.44	68.44	13.60	13.56	8181.71	8223.21	303.89	310.56	173.33	176.67	88.89	311.11	666.67	1022.22	22800.00	22133.33
	S.C. 30K8	64.67	63.44	67.00	65.78	12.48	12.18	7683.58	7571.98	275.00	272.78	125.56	124.44	1866.67	1866.67	311.11	533.33	24888.89	24177.78
	S.C. 2031	66.11	65.56	68.89	68.11	13.46	13.33	9244.92	9087.52	295.00	298.89	129.44	132.22	1200.00	755.56	577.78	577.78	23777.78	23066.67
120	S.C.7071	64.78	65.11	66.89	67.67	13.77	13.64	8456.19	8420.00	312.22	317.78	177.78	178.89	177.78	444.44	266.67	800.00	23244.44	22622.22
	S.C. 30K8	63.89	62.89	66.33	65.11	12.68	12.23	8019.78	7740.01	282.78	280.00	129.44	128.89	2222.22	2044.44	177.78	311.11	25288.89	24488.89
	S.C. 2031	65.67	64.89	68.11	67.44	13.62	13.41	9618.44	9330.60	305.56	305.56	132.78	133.33	1422.22	844.44	400.00	444.44	24266.67	23288.89
150	S.C.7071	64.11	64.44	66.22	66.89	13.88	13.72	8631.46	8565.22	317.78	323.33	181.11	183.33	311.11	622.22	177.78	444.44	23422.22	23111.11
	S.C. 30K8	**63.56**	**62.44**	**65.78**	**64.67**	**12.81**	**12.32**	**8238.35**	**7885.53**	**287.22**	**285.56**	**131.67**	**131.67**	**2711.11**	**2177.78**	**133.33**	**222.22**	**25822.22**	**24844.44**
	S.C. 2031	**65.00**	**64.44**	**67.44**	**66.89**	**13.73**	**13.48**	**9842.72**	**9489.33**	**310.56**	**310.00**	**137.22**	**136.67**	**1600.00**	**977.78**	**222.22**	**266.67**	**24666.67**	**23600.00**
L.S.D at 5%		**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**129.05**	**82.30**	**3.17**	**3.83**	**2.91**	**4.01**	**273.99**	**253.41**	**185.38**	**246.17**	**462.98**	**451.11**

Table 3: Mean values of No. of rows/ear, No. of kernels/row, No. of kernels/ear, ear weight (g), shelling %, 100-kernel weight (g), ear yield/fed (kg) and stover yield/fed (kg) as affected by nitrogen fertilizer rates, white single hybrids of maize and their interaction during 2016 and 2017 seasons.

Treatment	Trait	No. of rows/ear		No. of kernels/row		No. of kernels/ear		Ear weight (g)		Shelling %		100-kernel weight (g)		Ear yield/fed (kg)		Stover yield/fed (kg)	
	Season	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Nitrogen fertilizer rate (kg N/fed)																	
90		12.59	12.59	37.43	37.18	472.56	469.34	165.97	165.11	80.39	79.86	31.25	29.80	3353.70	3409.26	3937.04	3855.56
120		12.70	12.76	39.58	40.31	504.14	516.05	181.31	181.22	80.89	80.33	32.41	31.18	3742.59	3755.56	4196.30	4022.22
150		12.80	12.85	41.75	42.36	535.99	546.25	193.24	192.25	81.23	80.59	33.56	32.14	4037.04	3920.37	4338.89	4129.63
L.S.D at 5%		N.S.	N.S.	0.23	0.55	3.24	7.41	1.51	3.08	0.15	0.09	0.24	0.41	70.15	76.24	59.35	24.43
Maize hybrid																	
S.C.7071		12.31	12.08	40.16	40.36	495.29	488.83	156.58	163.44	84.01	82.41	29.74	28.82	3083.33	3229.63	4492.59	4346.30
S.C. 30K8		13.33	13.54	40.49	41.56	541.00	564.02	186.52	179.92	82.27	81.77	32.18	30.54	3996.30	3859.26	3629.63	3590.74
S.C. 2031		12.46	12.58	38.11	37.93	476.40	478.79	197.42	195.23	76.23	76.60	35.30	33.77	4053.70	3996.30	4350.00	4070.37
L.S.D at 5%		0.06	0.09	0.63	0.84	7.93	10.83	2.36	2.80	0.15	0.11	0.26	0.34	68.57	42.81	57.67	44.43
Interaction between nitrogen fertilizer rate and maize hybrid																	
90	S.C.7071	12.22	11.98	38.13	37.93	466.92	455.27	144.01	149.51	83.58	82.12	28.87	27.81	2794.44	2972.22	4244.44	4177.78
	S.C. 30K8	13.20	13.36	37.99	38.13	502.34	509.84	170.80	164.09	81.85	81.28	30.83	29.37	3605.56	3555.56	3444.44	3450.00
	S.C. 2031	12.36	12.44	36.18	35.47	448.42	442.90	183.09	181.74	75.75	76.19	34.04	32.22	3661.11	3700.00	4122.22	3938.89
120	S.C.7071	12.31	12.09	40.28	40.52	496.62	491.17	157.72	164.42	84.09	82.45	29.71	28.84	3105.56	3277.78	4538.89	4377.78
	S.C. 30K8	13.33	13.58	40.20	42.21	537.34	574.28	187.66	181.99	82.28	81.86	32.29	30.64	4027.78	3922.22	3661.11	3605.56
	S.C. 2031	12.47	12.60	38.27	38.20	478.45	482.70	198.57	197.26	76.30	76.66	35.23	34.06	4094.44	4066.67	4388.89	4083.33
150	S.C.7071	12.40	12.18	42.06	42.61	522.32	520.06	168.00	176.38	84.37	82.67	30.63	29.80	3350.00	3438.89	4694.44	4483.33
	S.C. 30K8	13.44	13.69	43.29	44.33	583.32	607.94	201.11	193.69	82.67	82.15	33.41	31.61	4355.56	4100.00	3783.33	3716.67
	S.C. 2031	12.56	12.69	39.90	40.12	502.32	510.76	210.60	206.68	76.65	76.96	36.63	35.02	4405.56	4222.22	4538.89	4188.89
L.S.D at 5%		N.S.	N.S.	1.10	1.45	13.74	18.76	4.09	4.86	0.25	0.19	0.46	0.59	118.76	74.14	99.89	76.96

Table 4: Mean values of grain yield/fed (kg), grain yield/plant (g), biological yield/fed (kg), harvest index (%), kernels nitrogen content (%), kernels crude protein content (%), nitrogen uptake/fed (kg) and protein yield/fed (kg) as affected by nitrogen fertilizer rates, white single hybrids of maize and their interaction during 2016 and 2017 seasons.

Treatment	Trait	Grain yield/fed (kg)		Grain yield/plant (g)		Biological yield/fed (kg)		Harvest index (%)		Kernels nitrogen content (%)		Kernels crude protein content (%)		Nitrogen uptake /fed (kg)		Protein yield/fed (kg)	
	Season	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Nitrogen fertilizer rate (kg N/fed)																	
90		2689.26	2722.12	119.01	123.63	7290.74	7264.81	37.07	37.54	1.639	1.655	10.24	10.34	44.50	45.41	278.12	283.80
120		3019.10	3015.40	133.54	136.57	7938.89	7777.78	38.21	38.84	1.670	1.685	10.44	10.53	50.91	51.19	318.17	319.94
150		3270.76	3158.06	144.59	142.56	8375.93	8050.00	39.19	39.32	1.693	1.704	10.58	10.65	55.90	54.20	349.38	338.73
L.S.D at 5%		58.54	57.94	3.33	2.35	99.93	84.26	0.39	0.38	0.004	0.008	0.03	0.05	1.05	1.13	6.57	7.05
Maize hybrid																	
S.C.7071		2594.72	2670.16	115.28	121.81	7575.93	7575.93	34.38	35.16	1.461	1.519	9.13	9.49	38.14	40.84	238.35	255.24
S.C. 30K8		3289.30	3158.74	144.44	142.40	7625.93	7450.00	43.20	42.49	1.664	1.697	10.40	10.61	54.83	53.71	342.66	335.67
S.C. 2031		3095.10	3066.68	137.43	138.55	8403.70	8066.67	36.90	38.05	1.877	1.829	11.73	11.43	58.35	56.25	364.66	351.56
L.S.D at 5%		55.74	33.46	3.65	3.20	98.53	69.04	0.39	0.27	0.010	0.007	0.07	0.04	0.99	0.66	6.16	4.15
Interaction between nitrogen fertilizer rate and maize hybrid																	
90	**S.C.7071**	2338.72	2449.30	103.83	112.60	7038.89	7150.00	33.40	34.20	1.428	1.490	8.92	9.31	33.54	36.72	209.65	229.51
	S.C. 30K8	2952.17	2893.29	129.33	130.76	7050.00	7005.56	42.02	41.41	1.637	1.679	10.23	10.49	48.36	48.65	302.23	304.07
	S.C. 2031	2776.89	2823.76	123.88	127.54	7783.33	7638.89	35.80	37.02	1.851	1.797	11.57	11.23	51.60	50.85	322.47	317.84
120	**S.C.7071**	2615.11	2710.66	116.16	123.28	7644.44	7655.56	34.41	35.35	1.466	1.522	9.16	9.51	38.51	41.51	240.68	259.42
	S.C. 30K8	3314.45	3213.37	145.67	145.45	7688.89	7527.78	43.24	42.80	1.667	1.700	10.42	10.63	55.29	54.70	345.55	341.84
	S.C. 2031	3127.74	3122.17	138.80	140.99	8483.33	8150.00	36.98	38.37	1.878	1.833	11.74	11.46	58.92	57.37	368.27	358.56
150	**S.C.7071**	2830.33	2850.51	125.85	129.57	8044.44	7922.22	35.32	35.93	1.489	1.544	9.31	9.65	42.35	44.29	264.71	276.79
	S.C. 30K8	3601.27	3369.55	158.32	150.99	8138.89	7816.67	44.35	43.26	1.688	1.713	10.55	10.71	60.83	57.78	380.20	361.11
	S.C. 2031	3380.67	3254.12	149.60	147.13	8944.44	8411.11	37.91	38.76	1.903	1.856	11.90	11.60	64.52	60.53	403.24	378.29
L.S.D at 5%		**96.54**	**57.96**	**6.32**	**5.54**	**170.66**	**119.59**	**0.68**	**0.46**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**1.71**	**1.15**	**10.67**	**7.19**

The superiority rations in the first season between the highest nitrogen rate (150 kg N/fed) and each of 120 and 90 kg N/fed were 2.37 and 6.38 % for leaf area/plant; 1.67 and 4.77 % for plant height; 6.58 and 16.43 % for ear weight; 3.55 and 7.39 % for 100-kernel weight; 7.87 and 20.38 % for ear yield/fed; 3.40 and 10.21 % for stover yield/fed; 8.34 and 21.62 % for grain yield/fed; 5.51 and 14.88 % for biological yield/fed in addition to 9.81 and 25.62 % for protein yield/fed, respectively. The increases rations in the second season when maize received 150 kg N/fed over each of 120 and 90 kg N/fed were 1.76 and 4.25 % for leaf area/plant; 1.72 and 4.16 % for plant height; 6.09 and 16.44 % for ear weight; 3.08 and 7.85 % for 100-kernel weight; 4.39 and 14.99 % for ear yield/fed; 2.67 and 7.11 % for stover yield/fed; 4.73 and 16.01 % for grain yield/fed; 3.50 and 10.81 % for biological yield/fed in addition to 5.87 and 19.36 % for protein yield/fed, respectively.

The increase in growth traits associated with increasing nitrogen fertilization rates may be attributed to the role of nitrogen in enhancement meristematic activity and cell division, which caused increase in internodes length, No. of internodes and both of them. The increase in maize yield and its attributes because of increasing nitrogen fertilizer rates up to 150 kg N/fed can be easily ascribed to the role of nitrogen in activating growth of plants, consequently enhancement yield components (ear dimension, No. of kernels/ear, ear weight as well as 100-kernel weight) and consequently increasing grain yield/unit area. In the other hand, nitrogen application up to 150 kg N/fed decreased the period from sowing to 50 % tasseling and silking in both seasons. This decrease may be due to enhanced growth rate and accumulate and dry matter accumulation of more assimilates and dry matter accumulation in an early stage. In addition, the increases in kernels nitrogen content % or kernels crude protein content % by raising nitrogen rates may be due to the fact that nitrogen for essential for building up to the protoplasm amino acids and proteins. These results are in compatible with those found by El-Gedwy 2007; Sallah et al., 2009; Szulc et al., 2009; Bamuaafa et al., 2010; Hokmalipour and Darbandi 2011; Dawadi and Sah 2012; Karasu 2012; Li et al., 2012; Kandil 2013; Radma and Dagash 2013; Adeniyan 2014; Ahmadu 2014; Delibaltova 2014; Khan et al., 2014; Rehman et al., 2014; Hafez and Abdelaal 2015; Kandil et al., 2016; Gharibi et al., 2016; Majid et al., 2017; Marković et al., 2017; Sapkota et al., 2017; Sharanabasappa et al., 2017; Takele et al., 2017; Ahmad et al., 2018 and Zeleke et al., 2018.

Effect of white single cross hybrids of maize:

Results presented in Tables 2, 3 and 4 showed that mean values of all growth traits, yield components, yield and kernels chemical properties were significant differences with the studied three white single cross hybrids of maize, *i.e.* S.C. 7071, S.C. 30K8 and S.C. 2031 during 2016 and 2017 seasons.

The maximum mean values of No. of plants carried two ears/fed (2266.67 and 2029.63 plants), No. of ears/fed (25333.33 and 24503.70 ears), No. of rows/ear (13.33 and 13.54 rows), No. of kernels/row (40.49 and 41.56 kernels), No. of kernels/ear (541.00 and 564.02 kernels), grain yield/fed (3289.30 and 3158.74 kg), grain yield/plant (144.44 and 142.40 g) and harvest index (43.20 and 42.49 %) as well as the lowest mean values of No. of barren plants/fed (207.41 and 355.56 plants) and the shortest period from planting to 50 % tasseling (64.04 and 62.93 days) and silking (66.37 and 65.19 days) during the first and second seasons, respectively were obtained from planting maize hybrid of S.C. 30K8. Planting maize hybrid of S.C. 30K8 increased grain yield kg/fed by 6.57 and 26.77 % in the first season, corresponding to 3.00 and 18.30 % in second season, over grain yield/fed of S.C. 2031 and S.C. 7071 maize hybrids, respectively.

Results may reveal the superiority of S.C. 2031 maize hybrid in mean values of leaf area/plant (9568.69 and 9302.48 cm^2), ear weight (197.42 and 195.23 g), 100-kernel weight (35.30 and 33.77 g), ear yield/fed (4053.70 and 3996.30 kg), biological yield/fed (8403.70 and 8066.67 kg), kernels nitrogen content (1.877 and 1.829 %), kernels crude protein content (11.73 and 11.43 %), nitrogen uptake/fed (58.35 and 56.25 kg) and protein yield/fed (364.66 and 351.56 kg) in the first and second seasons, respectively. Planting maize hybrid of S.C. 2031 increased ears yield kg/fed by 1.44 and 31.47 % in 2016 season, corresponding to 3.55 and 23.74 % in 2017 season, over ears yield/fed of S.C. 30K8 and S.C. 7071 maize hybrids, respectively.

Planting maize hybrid of S.C. 7071 gave the highest mean values of No. of green leaves/plant (13.75 and 13.64 leaves), plant height (311.30 and 317.22 cm), ear height (177.41 and 179.63 cm), shelling (84.01 and 82.41 %) and stover yield/fed (4492.59 and 4346.30 kg) in the first and second seasons, respectively. Planting maize hybrid of S.C. 7071 increased stover yield kg/fed by 3.28 and 23.78 % in 2016 season, corresponding to 6.78 and 21.04 % in 2017 season, over stover yield/fed of S.C. 2031 and S.C. 30K8 maize hybrids, respectively.

These differences may be due to the genetic differences between the three white single cross maize hybrids. Also, the differences in 100-kernel weight might be attributed to the variation in translocation rate of photosynthetic from leaves to the storing organs*, i.e.* the kernels. The superiority of S.C. 30K8 maize hybrid in grain yield/fed over the other maize hybrids might be due to the increase in yield components, namely, No. of plants carried two ears/fed, No. of ears/fed, No. of rows/ear, No. of kernels/row, No. of kernels/ear, grain yield/plant and harvest index. These results are in harmony with those reported by Sallah et al., 2009; Szulc et al.,2009; Bamuaafa et al., 2010; Hokmalipour and Darbandi 2011; Dawadi and Sah 2012; Karasu 2012; Li et al. 2012; Kandil 2013; Radma and Dagash 2013; Adeniyan 2014; Ahmadu 2014; Delibaltova 2014; Khan et al. 2014; Rehman et al. 2014; Hafez and Abdelaal 2015; Karki et al., 2015; Kinfe et al., 2016; Majid et al., 2017; Marković et al., 2017; Ahmad et al., 2018, Eyasu et al., 2018 and Sidi et al., 2019 showed that hybrids markedly varied for almost growth, yield, yield components and kernels chemical properties of maize.

Interaction effect:

Results in Tables 2, 3 and 4 showed that significant effect of the interaction between nitrogen fertilizer rates and white single cross hybrids obtained for almost growth, yield, yield components and kernels chemical properties of maize namely, leaf area/plant, plant height, ear height, No. of plants carried two ears/fed, No. of barren plants/fed, No. of ears/fed, No. of kernels/row, No. of kernels/ear, ear weight, shelling %, 100-kernel weight, ear yield/fed, stover yield/fed, grain yield/fed, grain yield/plant, biological yield/fed, harvest index, nitrogen uptake/fed and protein yield/fed in the both seasons. While, No. of days to 50 % tasseling, No. of days to 50 % silking, No. of green leaves/plant, No. of rows/ear, kernels nitrogen content and kernels crude protein content were not significantly affected by the interaction between nitrogen fertilizer rates and white single cross hybrids of maize in both seasons.

Planting maize hybrid of S.C. 30K8 which fertilized by the higher nitrogen rate (150 kg N/fed) recorded significantly the highest mean values of No. of plants carried two ears/fed (2711.11 and 2177.78 plants), No. of ears/fed (25822.22 and 24844.44 ears), No. of kernels/row (43.29 and 44.33 kernels), No. of kernels/ear (583.32 and 607.94 kernels), grain yield/fed (3601.27 and 3369.55 kg), grain yield/plant (158.32 and 150.99 g) and harvest index (44.35 and 43.26 %) as well as gave the lowest mean values of No. of barren plants/fed (133.33 and 222.22 plants) in the first and second seasons, respectively.

Sowing maize hybrid of S.C. 2031 under soil fertilized by 150 kg N/fed recorded the greatest mean values of leaf area/plant (9842.72 and 9489.33 cm^2), ear weight (210.60 and 206.68 g), 100-kernel weight (36.63 and 35.02 g), ear yield/fed (4405.56 and 4222.22 kg), biological yield/fed (8944.44 and 8411.11 kg), nitrogen uptake/fed (64.52 and 60.53 kg) and protein yield/fed (403.24 and 378.29 kg) during the first and second seasons, respectively.

The highest mean values of plant height (317.78 and 323.33 cm), ear height (181.11 and 183.33 cm), shelling (84.37 and 82.67 %) and stover yield/fed (4694.44 and 4483.33 kg) in the first and second seasons, respectively which were obtained from planting maize hybrid of S.C. 7071 when received 150 kg N/fed.

These results are in agreement with those obtained by Sallah et al., 2009; Szulc et al., 2009; Bamuaafa et al., 2010; Hokmalipour and Darbandi 2011; Dawadi and Sah 2012; Karasu 2012; Li et al., 2012; Kandil 2013; Radma and Dagash 2013; Adeniyan 2014; Ahmadu 2014; Delibaltova 2014; Khan et al., 2014; Rehman et al., 2014; Hafez and Abdelaal 2015; Majid et al., 2017; Marković et al., 2017 and Ahmad et al., 2018 they found that growth, yield components, yield and chemical properties of maize were significantly affected by the interaction between nitrogen fertilizer rates and maize hybrids.

CONCLUSION

From the obtained results of this study it could be concluded that planting maize hybrid of S.C. 30K8 with fertilizing by 150 kg N/fed in order to maximizing its productivity.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

This work was carried out in collaboration between all authors. Author A.A. El Hosary designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors Mohamed E. Sidi, G.Y. Hammam, El Saeed M. El-Gedwy and A.A.A. El-Hosary supervised the study and managed the literature searches. Author El Saeed M. El-Gedwy and A.A.A. El-Hosary managed the experimental process and performed data analyses. All authors read and approved the final manuscript.

REFERENCES

Adeniyan O N, 2014. Effect of different population densities and fertilizer rates on the performance of different maize varieties in two rain forest agro ecosystems of South West Nigeria. Afr, J. Plant Sci., 8 (8): 410-415.

Ahmad S, Khan A A, Kamran M, Ahmad I, Ali S, Fahad S, 2018. Response of maize cultivars to various nitrogen levels. Eur. Exp. Biol., 8 (1-2): 1-4.

Ahmadu I A, 2014. Performance of extra-early maize (*Zea mays*, L.) varieties as influenced by rate of nitrogen and intra-row spacing. M. Sc. Thesis, Fac. Agric., Ahmadu Bello Univ. Zaria, Nigeria.

AOAC, 1990. Official Methods of Analysis Association of Official Analysis Chemists, 13th Ed., Washington, D. C., U. S. A.

Bamuaafa M S, Abd El-Rahman K A, Abd El-Rahim H M , El-Far I A 2010. Impact of water stress and nitrogen fertilizer on yield, yield components and quality of maize hybrids (*Zea mays*, L.). Assiut J. Agric. Sci., 41 (4):41-62.

Black CA, Evans D D, 1965. Methods of Soil Analysis. Amer. Soc. of Agron., Inc. Pub. Madison, Wisconsin, USA.

Dawadi D R, Sah SK, 2012. Growth and yield of hybrid maize (*Zea mays*, L.) in relation to planting density and nitrogen levels during winter season in Nepal. Tropical Agric. Res., 23 (3): 218-227.

Delibaltova V, 2014. Response of maize hybrids to different nitrogen applications under climatic conditions of Plovdiv region. Intl. J. Farm. & Alli. Sci., 3 (4): 408-412.

El-Gedwy, EMM, 2007). Maize yield potential as affected by organic and mineral nitrogen, crop residues and tillage. M. Sc. Thesis, Fac. Agric., Benha Univ., Egypt.

EL-Hosary AAA, Sedhom, AS , EL-Badawy, M EL M, 2011. Genetic and Biotechnological Studies for Important Traits in Maize. LAP Lambert Academic Publishing, ISBN 978-3-8454-4108-5, paperback, 280 Pages

Eyasu E, Shanka D, Dalga D, Elias E 2018. Yield response of maize (*Zea mays*, L.) varieties to row spacing under irrigation at Geleko, Ofa Woreda, Wolaita Zone, and Southern Ethiopia. J. Exp. Agric. Inter., 20 (1): 1-10.

Gharibi, A I S, Hammam G Y M, Salwau M E M, Allam S A H and El-Gedwy E M M, 2016. Response of maize yield to nitrogen fertilization and foliar spray by some microelements. J. Plant Production, Mansoura Univ., 7 (5): 455-463.

Gomez KA, Gomez A A, 1984. Statistical Procedures for Agricultural Research. 2nd, (ed). John Wiley and Sons, NY, U.S.A.

Hafez EM, Abdelaal Kh AA, 2015. Impact of nitrogen fertilization levels on morphophysiological characters and yield quality of some maize hybrids (*Zea mays*, L.). Egypt. J. Agron., 37 (1): 35-48.

Hokmalipour S, Darbandi M H, 2011. Investigation of nitrogen fertilizer levels on dry matter remobilization of some varieties of corn (*Zea mays*, L.). World Appl. Sci. J., 12 (6): 862-870.

Kandil A A, Attia A N, EL-Moursy SA and Abd-Elnaby M M , 2016. Yielding and growth parameters of maize (*Zea mays*, L.) as affected by different foliar and nitrogen soil fertilization. Adv. Agric. Sci., 4 (3): 13-34.

Kandil E E E, 2013. Response of some maize hybrids (*Zea mays*, L.) to different levels of nitrogenous fertilization. J. Appl. Sci. Res., 9 (3): 1902-1908.

Karasu A, 2012. Effect of nitrogen levels on grain yield and some attributes of some hybrid maize cultivars. Bulg. J. Agric. Sci., 18 (1): 42-48.

Karki T B, Govind K C, Shrestha J , Yadav J P, 2015. Tillage and planting density affect the performance of maize hybrids in Chitwan, Nepal. J. Maize Res. Dev., 1 (1):10-20.

Khan F, Khan S, Fahad S, Faisal S, Hussain S, Ali S, Ali A, 2014. Effect of different levels of nitrogen and phosphorus on the phenology and yield of maize varieties. Amer. J. Plant Sci., 5: 2582-2590.

Kinfe H., Yiergalem T, Alem R., Redae W, Desalegn Y, Welegerima G, Kifle G, Husien D S, 2016. Evaluating hybrid maize genotypes for grain yield and yield related traits in north western Tigray, Ethiopia. Inter. J. Res. Agric. For., 3 (12): 17-21.

Li G, Zhang Z S, Gao H Y, Liu P, Dong S T, Zhang J W , Zhao B, 2012. Effects of nitrogen on photosynthetic characteristics of leaves from two different stay-green corn (*Zea mays*, L.) varieties at the grain filling stage. Can. J. Plant Sci., 92: 671-680.

Majid MA, Islam M S, EL Sabagh A, Hasan M K, Saddam M O, Barutcular C, Ratnasekera D, Abdelaal Kh A A , Islam MS, 2017. Influence of varying nitrogen levels on growth, yield and nitrogen use efficiency of hybrid maize (*Zea mays*, L.). J. Exp. Biol. Agric. Sci., 5 (2): 134-142.

Marković M , Josipović M, Šoštarić J, Jambrović A, Brkić A, 2017. Response of maize (*Zea mays*, L.) grain yield and yield components to irrigation and nitrogen fertilization. J. Cen. Eur. Agric., 18 (1): 55-72.

Michigan State University, 1983. MSTAT-C: Micro-computer Statistical Program, Version 2. Michigan State University, East Lansing.

Priya G, Parminder N, Jaspreet S, 2012. Antimicrobial and antioxidant activity on *Emblica officinalis* seed extract. IJRAP 3(4):591-596.

Radma I A M, Dagash Y M I, (2013) Effect of different nitrogen and weeding levels on yield of five maize cultivars under irrigation. Univ. J. Agric. Res., 1(4): 119-125.

Rehman K, Ali S, Pervez M W, Rehman M, Hussain S, Aishia G , Khalid M S, 2014. Performance of autumn planted maize hybrids under different fertilizer treatments in semi-arid Punjab Pakistan. J. Glob. Innov. Agric. Soc. Sci., 2 (3): 107-111.

Sallah PY K, Mukakalisa S, Nyombayire A, Mutanyagwa P, 2009. Response of two maize varieties to density and nitrogen fertilizer in the highland zone of Rwanda. J. Appl. Biosci., 20: 1194-1202.

Sapkota A, Shrestha R K, Chalise D, 2017. Response of maize to the soil application of nitrogen and phosphorous fertilizers. Int. J. Appl. Sci. Biotechnol., 5(4): 537-541.

Sharanabasappa, H C, Basavanneppa M A, Koppalkar B G , 2017. Productivity of quality protein maize (*Zea mays*, L.) and soil fertility as influenced by plant population and fertilizer levels under irrigated ecosystem. Int. J. Adv. Biol. Res., 7 (3): 504-508.

Sidi M E, El Hosary A A, Hammam G Y, El-Gedwy El Saeed M and El-Hosary A A A 2019 Maize hybrids yield potential as affected by plant population density in Qalyubia, Egypt. Bioscience Research, 16(2):1565-1576.

Stickler FC , 1964. Row Width and Plant Production Studies. Sixth edition, Iowa state Univ. Press, Ames. U.S.A.

Szulc P., 2009. Effect of nitrogen fertilization and methods of magnesium application on chlorophyll content, accumulation of mineral components, and morphology of two maize hybrid types in the initial growth period. i. Content of chlorophyll and mineral components. Acta. Sci. Pol. Agric., 8 (2): 43-50.

Takele E, Mekonnen Z, Tsegaye D, Abebe A, 2017. Effect of intercropping of legumes and rates of nitrogen fertilizer on yield and yield components of maize (*Zea mays*, L.) at Arba Minch. American J. Plant Sci., 8: 2159-2179.

Zeleke A, Alemayehu G, Yihenew G S 2018. Effects of planting density and nitrogen fertilizer rate on yield and yield related traits of maize (*Zea mays*, L.) in Northwestern, Ethiopia. Adv. Crop Sci. Tech., 6 (2): 1-5.