J. Plant Production, Mansoura Univ., Vol. 10 (8): 707- 714, 2019

Maize Grain Yield and its Quality as Affected by Previous Crop, Nitrogen Rate and Nutrients Foliar Application

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ABSTRACT

Two field experiment was conducted to evaluate effect of preceding winter crop (Wheat and Egyptian clover), nitrogen levels (90, 120 and 150 kg N/fed.) and foliar minerals application (control, potassium sulphate, and micro-nutrient compound as well as their interaction) were carried out at Exp. Stat., Fac. Agric., Cairo Univ., Egypt during 2015 and 2017 growing seasons. Analysis of data showed that all parameters of *Zea mays L.* cv. single cross 131 significantly increased grain protein, carbohydrates and oil contents. The highest values of the previous parameters were obtained when maize was preceded by Egyptian clover, while the lowest ones were noticed after wheat. Results indicated that protein, carbohydrates and oil contents of maize grain and grain yields markedly increased with the increase in N rates from 90 to 150 kg /fed. The maximum value of protein, carbohydrates, oil contents as well as, their yields/fed. were recorded with foliar application of micronutrients + potassium. Results also indicated that maize grown after Egyptian clover and Micronutrients + K sulfate foliar application recorded maximum grain protein content (10.1 and 10.6 %), grain carbohydrate content (63.0 and 68.5%) and oil content (10.0 and 9.9 %) in both seasons, respectively, as well as, recorded maximum protein yield/fed. (0.364 and 0.389 ton) and oil yield/fed. (0.359 and 0.360 ton) in both seasons. Maize grown after Egyptian clover and received 120 kg N/fed. combined with nutrients foliar application of potassium sulphate and micro-nutrients are recommended for high maize grains, protein, carbohydrates and oil yields. On the other hand, maize grown after wheat and received 150 kg N/fed. and nutrients foliar application of potassium sulphate + micronutrients resulted in producing the maximum maize grain, protein, carbohydrates and oil yields.

Keywords: Maize, Nitrogen rates, Potassium, Micronutrients, Foliar application, Grains, Protein, Carbohydrates and Oil yield

INTRODUCTION

More recently, a real challenge faces the workers in the agricultural research field to stop using the high rates of agro-chemicals which negatively affect human health and environment. It is well known that maize crop is considered among the most important cereal crops either in Egypt or all over the world that consumes huge quantities of chemical fertilizers. The crop is primarily grown for its grain which is consumed as human food. Grain quality is a wide term that means different things to maize producers, crop consultants, dairy producers or ruminant and human nutritionist. From the nutritional point of view maize grain content such as fat, protein, oil and starch define maize quality characteristics. Chemical contents of maize grain are very important for human and animal diets. In some developing countries maize is also grown for animal feed and as a base for industrial products such as oils, syrup and starch.

Varvel and Peterson (1990) stated that crop rotation reduced inorganic nitrogen fertilizer needs and at the same time reduced the amount of nitrogen available for leaching, both of which were important for increasing crop yields. Shams (2000) showed that wheat as preceding crop stimulated maize to be more responsive to utilize N applied as compared to legume as preceding crops. Khalil *et al.*, 2001; El-Douby, 2002 and Toaima and Saleh, 2003 studied the effect of preceding crops on the growth and grain yield of maize. Results of them indicated that winter legumes are the ideal preceding crops for maize. El-Gizawy (2009) demonstrated that preceding winter crops were significantly affected plant height, ear weight, grain yield/fed. and grain protein content of maize. Sowing maize after faba bean gave the highest of values of grain yield and its components.

Egyptian soils are known to be poor in available nitrogen due to their low content of organic matter and the small amounts of organic manures added annually.

The positive effects of N application on quality of maize grains were demonstrated by several investigations. Applying N increased protein content in grain and was optimum at 200 kg N ha^{-1} (Razzaq, 1990). Wasaya (2011) reported that increasing nitrogen rate had positive impact on yield and kernel quality of maize, The increase in grain yield was recorded with 200 kg ha^{-1} nitrogen. Maize yield with 200 kg N ha^{-1} was 17% and 8.50% higher than 100 and 150 kgN ha^{-1}, respectively. Kandil, 2013 found that the maximum protein content was achieved by the application of either 429 or 357kg N ha^{-1}. Wei *et al.* (2016) observed that, the rate of photosynthesis significantly decreased under N deficiency, and this response was due to leaf senescence

Potassium is known to interact with almost all of the essential macronutrients, secondary nutrients, and micronutrients. Potassium enhanced the yield related parameters of maize crop. Applying K_2O at 200, 150, and 100 kg ha^{-1} increased maize grain yield by 24.50, 20.31, and 13.14%, respectively, over the control, while K_2O at 200 kg ha^{-1} increased grain yield, grain starch and oil contents, grain protein content, and net income by 24.50, 3.58, 0.23, 0.25, and 31.19%, respectively, over the control (Abdul Rehman *et al*. 2011)

In the last two decades, several investigators in Egypt reported positive response of different field crops to micronutrients fertilization (El-Fouly *et al*., 2010 and 2011 and Salem and El-Gizawy, 2012).

The main goal of the current study in looking for maize production with high quality through feeding the plants with the right does of nitrogen as soil application and applying micronutrients and potassium as foliar feeding, putting into consideration the previous winter crop.

MATERIALS AND METHODS

Two field experiments were carried out at Agric. Res. Exp. Sta. Giza, Fac. Agric., Cairo University, Egypt to assess the effect of N rates and foliar application of micronutrients and K on growth, grain yield and grain quality of maize grown after wheat and Egyptian clover.

Representative soil samples were taken from each site at the depth of 30 cm from the soil surface. Physical and chemical properties of the soil were determined according to the standard procedures described by Black (1965). The soil analysis of the experimental soil for the growing season 2014/2015 before planting winter crops, indicated that the soil is clay loam (3.88% coarse sand, 31.42% fine sand, 29.11% silt and 35.59% clay). pH (paste extract) is 8.33, the EC is 0.72 dSm^{-1},calcium carbonate is 4.0% and organic matter is 1.89%. The available nutrients are nitrogen (0.12 mg/100 g soil), phosphorous (0.13mg/100 g soil), potassium (30.00 mg /100 g soil), calcium (518.0 mg/100 g soil), magnesium (117.0 mg/100 g soil), Iron (4.60 ppm), manganese (1.70 ppm) and zinc (1.00 ppm). The soil chemical analysis of the experimental soil in 2015 and 2017 seasons after planting winter crops is recorded in Table 1.

Table 1. Soil chemical analysis of the experimental site in 2015 and 2017 seasons.

Preceding crop	2015				2017			
	Organic matter (%)	N	P	K	Organic matter (%)	N	P	K
		(mg/100 g soil)				(mg/100 g soil)		
Wheat	2.00	0.17	1.25	32.00	2.12	0.18	1.38	36.00
Egyptian lover	2.75	0.18	2.20	43.50	2.78	0.21	2.80	50.40

Treatments and Experimental Design

Each experiment included 24 treatments which were the combination of two preceding crops (wheat and Egyptian clover), three N rates (90, 120 and 150 kg N/fed.) and four foliar application of K and micro-nutrient compound (Control, Micronutrients compound high in its zinc content 1g/liter (Fe 1.5%, Mn 1.5%, and Zn 4. 5%), K sulphat (1%) and Micro + K to initiate the preceding crop treatments. The experiment was done in form of split split plot based on randomized complete block design with three replications. The studied treatments included: Two preceding crops which considered as the main factor. Nitrogen rates as subplots and foliar application for K and micro-nutrient compound as sub-sub plots. Plot size was 14 m^2 (4×3.5m) having 5 ridges of 4 m in length and 0.7 m in width.

Crop Management Practices

Maize cv. S.C.131 (developed by Maize Research Section of the Agriculture Research Center, Giza, Egypt) was planted on 1^{th} May in 2015 and 2017 growing seasons, respectively. Two maize kernels were hand planted in hills spaced 25 cm and 70 cm between rows. Phosphorus fertilizer was applied before planting at the rate of 150 kg calcium super phosphate (15.5% P_2O_5)/fed. Plots were hand-thinned at the V_3-V_4 leaf stage (before the 1^{st} irrigation) to one plant per hill. Ammonium nitrate (NH_4NO_3-33.5 N %) was applied as the nitrogen source in both seasons in two equal doses, at the V_3-V_4 and at V_5-V_6 leaf stage (before the 1^{st} and 2^{nd} irrigations). Potassium fertilizer in the form of potassium sulphate with rates (1%) applied as foliar application, micronutrients compound high in its zinc was applied as foliar application with rate of 1g/liter (Fe 1.5%, Mn 1.5%, and Zn 4. 5%) two times at 45 and 60 day after sowing. The plots were hand hoed twice for controlling weeds before the first and second irrigations.

Chemical analysis of maize grains

At harvest sample of 120 Day's (included husk and grains) was taken to determine protein, carbohydrates and oil content. Grain protein content (GPC %) was determined as N % * 6.25 on dry weight basis (N % in grain was determined by the microkjeldahl method according to A.O.A.C. (2000). Carbohydrate percentage in grains was determined according to the method adapted by (Dubois *et al*., 1956). Grains oil content (%) was determined by using Soxhelt units and petroleum ether (40-60^oC) as a solvent according to A.O.A.C. (2000).

Statistical analysis

Data were statistically analyzed according to Gomez and Gomez (1984) using the MSTAT-C Statistical Software Package (Freed, 1991) and for drawing the diagrams, Excel software was used. Where the F-test showed significant differences among means, least significant differences (LSD) test was performed at the 0.05 level of probability to compare between means.

RESULTS AND DISCUSSION

Chemical composition of maize grain is the most important trait to the end-use quality. Analysis of variance (ANOVA) showed that all analyzed characteristics were significantly different at level p = 0.05.

Effect of the preceding crop

Data presented in Tables 2 revealed that the previous winter crop had significant effects ongrain protein, carbohydrates and oil contents in both seasons. Results revealed that the highest values of grain protein, carbohydrates and oil contents were obtained when maize sown after Egyptian clover while the lowest ones were noticed with sowing after wheat in both seasons . These increases correspond to 21.3 and 17.1% for grain protein content, 1.6 and 0.6 % for grain carbohydrate content and 5.6 and 5.7 % for grain oil content in the first and second seasons, respectively as compared with maize planted after wheat.

Table 2. Effect of preceding crop on grain protein, carbohydrates and oil contents of maize grain and its yields in 2015 and 2017 seasons.

Parameter	After wheat	After Egyptian clover	F test	After wheat	After Egyptian clover	F test
	Season 2015			Season 2017		
Protein content (%)	7.55	9.11	**	8.16	9.58	*
Carbohydrate content (%)	61.42	62.42	**	67.77	68.22	**
Oil content (%)	8.95	9.46	*	8.69	9.24	**
Yield/fed. (ton)	3.038	3.474	**	3.078	3.487	**
Protein yield (ton)	0.233	0.320	**	0.255	0.338	**
Carbohydrate yield (ton)	1.870	2.171	**	2.089	2.381	**
Oil yield (ton)	0.275	0.332	**	0.271	0.324	**

***,** significantly different at 0.05 and 0.01 probability levels, respectively.**

Results presented in Table 2 indicated that the previous winter crops had significant effect grain, protein, carbohydrate and oil yields/fed. in both seasons. Maize planted after Egyptian clover gave the highest values of grain yield/fed. (3.474 and 3.487ton), protein yield/fed. (0.320 and 0.338 ton), carbohydrate yield/fed. (2.171 and 2.381 ton), as well as oil yield/fed. (0.332 and 0.324 ton) in both seasons, respectively (Table 2). These results could be attributed to the effect of Egyptian clover as a legume forage crop enriching the soil with N and organic matter and to the effect of its residues in improving the physical, chemical and biological characteristics of the soil . These results are in agreement with those obtained by Shams (2000), Abd El-All (2002) and El-Gizawy (2009) who found that maize grown after leguminous crops gave higher yield than after cereal crops.

Effect of nitrogen rate

Data presented in Table 3 showed the significant effect of N rates on grain protein content, grain carbohydrates content and oil content traits of maize in 2015 and 2017seasons. Results in Table 3 clearly indicated that grain contents of protein, grain carbohydrate and oil markedly increased with increasing N rates from 90 to 150 kg/fed. in both seasons. Such increases amounted to 20.0, 2.6 and 16.5 % in the first season and 20.0, 1.9 and 14.3 % in the second one, respectively. The lowest grain protein, carbohydrate, and oil percentages were recorded with the low rate of N (90 kg/fed.) in both seasons. This stimulating effect was due to the close relationship between N and protein. These results are similar to the findings of Uribelarra *et al.* (2004), as well as, Javed *et al.* (1985) and Hejjati and Maleki (1992), who reported the stimulating effect of NPK on protein content. Abdul Rehman *et al.* (2011) found that seed oil, protein and starch contents were the lowest in the control (0 N applied). Howerever, seed oil contents continued to decrease, while seed protein and seed starch increased with each NPK fertilizer increment. Low grain oil content was due to availability of nitrogen to plant at proper time and in proper proportion because if protein content is increased, then oil content is decreased. These results narrate the findings of Witt and Pasuquin (2007).

Table 3. Effect of nitrogen rate on grain protein, carbohydrate and oil contents and its yields of maize in 2015 and 2017 seasons.

Maize grain parameter	90 kg N/fed.	120 kg N/fed.	150 kg N/fed.	LSD	90 kg N/fed.	120 kg N/fed.	150 kg N/fed.	LSD
	Season 2015				Season 2017			
Protein content (%)	7.54	8.44	9.00	0.29	8.01	9.05	9.55	0.29
Carbohydrate content (%)	61.18	61.79	62.79	0.16	67.43	67.88	68.68	0.10
Oil content (%)	8.50	9.19	9.93	0.23	8.41	8.83	9.64	0.09
Grain yield/fed. (ton)	2.676	3.333	3.759	0.047	2.684	3.378	3.786	0.056
Protein Yield (ton)	0.204	0.284	0.340	0.018	0.217	0.308	0.364	0.017
Carbohydrate yield (ton)	1.639	2.061	2.362	0.029	1.811	2.294	2.601	0.037
Oil yield (ton)	0.228	0.307	0.374	0.067	0.227	0.299	0.366	0.016

The results in Table 3 showed that N application resulted in significant increases in yields of grain, protein, carbohydrate and oil. Application of 150 kg/fed. was more effective in increasing yields of grain, protein, carbohydrate and oil/fed. Such results clarified that N is essential for cell division and elongation as well as root growth and dry matter of maize plants (Marschner, 1995). These results are in full agreement with those reported by Al-Naggar *et al.* (2009), El-Gizawy (2009), Wasaya (2011) and Dawadi and Sah (2012).

The effect of micronutrients and potassium foliar applications

Foliar application technique is a particular way to supply macro and micro-nutrients due to its rapid absorption of nutrients. Data concerning protein, carbohydrates and oil contents of grains were subjected to statistical analysis and is represented in Table 4. The results showed significant affect of multi-nutrients (micronutrients + K) application as compared to control. The comparative view of means revealed that protein, oil and carbohydrates contents in grains were markedly increased by all foliar applied treatments as compared with control.

The maximum values of protein, carbohydrates and oil contents of maize grains were recorded in micronutrients in combination with K (9.3 and 9.9%), (62.5 and 68.4%) and (9.8 and 9.5 %) followed by K (9.0 and 9.9%), (62.3 and 68.2 %) and (9.6 and 9.2%) and micronutrients (8.5 and 9.1%),(61.8 and 68.0) and (9.2 and 9.0 %) in the first and second seasons, respectively (Table 4). The least values for the aforementioned parameters were recorded in control treatment. Similar results were found that by Anees *et al.* (2016) who reported that foliar spray of potassium and zinc was efficient technique for increasing the maize yield attributes and net income under rained conditions.

The results in the Table 4 showed that the highest values of maize yields were obtained from spraying micronutrients and potassium together and not individually for the traits: grain yield (3.364 and 3.404 ton/fed.), protein yield (0.318 and 0.341 ton/fed.), carbohydrates yield (2.108 and 2.329 ton/fed.) and oil yield (0.333 and 0.327 ton/fed.) during the first and second seasons, respectively. On the contrast, the control treatment showed the lowest values of the grain, protein, carbohydrates and oil yields/fed. This showed the synergetic role of micronutrients in improving plant growth and other biochemical and physiological activities (Kassab *et al.*, 2004 and Zeidan *et al.*, 2010). Salem and El-Gizawy (2012) demonstrated that micronutrient fertilization using Zn+Mn+Fe treatment was the most effective treatment in all studied traits. Also, Safyan *et al.* (2012) found that spraying micronutrients have a great role in increasing yield of grain maize in Iran.

Table 4. Effect of foliar application on grain protein, carbohydrate and oil contents (%) and its yields (ton/fed.) of maize in 2015 and 2017 seasons.

Maize grain parameter	Control	Micro	K sulfate	Micro + K	LSD	Control	Micro	K sulfate	Micro + K	LSD
	Season 2015					Season 2017				
Protein content	6.43	8.52	9.04	9.32	0.31	6.95	9.07	9.59	9.87	0.25
Carbohydrate content	61.03	61.83	62.28	62.53	0.17	67.50	67.96	68.18	68.35	0.10
Oil content	8.21	9.24	9.57	9.80	0.19	8.17	8.97	9.19	9.52	0.11
Grain yield	3.149	3.223	3.287	3.364	0.071	3.180	3.243	3.305	3.404	0.064
Protein yield	0.205	0.280	0.302	0.318	0.018	0.223	0.300	0.322	0.341	0.017
Carbohydrate yield)	1.925	1.997	2.052	2.108	0.048	2.149	2.207	2.256	2.329	0.043
Oil yield	0.262	0.301	0.318	0.333	0.016	0.262	0.294	0.307	0.327	0.015

Effect of the interaction between previous crop and nitrogen rate

Table 5 revealed that the interaction between previous crop and N rate had significant effects on protein, carbohydrate and oil contents of maize grain in both seasons. Planting maize after Egyptian clover and applying 150 kg N/fed. induced maximum protein, carbohydrates and oil contents in maize grain. Similar trend was observed by Abdul Rehman *et al*. (2011) who found that seed oil, protein, and starch contents were the lowest in the control. Thereafter, seed oil contents continued to decrease, while seed protein and seed carbohydrates increased with each NPK fertilizer increments.

Table 6 showed significant interaction effects between previous crop and N fertilizer on grain, protein, carbohydrates and oil yields/fed. The lowest value of these traits were obtained when maize sown after wheat in combination with 90 kg N/fed. in both seasons. It is very clear that by increasing N rate applied to maizesown after Egyptian clover showed the highest yields in both seasons. Similar results were found by Shams (2000) and El-Gizawy (2009). Idikut *et al.* (2009) indicated that a previous crop x N rate interaction had significant effect on grain yield during both years.

Table 5. Effect of the interaction between previous crop and nitrogen rate on grain protein, carbohydrate and oil contents of maize in 2015 and 2017 seasons.

Previous crop	N rate (ton/fed.)	Grain protein content (%)		Grain carbohydrate content (%)		Grain oil content (%)	
		2015	2017	2015	2017	2015	2017
	90	6.8	7.4	60.6	67.2	8.3	7.9
Wheat	120	7.6	8.3	61.3	67.6	9.0	8.7
	150	8.3	8.8	62.4	68.6	9.6	9.5
	90	8.3	8.6	61.8	67.7	8.7	8.9
Egyptian clover	120	9.3	9.8	62.2	68.2	9.4	9.0
	150	9.7	10.3	63.2	68.8	10.2	9.8
LSD 5%		0.1	0.3	0.2	0.1	0.1	0.2

Table 6. Effect of the interaction between previous crop and nitrogen rate on grain yield, protein yield, carbohydrate yield and oil yield of maize in 2015 and 2017 seasons.

Previous crop	N rate (ton/fed.)	Grain yield ton/fed.		Protein Yield (ton)		Carbohydrate yield (ton)		Oil yield (ton)	
		2015	2017	2015	2017	2015	2017	2015	2017
	90	2.447	2.450	0.166	0.183	1.482	1.646	0.203	0.194
Wheat	120	3.113	3.195	0.236	0.265	1.910	2.161	0.279	0.277
	150	3.555	3.590	0.296	0.317	2.217	2.461	0.343	0.342
	90	2.906	2.918	0.242	0.251	1.795	1.975	0.254	0.261
Egyptian clover	120	3.553	3.561	0.333	0.352	2.212	2.427	0.336	0.322
	150	3.963	3.983	0.385	0.412	2.506	2.741	0.406	0.390
LSD 5%		0.067	0.079	0.014	0.009	0.042	0.052	0.013	0.012

Effect of the interaction between previous crop and foliar application

The effects of previous crop and nutrient foliar application interaction were significant on grain protein, grain carbohydrate s and oil contents in both seasons. Results presented in table 7 indicated that maize plants grown after Egyptian clover and sprayed with Micronutrients compound + K sulfate recorded the maximum protein (10.1 and 10.6 %), carbohydrates (63.0 and 68.5%) and oil (10.0 and 9.9 %) contents of grains in both seasons, respectively. The lowest value of these traits were obtained when maize sown after wheat and spraying plants with water (control) in both seasons. Salem and El-Gizawy (2012) revealed that micronutrient compound of Zn+Mn+Fe was the most effective treatment in all studied traits. Foliar spraying with nutrients gave the highest value of grain yield in both seasons.

The results presented in the Table 8 showed the interaction effects of previous crop and foliar application on protein and oil yields/fed. were significant in both seasons. While, grain yield/fed. and carbohydrate yield/fed. was not significantly affected in both seasons. The results showed that maize plants which sown after Egyptian clover and foliar sprayed Micronutrients + K sulfate as foliar applications recorded the maximum protein yield/fed. (0.364 and 0.389 ton) and oil yield/fed. (0.359 and 0.360 ton) in both seasons, respectively. The lowest value of these traits were obtained when maize sown after wheat and sprayed with water (control) in both seasons.

Table 7. Effect of the interaction between previous crop and foliar application on protein, carbohydrate and oil contents of maize grain in 2015 and 2017 seasons.

Previous crop	Nutrients Foliar app.	Grain protein content (%) 2015	Grain protein content (%) 2017	Grain carbohydrate content (%) 2015	Grain carbohydrate content (%) 2017	Grain oil content (%) 2015	Grain oil content (%) 2017
Wheat	Control	5.8	6.6	60.5	67.2	7.9	8.0
	Micronutrients	7.7	8.2	61.3	67.7	9.0	8.7
	K sulfate	8.2	8.8	61.8	68.0	9.3	8.9
	Micro + K	8.6	9.1	62.1	68.2	9.6	9.1
Egyptian clover	Control	7.1	7.3	61.6	67.8	8.6	8.4
	Micronutrients	9.4	9.9	62.3	68.2	9.5	9.3
	K sulfate	9.9	10.4	62.8	68.4	9.8	9.5
	Micro + K	10.1	10.6	63.0	68.5	10.0	9.9
LSD 5%		0.2	0.4	0.1	0.1	0.1	0.2

Table 8. Effect of the interaction between previous crop and foliar application on yield, protein yield, carbohydrate yield and oil yield of maize grain in 2015 and 2017 seasons.

Previous crop	Nutrients foliar app.	Grain yield ton/fed. 2015	Grain yield ton/fed. 2017	Protein Yield (ton) 2015	Protein Yield (ton) 2017	Carbohydrate yield (ton) 2015	Carbohydrate yield (ton) 2017	Oil yield (ton) 2015	Oil yield (ton) 2017
Wheat	Control	2.936	2.987	0.171	0.197	1.778	2.008	0.233	0.240
	Micronutrients	3.004	3.046	0.233	0.253	1.845	2.066	0.272	0.268
	K sulfate	3.066	3.097	0.255	0.275	1.899	2.109	0.289	0.280
	Micro + K	3.146	3.184	0.272	0.293	1.958	2.174	0.306	0.294
Egyptian clover	Control	3.362	3.372	0.239	0.249	2.072	2.290	0.291	0.283
	Micronutrients	3.442	3.441	0.327	0.346	2.149	2.348	0.330	0.320
	K sulfate	3.508	3.512	0.349	0.369	2.205	2.403	0.347	0.333
	Micro + K	3.583	3.623	0.364	0.389	2.259	2.483	0.359	0.360
LSD 5%		ns	ns	0.011	0.012	ns	ns	0.013	0.014

ns, not significant.

Effect of the interaction between nitrogen rate and nutrients foliar application

Data presented in table 9 showed that nitrogen rate in combination with nutrients foliar treatments markedly increased grain protein and oil contents. However, no significant effects were recorded concerning grain carbohydrates content. Results also indicated that maize plants received 150 kg N/fed. and Micronutrients + K sulfate foliar applications recorded maximum grain protein and oil contents in both seasons. The lowest value of these traits were obtained when maize plants received 90 kg N/fed. with control in both seasons. Similar findings were recorded concerning grain yields protein, carbohydrate and oil/fed. (Table 10).

Table 9. Effect of the interaction between nitrogen rate and nutrients foliar application on protein, carbohydrate and oil contents of maize grains in 2015 and 2017 seasons.

N rate (kg/fed.)	Nutrients foliar app.	Grain protein content (%) 2015	Grain protein content (%) 2017	Grain carbohydrate content (%) 2015	Grain carbohydrate content (%) 2017	Grain oil content (%) 2015	Grain oil content (%) 2017
90	Control	6.1	6.6	60.6	66.9	7.5	7.7
	Micronutrients	7.5	7.8	61.1	67.4	8.5	8.4
	K sulfate	8.2	8.7	61.4	67.6	8.9	8.6
	Micro + K	8.5	9.0	61.6	67.8	9.1	8.9
120	Control	6.5	7.0	61.0	67.4	8.2	8.1
	Micronutrients	8.6	9.4	61.8	67.8	9.2	8.8
	K sulfate	9.3	9.9	62.1	68.1	9.6	9.0
	Micro + K	9.5	9.8	62.3	68.3	9.9	9.5
150	Control	6.8	7.3	61.6	68.2	8.9	8.7
	Micronutrients	9.5	10.0	62.6	68.7	10.0	9.7
	K sulfate	9.7	10.2	63.4	68.9	10.3	10.0
	Micro + K	10.0	10.7	63.6	69.0	10.5	10.2
LSD 5%		0.2	0.4	ns	ns	0.1	0.2

ns, not significant.

Table 10. Effect of the interaction between nitrogen rate and nutrients foliar application on protein, carbohydrate and oil yields of maize grain in 2015 and 2017 seasons.

Nrate (kg/fed.)	Nutrients foliar app.	Grain yield ton/fed. 2015	Grain yield ton/fed. 2017	Protein Yield (ton) 2015	Protein Yield (ton) 2017	Carbohydrate yield (ton) 2015	Carbohydrate yield (ton) 2017	Oil yield (ton) 2015	Oil yield (ton) 2017
90	Control	2.595	2.585	0.159	0.171	1.572	1.730	0.196	0.200
	Micro.	2.641	2.651	0.200	0.208	1.616	1.787	0.225	0.225
	K sulfate	2.702	2.716	0.222	0.237	1.661	1.836	0.240	0.236
	Micro + K	2.766	2.784	0.236	0.251	1.707	1.888	0.252	0.249
120	Control	3.210	3.269	0.209	0.230	1.959	2.205	0.263	0.266
	Micro.	3.304	3.346	0.285	0.315	2.042	2.268	0.305	0.293
	K sulfate	3.375	3.397	0.315	0.339	2.096	2.313	0.323	0.304
	Micro + K	3.443	3.500	0.328	0.348	2.146	2.389	0.339	0.334
150	Control	3.644	3.684	0.248	0.268	2.243	2.513	0.327	0.320
	Micro.	3.724	3.733	0.355	0.376	2.333	2.566	0.374	0.363
	K sulfate	3.784	3.801	0.369	0.389	2.399	2.618	0.390	0.380
	Micro + K	3.883	3.927	0.391	0.424	2.471	2.708	0.406	0.399
LSD 5%		0.123	0.111	0.012	0.011	ns	ns	0.013	0.012

ns, not significant.

Effect of the interaction between previous crop, nitrogen rate and nutrients foliar application

Data presented in table 11 showed that the interaction of previous crop, nitrogen rate and nutrients foliar application had no significant effects on grain contents of protein, carbohydrate and oil in both seasons. However, data presented in table 12 concerning grain yields of protein, carbohydrate, oil and grains showed significant increments in both seasons. The highest value for grain yield (4.083 and 4.139 ton/fed.) resulted from combination of maize planted after Egyptian clover and 150 kg N/fed. and foliar application of micronutrients + K in both seasons respectively, the same trend was recorded for protein and oil yields. However, the lowest grain and protein yields were recorded from maize planted after wheat + 90 kg N/fed. and water foliar spray. On the other hand, Moreover, the highest value of carbohydrates was recorded yield when maize sown after wheat combined with 150 kg N/fed. and foliar of micronutrients + K in both seasons (2.332 and 2.561 resp.). The lowest value was recorded when maize sown after wheat + 90 kg N/fed. and spraying plants with water (control).

Table 11. Effect of the interaction between previous crop, nitrogen rate and nutrients foliar application on protein, carbohydrate and oil contents of maize grain in 2015 and 2017 seasons.

N rate (kg/fed.)	Nutrient foliar app.	Grain protein content (%) 2015	Grain protein content (%) 2017	Grain carbohydrate content (%) 2015	Grain carbohydrate content (%) 2017	Grain oil content (%) 2015	Grain oil content (%) 2017
Wheat							
90	Control	5.2	6.4	60.0	66.5	7.2	7.5
	Micronutrients	6.9	7.3	60.5	67.1	8.2	7.9
	K sulfate	7.3	7.7	60.9	67.3	8.6	8.0
	Micro + K	7.7	8.3	60.8	67.7	9.0	8.3
120	Control	5.8	6.5	60.4	67.0	7.9	7.9
	Micronutrients	7.3	8.3	61.4	67.6	8.9	8.6
	K sulfate	8.3	9.0	61.6	67.9	9.3	8.9
	Micro + K	8.8	9.2	62.0	68.0	9.7	9.2
150	Control	6.3	6.8	61.1	68.0	8.4	8.5
	Micronutrients	8.8	9.0	62.1	68.6	9.8	9.6
	K sulfate	9.0	9.6	62.9	68.8	10.1	9.9
	Micro + K	9.2	9.8	63.3	68.9	10.2	10.0
Egyptian clover							
90	Control	6.9	6.8	61.1	67.3	7.8	7.9
	Micronutrients	8.1	8.3	61.7	67.7	8.8	9.0
	K sulfate	9.0	9.5	61.9	67.8	9.1	9.3
	Micro + K	9.2	9.6	62.3	67.9	9.2	9.5
120	Control	7.1	7.5	61.6	67.9	8.4	8.3
	Micronutrients	9.8	10.4	62.2	68.0	9.5	8.9
	K sulfate	10.2	10.6	62.5	68.3	9.8	9.0
	Micro + K	10.3	10.8	62.6	68.8	10.0	9.9
150	Control	7.3	7.7	62.0	68.4	9.4	8.9
	Micronutrients	10.2	11.0	63.1	68.9	10.3	9.8
	K sulfate	10.4	10.8	638	69.0	10.5	10.1
	Micro + K	10.8	11.7	63.9	69.1	10.7	10.3
LSD 5%		ns	ns	ns	ns	ns	ns

ns, not significant.

Table 12. Effect of the interaction between previous crop, nitrogen rate and nutrient foliar application on grain yield, protein yield, carbohydrate yield and oil yield of maize in 2015 and 2017 seasons.

N rate (kg/fed.)	Nutrient foliar app.	Grain yield ton/fed. 2015	Grain yield ton/fed. 2017	Protein Yield (ton) 2015	Protein Yield (ton) 2017	Carbohydrate yield (ton) 2015	Carbohydrate yield (ton) 2017	Oil yield (ton) 2015	Oil yield (ton) 2017
Wheat									
90	Control	2.375	2.375	0.123	0.152	1.425	1.580	0.172	0.178
	Micronutrients	2.417	2.427	0.167	0.177	1.462	1.628	0.198	0.191
	K sulfate	2.464	2.464	0.180	0.190	1.500	1.659	0.213	0.196
	Micro + K	2.529	2.534	0.195	0.211	1.541	1.716	0.228	0.210
120	Control	3.003	3.103	0.175	0.202	1.813	2.079	0.237	0.246
	Micronutrients	3.080	3.164	0.225	0.264	1.890	2.138	0.274	0.271
	K sulfate	3.143	3.211	0.262	0.289	1.937	2.180	0.291	0.287
	Micro + K	3.225	3.304	0.283	0.304	2.000	2.246	0.314	0.303
150	Control	3.430	3.481	0.215	0.237	2.096	2.366	0.290	0.296
	Micronutrients	3.514	3.547	0.308	0.319	2.182	2.432	0.344	0.342
	K sulfate	3.592	3.617	0.324	0.347	2.258	2.487	0.362	0.358
	Micro + K	3.682	3.715	0.339	0.364	2.332	2.561	0.374	0.370
Egyptian clover									
90	Control	2.814	2.795	0.194	0.190	1.719	1.880	0.221	0.221
	Micronutrients	2.865	2.875	0.233	0.239	1.769	1.947	0.251	0.259
	K sulfate	2.940	2.968	0.264	0.285	1.821	2.014	0.268	0.276
	Micro + K	3.004	3.033	0.276	0.291	1.872	2.060	0.275	0.287
120	Control	3.416	3.435	0.243	0.258	2.105	2.331	0.288	0.285
	Micronutrients	3.528	3.528	0.346	0.367	2.193	2.398	0.335	0.315
	K sulfate	3.607	3.584	0.368	0.389	2.255	2.447	0.354	0.321
	Micro + K	3.661	3.696	0.374	0.393	2.293	2.533	0.365	0.365
150	Control	3.857	3.887	0.281	0.299	1.719	2.659	0.364	0.344
	Micronutrients	3.934	3.920	0.401	0.432	1.769	2.700	0.404	0.385
	K sulfate	3.976	3.985	0.414	0.432	1.821	2.749	0.419	0.402
	Micro + K	4.083	4.139	0.442	0.483	1.872	2.856	0.438	0.428
LSD 5%		0.174	0.113	0.017	0.015	0.117	0.105	0.016	0.017

Data also showed that the highest grains yield/fed. (4.083 and 4.139 ton), protein yield/fed. (0.442 and 0.483 ton), carbohydrates yield/fed. (1.872 and 2.872 ton) and oil yield/fed. (0.438 and 0.428 ton)was achieved by combination among plants grown after Egyptian clover and received 150 kg N/fed. and sprayed with micronutrients + K in both seasons, respectively. The lowest value of these traits under study were shown when maize was grown after wheat and fertilized with 90 kg N/fed. and sprayed with micronutrients and k in both seasons.

CONCLUSION

Based on findings of study, it could be concluded that maize grown after Egyptian clover and fertilized with 150 kg N/fed. and sprayed with micronutrients + K is recommended for high yield and good quality of maize production to achieve. In case maize grown after wheat, the previous combination is also recommended for achieving the aforementioned goal.

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تأثير المحصول السابق ومعدلات التسميد النيتروجيني والرش الورقي بالعناصر المغذية على محصول الذرة وجودة حبوبه

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أجريت تجربتان حقليتان لدراسة تأثير المحصول الشتوي السابق مثل (القمح والبرسيم المصري) ومعدلات التسميد النيتروجينى (٩٠-١٢٠-١٥٠ كجم/ف) والرش الورقي (الكنترول-سلفات البوتاسيوم-العناصر الصغرى) بالإضافة إلى التفاعل بينهم. نفذت التجربة بمحطة التجارب الزراعية بكليه الزراعة- جامعة القاهرة خلال موسمين النمو ٢٠١٥/٢٠١٧. أظهرت النتائج زيادة فى كل قياسات الذرة (هجين فردى ١٣١) زيادة معنوية مثل محتوى الحبوب من البروتين,الكربوهيدرات والزيت. أعلى القيم في عامل المحصول السابق تم الحصول عليها عند زراعة نباتات الذرة بعد البرسيم المصري كمحصول شتوي سابق بينما اقلها ظهرت عند زراعه نباتات الذرة بعد القمح كمحصول شتوى سابق ايضا. أوضحت النتائج أن محصول البروتين, الكربوهيدرات والزيت لحبوب الذرة زادت بزيادة معدلات النيتروجين من ٩٠ الى ١٥٠ كجم نيتروجين/ف. أعلى القيم فى محتوى ومحصول الحبوب من البروتين, الكربوهيدرات والزيت سجلت عند الرش الورقي بالعناصر الصغرى وسلفات البوتاسيوم. أظهرت النتائج أيضا أن نباتات الذرة المزروع بعد البرسيم المصري وتم رشها بالعناصر الصغرى وسلفات البوتاسيوم أظهرت أعلى محتوى حبوب للبروتين (١٠.١-١٠.٦%), الكربوهيدرات (٦٣.٠-٦٨.٥%) والزيت (١٠.٠-٩.٩%) بالإضافة إلى أعلى قيم من محصول البروتين/ف (٠.٣٦٤-٠.٣٨٩ طن) ومحصول الزيت (٠.٣٥٩-٠.٣٦٠ طن) خلال الموسمين. الذرة المزروع بعد البرسيم المصري والمضاف لها ١٢٠ كجم/نيتروجين/ف وتم رشها بالعناصر الصغرى وسلفات بوتاسيوم هي الموصى بها للحصول على أعلى قيم من محصول البروتين, الكربوهيدرات والزيت لحبوب الذرة. ومن ناحية أخرى الذرة المزروع بعد قمح والمضاف لها ١٥٠ كجم/ نيتروجين/ف والرش الورقي للعناصر الصغرى وسلفات البوتاسيوم نتج عنه أعلى محصول بروتين, كربوهيدرات وزيت لحبوب الذرة.