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Response of Five Wheat Cultivars (*Triticum aestivum* L.) To Urea Fertilizer Levels and Some Micronutrients Application at North Delta of Egypt.

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ABSTRACT

The study was carried out at a field experiment of the Faculty of Agriculture, Kafr Elshiekh University, Egypt, during the 2019/2020 and 2020/2021 growing seasons aimed to study the impact of Urea fertilizer application levels and micronutrient applications on wheat productivity in the North Delta region. The experimental design was a split-split plot with three replications, the experiment involved soil application of urea at levels i.e., 25, 50, and 75 kg N fed^{-1}. (feddan=4200 m^2) allocated in main plots, and foliar application of micronutrients (Fe, Mn, Zn and Cu) allocated in the sub-plots. Five wheat cultivars (Shandaweel 1, Misr 2, Misr 3, Sakha 95 and Giza 171)were assigned to sub-sub plots. Results indicated that significant increases in days to heading (100.4 days) and maturity (147.3 days), plant height (91.4 cm), number of fertile tillers m^{-2} (265), TGW (45.3 g), grains spike^{-1} (64.5), grain yield (2.211tons fed.$^{-1}$) and protein content (14.0%) with the highest nitrogen fertilizer rate and M2 micronutrient (Fe = 300 mg L^{-1}, Mn = 100 mg L^{-1}, Zn = 50 mg L^{-1} and Cu = 50 mg L^{-1}). Giza 171 exhibited superiority for heading and maturity days, fertile tillers, and TGW. Sakha 95 recorded the highest biological and grain yield (10.844 and 3.477 tons fed^{-1}.) respectively, while Giza 171 yielded 7.420ton fed.$^{-1}$ straw, and Misr 3 showed superior protein content (13.51%). Increased nitrogen fertilizer and micronutrient application, along with specific cultivars, enhanced most traits, with Giza 171 and Sakha 95 demonstrating superior grain yield, components, and quality.

Keywords: wheat cultivars, nitrogen fertilizer rates, micronutrients, yield, its components, grain quality.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is among the most vital cereal crops worldwide and serves as a staple food for roughly one-third of the global population. It supplies more than 20% of the food energy for the population in Egypt. The primary goal is to boost wheat production to narrow the gap between production and consumption in Egypt. During the 2020/2021 season, Egypt cultivated around 1.344 million ha of wheat, yielding over 8.8 million ton (FAO, 2020). Thus, it is essential to expand the cultivated area for wheat in the long term and enhance productivity per unit area in the short term by adopting good agricultural practices (GAP). This includes identifying the most effective application, nutrient levels, and combinations.

Nitrogen is a crucial element in plant nutrition as it enhances yield and improves crop quality. It is the most limiting nutrient for plants, affecting key growth characteristics such protein content, chlorophyll and protoplasm. Nitrogen is crucial for numerous metabolic processes and is fundamental in the developing living tissues. Increasing nitrogen application (75, 100and 125 kg N fed.$^{-1}$), significantly increases yield and its components (Ibrahim *et al.*, 2014).

Applying micronutrients greatly boosts wheat yield and its components at various growth stages. Specifically, the use of micronutrients like Fe, Mn, and Zn improves grain yield, straw yield, 1000-grain weight, number of grains spike^{-1} and increases Fe, Mn, and Zn concentrations in flag leaves and grains, as well as protein content in grains (Zeidan *et al.*, 2010). Foliar application of zinc, boron and copper positively affects yield and yield components, especially in wheat, where yield and yield components are improved (Daneshbakhsh *et al.*, 2013). Foliar application of micronutrients significantly enhances plant height, spike length, spikelets spike^{-1}, grains spike^{-1}, test weight, tillers m^{-1}, grain yield, biological yield and harvest index of wheat (Mekkei and El-Haggan 2014; Zain *et al.*, 2015). Additionally, Faizy *et al.*, (2017) found that the most effective treatments for wheat grain and straw yield were 80 kg N / hectare, 100 mg L^{-1} Mn, and 50 mg L^{-1} Zn, applied 35 and 70 days after sowing.

Significant variation exists among wheat cultivars due to genetic differences. El-Hag and Alaa (2017) observed differences among cultivars in the number of days to heading and maturity, plant height, number of fertile tillers m^{-2}, thousand-grain weight, number of grains spike^{-1}, grain yield, straw yield and harvest index. Similarly, Singh and Singh (2013), El-Hag (2016), and Kandil *et al.*, (2016) reported varietal differences in day to heading and maturity, plant height, number of spikes m^{-2}, number of grains spike^{-1}, thousand-grain weight, grain yield, straw yield and harvest index.

This study aimed to examine the impact of three nitrogen fertilizer rates applied as soil treatment and the foliar application of micronutrients (Fe, Mn, Zn and Cu) on five wheat cultivars, with a focus on yield and its components in the North Delta region of Egypt.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of the Faculty of Agriculture, Kafr el-

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Sheikh University, Kafr el-Sheikh Governorate, Egypt, during the winter growing seasons of 2019/2020 and 2020/2021. The study aimed to evaluate the effects of three Urea fertilizer levels (25, 50, and 75 kg N fed.$^{-1}$) and four micronutrients (Fe, Mn, Cu and Zn) applied as a combined foliar treatment on five wheat cultivars (*Triticum aestivum* L.), specifically Shandaweel 1, Misr 2, Misr 3, Sakha 95and Giza 171.

Preparation of mixed micronutrient solutions: Stock solutions of Fe, Mn, Cu and Zn were prepared by dissolving the required amounts of pure metal salts (sulfates) in a minimal volume of distilled water, then transferring the solutions to a 1-liter measuring flask. Mixture solutions of metal ions were then created by combining different volumes of the stock solutions to achieve M0 (Control): Spraying with distilled water at the same time with M1 and M2, (M1): Fe = 200 mg L^{-1}, Mn = 70 mg L^{-1}, Zn = 30 mg L^{-1}, and Cu = 30 mg L^{-1} and (M2): Fe = 300 mg L^{-1}, Mn = 100 mg L^{-1}, Zn = 50 mg L^{-1} and Cu = 50 mg L^{-1}. The solutions were then combined with 1.0% chelating agents, including EDTA, amino acids and humic acids, which were prepared at the central laboratory of Sakha Agricultural Research Station.

Wheat grain was generously provided by the Wheat Department at the Agricultural Research Station, Sakha, Kafr El Sheikh, Egypt. A split-split plot design with three replicates was employed. The main plots were designated for three Urea levels (25, 50 and 75 kg N fed.$^{-1}$), while the subplots were assigned three forms of micronutrient applications in two concentrations each for Fe, Cu, Mn and Zn:

Micronutrients were applied in two sprays: the first at the tillering stage (35 days after sowing) and the second at the booting stage (70 days after sowing).

The field was thoroughly prepared before sowing by plowing twice with a tractor, followed by planking to create a fine seedbed. Wheat cultivars were allocated to sub-sub plots, each consisting of 6 rows spaced 20 cm apart and 3.5 meters long, covering a total area of 4.2 m². Wheat seeds were sown to achieve a target population of 350 plants per square meter.

Table 1. physical and chemical analysis in 2019/20 and 2020/21.

Character								
Physical characteristics					**Chemical analysis**			
Seasons	**Sand %**	**Silt %**	**Clay %**	**Soil texture**	**N (exchangeable ppm)**	**P (exchangeable ppm)**	**K (exchangeable ppm)**	**Soil pH**
2019/20	22.12	28.10	50.15	clay	19	19.5	400	8.00
2020/21	20.30	30.50	48.20	clay	20	28.7	415	7.75

Nitrogen was applied as urea (46% N) in three doses: the first dose (20%) at sowing, the second dose (40%) at the first irrigation (25 days after sowing) and the remaining dose (40%) 53 days after sowing.

Phosphorus was applied as mono super phosphate (15.5% P_2O_5) at a rate of 15 kg P_2O_5 fed.$^{-1}$ during soil preparation. Potassium was applied as potassium sulfate (48% K_2O) at a rate of 24 kg K_2O fed.$^{-1}$ at the first irrigation. Other agricultural practices followed the recommendations of the Ministry of Agriculture.

At maturity, plants were harvested, and various traits: including plant height, number of spikes m^{-2}, number of grains spike^{-1} and thousand-grain weight (TGW): were recorded from 10 randomly selected plants in each plot. Seed protein content was measured using a seed analyzer device (Zeltex ZX9500, Japan). Grain yield and biological yield were determined by harvesting an area of 3 m² from each plot to account for marginal effects.

The studied traits:

The analyzed parameters included the number of days to 50% heading, number of days to physiological maturity, plant height at harvest, number of spikes m^{-2}, thousand-grain weight (TGW), number of grains spike^{-1}, number of spikelets spike^{-1}, straw yield (tons fed.$^{-1}$), grain yield (tons fed.$^{-1}$) and grain quality (crude protein percentage).

Statistical analysis:

Statistical analysis involved calculating the mean values from three replicates. The data were analyzed using analysis of variance (ANOVA) according to the method described by Gomez and Gomez (1984). The MSTATC computer software (Russel and Eisensmith 1983) was used for statistical analysis, and differences among means were determined using Duncan's multiple range test (Duncan 1955).

RESULTS AND DISCUSSION

Results

Effect of Urea fertilizer:

The data presented in Table (2) show that Urea fertilizer application had a significant impact on various growth and development parameters of wheat. In both seasons, Urea fertilizer levels affected the number of days to heading, days to maturity, plant height, and number of productive tillers.

Applying 75 kg N fed.$^{-1}$ resulted in the longest duration to heading (101.5 and 99.2 days), indicating a delay in reaching the heading stage compared to other Urea rates. This delay might affect the developmental stages and growth patterns of the wheat plants. Additionally, the number of days to maturity was notably extended with the 75 kg N fed.$^{-1}$ application, signifying a longer maturation period relative to lower Urea levels.

Plant height was significantly influenced by Urea levels in both seasons. The application of 75 kg N fed.$^{-1}$ led to the tallest plants (90.5 and 92.3 cm), whereas reducing the Urea level to 25 kg N fed.$^{-1}$ resulted in shorter plants (81.8 and 81.7 cm) in both seasons.

The number of productive tillers also showed significant variation due to nitrogen application in both seasons. The highest number of productive tillers (279.4 and 250.5 m^{-2}) was achieved with 75 kg N fed.$^{-1}$, whereas a reduction to 25 kg N fed.$^{-1}$resulted in fewer productive tillers (212.07 and 210.2 m^{-2}).

Table (3) shows that increasing Urea fertilizer levels from 25 to 50 and 75 kg N fed.$^{-1}$ had a highly significant effect on thousand-grain weight (TGW) in the 2019/20 season and a significant effect in the 2020/21 season. The highest TGW was observed with 75 kg N fed.$^{-1}$, at 45.0 and 45.5 grams for the respective seasons. In contrast, 25 kg N fed.$^{-1}$ resulted in lower TGW values of 39.5 and 41.6 grams. This indicates that Urea, a crucial nutrient, contributed to the increase in TGW.

The number of grains spike^{-1}, an important yield component, was significantly affected by various factors, including balanced nutrition. The highest number of grains spike^{-1} (67.0 and 62.0) was observed with 75 kg N fed.$^{-1}$, while 25 kg N fed.$^{-1}$ resulted in fewer grains spike^{-1} (52.9 and 53.2). Additionally, the number of spikelets spike^{-1} and biological yield were significantly influenced by Urea levels. The highest levels led to increased values for both traits, with 20.0 and 18.8 spikelets spike^{-1} and 9.583 and 8.419 tons fed.$^{-1}$ for the respective seasons.

Table (4) indicates that Urea fertilizer levels of 25 to 50 and 75 kg N fed.$^{-1}$ significantly improved grain yield, straw yield and protein percentage. The highest yields for both grain and straw were achieved with 75 kg N fed.$^{-1}$, measuring 2.642 and 3.275 tons fed.$^{-1}$for grain and 6.941 and 5.144 tons fed.$^{-1}$ for straw in the 2019/20 and 2020/21 seasons, respectively. Conversely, the lowest values were recorded with 25 kg N fed.$^{-1}$, with grain yields of 2.268 and 2.772 tons fed.$^{-1}$and straw yields of 6.074 and 4.929 tons fed.$^{-1}$. The mean crude protein percentage was higher with increased Urea levels, recorded as 12.42 and 11.51% for the respective seasons. The lowest percentages were found with 25 kg N fed.$^{-1}$, at 11.67 and 10.11%.

These results underline the beneficial impact of higher Urea fertilizer levels on grain yield, straw yield and protein content. The improvements in grain yield can be attributed to increased numbers of fertile tillers, TGW, and grains spike^{-1}, which were positively affected by higher Urea levels up to 75 kg N fed.$^{-1}$. These findings align with previous studies that have reported a positive correlation between Urea levels and yield components.

Table 2. Means of number of days to heading, number of days to maturity, plant height and number of productive tillers as affected by urea fertilizer, foliar application of micronutrients and their interaction effects on five bread wheat cultivars in 2019/20 and 2020/21.

Trait / Treatment	No. of days to heading		No. of days to maturity		Plant height (cm)		No. of productive tillers	
	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21
Urea fertilizer levels kg N fed^{-1}.								
25	95.4b	93.6c	139.8c	140.0b	81.8b	81.7c	212.0c	210.2b
50	100.3a	96.6b	146.2b	142.0ab	87.2a	87.7b	253.9b	236.1a
75	101.5a	99.2a	150.2a	144.4a	90.5a	92.3a	279.4a	250.5a
F test	**	**	**	*	*	*	**	*
Micronutrients treatments (M)								
Control	98.6c	95.8b	144.3c	141.36b	85.3b	86.1b	246.3	227.4
M1	99.1b	96.6a	145.5b	142.24a	86.4b	87.2ab	248.8	233.8
M2	99.6a	96.9a	146.4a	142.82a	87.8a	88.4a	250.1	235.6
F test	**	**	**	**	**	**	NS	NS
Wheat cultivars (Cu)								
Shandaweel 1	97.6d	96.6c	147.0ab	143.8a	89.3a	96.0a	231.3c	217.3b
Misr 2	100. 9b	97.7b	145.9b	142.5b	86.9b	87.5bc	241.6bc	199.9b
Misr 3	99.5c	94.7d	142.6c	138.9d	83.7d	79.8d	240.6bc	206.2b
Sakha 95	95.1e	93.2e	143.5c	140.8c	85.4c	85.0c	250.9b	270.3a
Giza 171	102.2a	100.3a	147.9a	144.7a	87.2b	88.0b	277.6a	267.6a
F test	**	**	**	**	**	**	**	**
Interaction								
N x M	NS	NS	NS	NS	NS	NS	NS	NS
N x Cu	**	*	NS	*	**	**	*	**
Cu x M	NS	NS	NS	NS	NS	NS	NS	NS
N x M x CU	NS	NS	NS	NS	NS	NS	NS	NS

***,** and NS significant, highly significant and not significant**

The data in Table (4), together with the referenced study, indicate that higher nitrogen fertilizer rates have a positive effect on grain yield, straw yield, and crude protein content. Effective nitrogen fertilization is essential for maximizing wheat productivity and enhancing the quality of harvested grains.

Effect of micronutrients application:

Regarding the effects of foliar fertilization application with the highest concentration (M2) led to an increase and recorded highly significant values for the number of days to heading (99.6 and 96.9 days) and number of days to maturity (146.4 and 142.8 days), as well as an increase in plant height (87.8 and 88.4 cm) in both seasons. Treatment (M0) resulted in the lowest values of (98.6, 95.8, 144.3, 141.4, 85.3, and 86.1) for these traits in 2019/20 and 2020/21 seasons, respectively.

However, the number of productive tillers was insignificantly affected by micronutrients application in both seasons. This lack of effect can be attributed to the timing of micronutrient addition, which was applied after the formation of the tillering stage. Tillering begins after germination and occurs between 30-35 days after sowing. As a result, the number of productive tillers remained unaffected by the application of micronutrients.

The data presented in Table (3) show that foliar application of micronutrients significantly affected thousand-grain weight (TGW) and the number of grains spike^{-1}, with statistical significance levels of ($p < 0.001$) and ($p < 0.05$) for the 2019/20 and 2020/21 growing seasons. The TGW was recorded at (42.6 and 43.8 grams) and the number of grains spike^{-1} was (62.5 and 57.8) with the M2 treatments.

Additionally, the number of spikelets spike^{-1} and biological yield were significantly influenced by the foliar application of micronutrients in both seasons. The highest concentration treatment M2 achieved biological yields of (9.147 and 8.194 tons fed.$^{-1}$)for the respective seasons, compared to the control treatment, which recorded yields of (8.725 and 7.841 tons fed.$^{-1}$) in the 2019/20 and 2020/21 growing seasons, respectively.

Regarding the application of micronutrients, Table (4) indicates that it's had highly significant effects, the M2 treatment recorded the highest grain yield (2.518 & 3.123tons fed.$^{-1}$), straw yield (6.628 & 5.071tons fed.$^{-1}$) and protein percentage (10.16 & 9.82%) in the 2019/20 and 2020/21 seasons, respectively. In contrast, M0 treatment recorded lower values for these traits, with values of (2.384 & 2.915 tons fed.$^{-1}$) for grain yield and (6.341 & 4.926 tons fed.$^{-1}$) for straw yield in 2019/20 & 2020/21 seasons, respectively. Similarly, the protein percentage was lower for the M0 treatment, with values of (11.89 & 10.6%) in 2019/20 & 2020/21 seasons, respectively.

Variation of wheat cultivars:

The results shown in Table (2) also reveal variations among wheat cultivars concerning the number of days to heading, days to maturity, plant height, and the number of productive tillers across both seasons.

Giza 171 exhibited the highest number of days to heading and maturity, with values of (102.2, 100.3, 147.9 and 144.7 days) respectively, compared with Sakha 95. For maturity, Misr 3 recorded (142.6 and 138.9 days). In terms of plant height, Shandaweel 1 was the tallest, measuring (89.3 and 96.0 cm), whereas Misr 3 was the shortest, with heights of (83.7 and 79.8 cm) in both two seasons, respectively.

Regarding the number of spikes m^{-2} Giza 171 displayed and recorded (277.6) in the 2019/20 season, while Sakha 95 and Giza 171 both recorded (270.3 and 267.6) spikes m^{-2} in 2020/21 season. These varietal variations emphasize the importance of choosing suitable cultivars based on specific growth and yield characteristics.

Table 3. Means of TGW, number of grain spike^{-1}, number of spikelets spike^{-1} and biological yield as affected by Urea fertilizer, foliar application of micronutrients and their interaction effects on five bread wheat cultivars in 2019/20 and 2020/21.

Trait	TGW		No.of grain spike^{-1}		No. of spikelets spike^{-1}		Biological yield ton fed.$^{-1}$	
Treatment	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21
Urea fertilizer levels kg N fed.$^{-1}$								
25	39.5c	41.6b	52.9b	53.2b	14.3c	18.0c	8.341c	7.700b
50	41.9b	43.5b	65.4a	56.7b	17.4b	18.5b	8.868b	8.009b
75	45.0a	45.5a	67.0a	62.0a	20.0a	18.8a	9.583a	8.419a
F test	**	*	**	*	**	**	**	**
Micronutrients treatments (M)								
Control	41.6b	43.1b	60.9b	56.6b	16.7c	17.6c	8.725c	8.725c
M1	42.2a	43.6ab	61.9ab	57.5a	17.2b	18.5b	8.921b	8.921b
M2	42.6a	43.8a	62.5a	57.8a	17.8a	19.2a	9.147a	9.147a
F test	**	*	*	**	*	*	**	**
Wheat cultivars (Cu)								
Shandaweel 1	37.1c	39.7c	57.4c	53.5d	18.4a	20.2a	8.648b	8.648b
Misr 2	35.7d	36.8d	62.0b	54.3d	16.1c	18.5c	8.656c	8.656b
Misr 3	43.3b	45.0b	61.2b	56.0c	16.0c	16.5e	6.796d	6.796d
Sakha 95	47.4a	48.0a	63.8a	62.1a	17.1b	17.5d	7.069b	7.069c
Giza 171	47.2a	48.1a	64.3a	60.7b	18.5a	19.6b	9.045a	9.045a
F test	**	**	**	**	**	**	**	**
Interaction								
N x M	NS	NS	NS	NS	NS	NS	NS	*
N x C	**	**	**	**	NS	**	*	**
C x M	NS	NS	NS	NS	**	NS	NS	NS
N x M x C	NS	NS	NS	NS	NS	NS	NS	NS

***,** and NS significant, highly significant and not significant**

The varietal differences in TGW, grains spike^{-1}, spikelets spike^{-1} and biological yield were highly significant in both two seasons. Sakha 95 and Giza 171 superior TGW values, with measurements of (47.4, 47.2, 48.0 and 48.1g) in 2019/20 & 2020/21 seasons, respectively. Regarding the number of grains spike^{-1}, Sakha 95 recorded the highest values of (63.8 and 62.1) in both seasons, whereas Giza 171 had (64.3) in the first season and Sakha 95 had (62.1) in the 2020/21 season.

Significant variations were observed among wheat cultivars for the number of spikelets spike^{-1}, and highly significant differences were noted for biological yield in both the 2019/20 and 2020/21 seasons. In the 2019/20 season, Giza 171 and Shandaweel 1 recorded (18.5 & 18.4) spikelets spike^{-1}, respectively, while Shandaweel 1 had (20.2) in 2020/21 season. In terms of biological yield, Giza 171 obtained (9.311 and 9.045ton fed.$^{-1}$) in 2019/20 season and 2020/21 season, respectively.

These significant varietal differences highlight the importance of selecting appropriate wheat cultivars based on their specific characteristics, which can impact grain yield and overall productivity in different growing seasons.

The varietal differences were highly significant among wheat cultivars for grain yield, straw yield and protein percentage in the 2019/20 and 2020/21 seasons. Sakha 95 achieved the highest grain yield, with 2.536 and 3.144 tons fed.$^{-1}$ in the respective seasons. Giza 171 produced the highest straw yield, recording 6.814 and 5.949 tons fed.$^{-1}$ for the respective seasons. The varietal variation differences for protein percentage, were also highly significant. Misr 3 had the highest values for protein percentage (14.54 & 12.49%) in 2019/20 & 2020/21 seasons, compared with Shandaweel 1 which recorded (10.93 & 9.77%) in 2019/20 & 2020/21 seasons, respectively (Table 4).

These significant varietal differences in grain, straw yield and protein percentage highlight the importance of selecting appropriate wheat cultivars that can meet specific production and quality requirements, considering both seasons' growing conditions.

Table 4. Means of grain yield (ton fed.$^{-1}$), straw yield (ton fed.$^{-1}$) and protein % as affected by Urea fertilizer, foliar application of micronutrients and their interaction effects on five bread wheat cultivars in 2019/20 and 2020/21.

Trait	Grain yield ton fed.$^{-1}$		Straw yield ton fed.$^{-1}$		Protein percentage	
Treatment	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21
			Urea fertilizer levels kg N fed.$^{-1}$			
25	2.268c	2.772c	6.074b	4.929	11.67c	10.11c
50	2.439b	3.024b	6.430b	4.985	12.04b	10.78b
75	2.642a	3.275a	6.941a	5.144	12.42a	11.51a
F test	**	**	*	NS	**	**
			Micronutrients treatments (M)			
Control	2.384c	2.915c	6.341b	4.926b	11.89c	10.60c
M1	2.446b	3.033b	6.475a	5.061a	12.08b	10.77b
M2	2.518a	3.123a	6.628a	5.071a	12.16a	11.82a
F test	**	**	**	*	**	**
			Wheat cultivars (Cu)			
Shandaweel 1	2.481c	3.016c	6.579b	5.632b	10.93e	9.77e
Misr 2	2.392d	2.965d	6.518b	5.692b	11.71c	10.55c
Misr 3	2.341e	2.897e	5.992c	3.899c	14.54a	12.49a
Sakha 95	2.536a	3.144a	6.506c	3.925c	11.79b	10.93b
Giza 171	2.497b	3.097b	6.814a	5.949a	11.26d	10.26d
F test	**	**	**	**	**	**
			Interaction			
N x M	NS	**	NS	NS	**	**
N x C	NS	**	**	*	**	**
C x M	NS	**	NS	NS	**	**
N x M x C	NS	**	NS	NS	NS	**

***,** and NS significant, highly significant and not significant**

Interactions effects

1- The effect of interaction between Urea fertilizer levels and micronutrient treatments

The interaction between Urea fertilizer levels and micronutrient treatment had a highly significant effect on biological yield, grain yield and crude protein percentage (see Fig. 1). The highest values were observed with the combination of 75 kg N fed.$^{-1}$ and M2 treatment, achieving a biological yield of 9.544 tons fed.$^{-1}$, a grain yield of 3.804 tons fed.$^{-1}$ and crude protein percentages of 14.75% and 13.71% for the 2019/20 and 2020/21 seasons, respectively. Conversely, the lowest values for biological yield and grain yield were 8.184 and 2.944 tons fed.$^{-1}$ and for crude protein percentage were 11.53% and 9.95%, observed with the combination of 25 kg N fed.$^{-1}$ and M0 treatment for the respective seasons. This suggests that the application of 75 kg N fed.$^{-1}$ with M2 treatment resulted in the highest values for biological yield, grain yield and crude protein content.

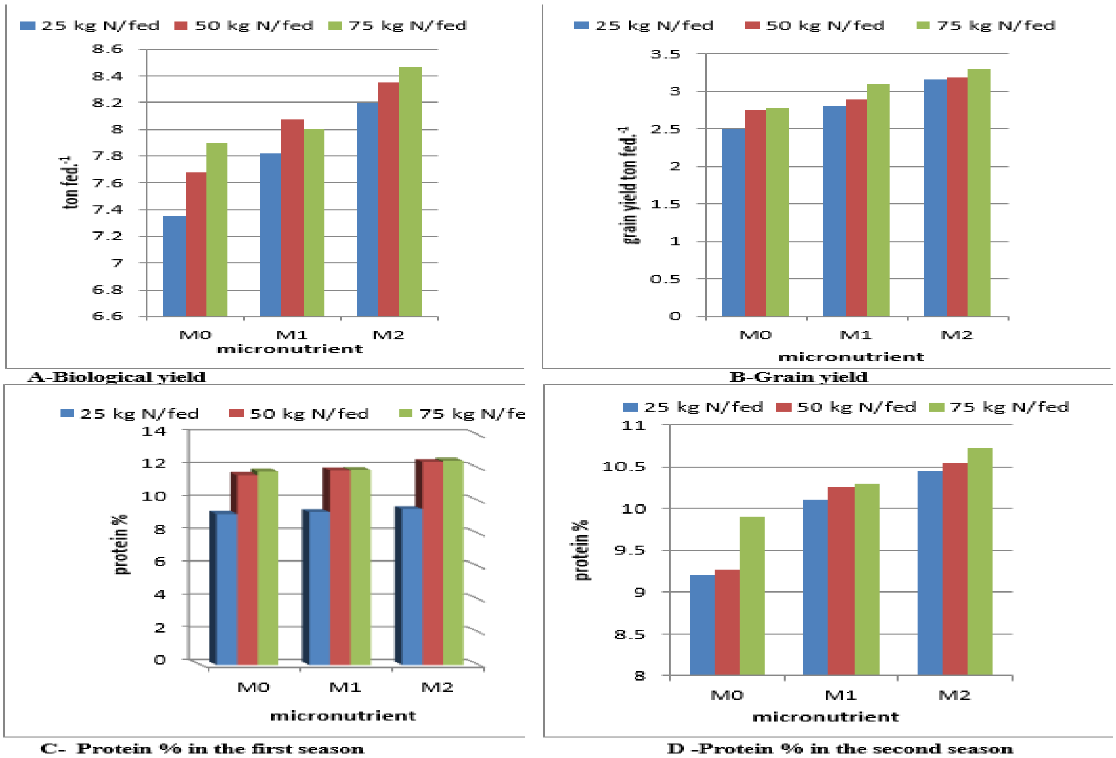


Fig 1. Means of biological yield ton fed.$^{-1}$ (A), grain yield ton fed.$^{-1}$ (B) in the 2020/21 season and crude protein % (C, D), as affected by Urea fertilizer levels and micronutrients treatments in 2019/20 and 2020/21.

2- The interaction effect between Urea fertilizer levels and wheat cultivars:

The data presented in Tables (5, 6and7) highlight the significant impact of the interaction between wheat cultivars and Urea application on various traits. Specifically, there were significant effects ($p < 0.001$) and ($p < 0.05$)) on the number of days to heading in both the 2019/20 and 2020/21 seasons, the number of days to maturity in the 2020/21 season and plant height in both seasons. Increasing Urea levels resulted in longer periods to heading and maturity, as well as taller plants. For example, Giza 171 required (104.2 and 102.7 days) to reach heading with 75 kg N fed.$^{-1}$ in the 2019/20 and 2020/21 seasons, respectively. Additionally, Giza 171 achieved the longest maturity period of (147 days) with 75 kg N fed.$^{-1}$. Giza 171 and Shandaweel 1 recorded the tallest plants at (93.1 cm and 99.1 cm) in the 2019/20 and 2020/21 seasons, respectively, with the same Urea treatment.

Giza 171 showed the highest number of spikes m^{-2} (320 spikes) in the 2019/20 season, while Sakha 95 had the highest number (352.4 spikes) in the 2020/21 season with 75 kg N fed.$^{-1}$. Significant effects were also observed on thousand-grain weight (TGW), number of grains spike^{-1} and biological yield. Sakha 95 achieved the highest TGW (50.1 and 50.5 grams) with 75 kg N fed.$^{-1}$ Misr 3 and Giza 171 had the highest number of grains spike^{-1} (70.0 and 66.2) in the 2019/20 and 2020/21 seasons, respectively. For the number of spikelets spike^{-1}, Giza 171 and Sakha 95 recorded the highest values (21.9 and 20.4) in the 2019/20 season, while Shandaweel 1 and Giza 171 had the highest values (20.5 and 20.3) in the 2020/21 season with 75 kg N fed^{-1}. Giza 171 also recorded the highest biological yield (9.942 and 9.573 tons fed.$^{-1}$) in the respective seasons with 75 kg N fed.$^{-1}$.

Regarding grain and straw yield, Sakha 95 achieved the highest grain yield (3.392 tons fed.$^{-1}$) in the 2019/20 season, while Giza 171 recorded the highest straw yield (7.248 tons fed.$^{-1}$) in the 2020/21 season with 75 kg N fed.$^{-1}$, For protein percentage, Misr 3 showed superior results with 75 kg N fed.$^{-1}$, recording protein percentages of 14.53% and 13.54% in the 2019/20 and 2020/21 seasons, respectively.

Table 5. Means of number of days to heading, number of days to maturity, plant height and number of tillers m^{-2} as affected by interaction between Urea fertilizer and wheat cultivars in 2019/20 and 2020/21 seasons.

Urea fertilizer	Wheat cultivars	No. of days to heading 2019/20	No. of days to heading 2020/21	No. of days to maturity 2020/21	Plant height 2019/20	Plant height 2020/21	Number of tillers m^{-2} 2019/20	Number of tillers m^{-2} 2020/21
25 kg N fed.$^{-1}$	Shandaweel 1	96.3e	93.8f	141.2f-h	87.1cd	92.4bc	192d	187.9gh
	Misr 2	96.8e	95.2e	140.0g-i	83.7f	87.3d	206d	206.1f-h
	Misr 3	93.3f	91.8g	136.3j	80.1gh	74.8fg	207d	205.2f-h
	Sakha 95	91.3g	90.1h	139.9hi	77.7h	73.8g	207d	220.7e-g
	Giza 171	99.1c	97.1d	142.7ef	80.4g	80.5e	247c	231.1d-f
50 kg N fed.$^{-1}$	Shandaweel 1	97.9d	97.0d	143.3de	88.3b-d	96.4ab	242c	244.9c-e
	Misr 2	102.6b	97.8d	142.2ef	86.4de	87.2d	260c	185.1h
	Misr 3	102.2b	94.8e	138.7i	84.0ef	78.9ef	255c	212.3e-h
	Sakha 95	95.7e	92.5g	141.0f-h	89.1b-d	87.5d	253c	264.8b-d
	Giza 171	103.3ab	100.9b	144.5cd	88.1b-d	88.5cd	260c	273.2bc
75 kg N fed.$^{-1}$	Shandaweel 1	98.7cd	99.1c	146.9ab	92.4a	99.1a	260c	219.0e-h
	Misr 2	103.3ab	100.1b	145.3bc	90.7ab	87.9cd	259c	208.6f-h
	Misr 3	102.9b	97.4d	141.6fg	86.9cd	85.8d	260c	201.0f-h
	Sakha 95	98.3cd	96.9d	141.4f-h	89.4bc	93.7b	293b	325.4a
	Giza 171	104.2a	102.7a	147.0a	93.1a	95.0ab	326a	298.6ab
F test		**	*	*	**	**	*	*

***,** significant, highly significant**

Table 6. Means of 1000-grain weight, number of grains spike^{-1}, number of spikelets spike^{-1} and biological yield as affected by interaction between Urea fertilizer and wheat cultivars in 2019/20 and 2020/21 seasons.

Urea fertilizer	Wheat cultivars	TGW 2019/20	TGW 2020/21	No. of grains spike^{-1} 2019/20	No. of grains spike^{-1} 2020/21	Number of spikelets spike^{-1} 2019/20	Number of spikelets spike^{-1} 2020/21	Biological yield (ton fed.$^{-1}$) 2019/20	Biological yield (ton fed.$^{-1}$) 2020/21
25 kg N fed.$^{-1}$	Shandaweel 1	34.6h	37.0fg	45.5i	47.6j	16.7d	19.6ab	8.424gh	7.924e
	Misr 2	32.8i	35.3g	52.2g	50.5i	13.7f	19.1b	8.504g	8.490d
	Misr 3	39.9f	44.0d	48.1h	53.7gh	12.6g	15.8ef	7.733i	6.695g
	Sakha 95	44.5d	44.8cd	57.6f	57.5de	13.8f	16.2e	8.349h	6.747g
	Giza 171	45.9cd	46.8bc	61.3e	56.7ef	15.0e	19.3b	8.694f	8.646cd
50 kg N fed.$^{-1}$	Shandaweel 1	36.4g	39.1f	62.2de	54.6fg	18.8bc	20.0ab	9.018e	8.745d
	Misr 2	36.9g	37.4fg	65.5c	51.5hi	16.3d	18.9c	8.712f	8.441g
	Misr 3	42.3e	44.7d	65.3c	53.5gh	16.2d	16.3e	8.285h	6.724f
	Sakha 95	47.5b	47.8bc	69.3ab	64.9ab	17.1cd	17.7cd	9.032e	7.217f
	Giza 171	46.2bc	48.3ab	64.4cd	59.1ed	18.7c	19.1b	9.295d	8.917bc
75 kg N fed.$^{-1}$	Shandaweel 1	40.3f	43.0e	64.6cd	58.2de	19.7bc	20.5a	9.738b	9.275ab
	Misr 2	37.5g	37.7g	68.3ab	60.9c	18.4c	17.6cd	9.513c	9.038bc
	Misr 3	47.6b	46.1d	70.0a	60.8c	19.3b	17.4d	8.979e	6.969fg
	Sakha 95	50.1a	51.5a	64.7cd	64.0b	20.4a	18.3c	9.742b	7.242f
	Giza 171	49.5a	49.2b	67.2bc	66.2a	21.9a	20.3a	9.942a	9.573a
F test		**	**	**	**	**	**	**	*

***,** significant, highly significant**

Table 7. Means of grain yield, straw yield and protein percentage as affected by interaction between Urea fertilizer and wheat cultivars in 2019/20 and 2020/21 seasons.

Urea fertilizer	Wheat cultivars	Grain yield (ton fed.$^{-1}$)	Straw yield (ton fed.$^{-1}$)		Protein %	
		2020/21	2019/20	2020/21	2019/20	2020/21
25 kg N fed.$^{-1}$	Shandaweel 1	2.664i	6.129e	5.260d	10.52j	9.23m
	Misr 2	2.743i	6.291de	5.748bc	11.27gh	9.71l
	Misr 3	2.680i	5.559f	4.016e	13.38b	11.25e
	Sakha 95	2.908g	6.004f	3.839e	11.33fg	10.64h
	Giza 171	2.864h	6.385de	5.782bc	10.86i	9.70l
50 kg N fed.$^{-1}$	Shandaweel 1	3.064e	6.547cd	5.681b-d	10.88i	9.69l
	Misr 2	2.953f	6.330de	5.488cd	11.67e	10.61i
	Misr 3	2.886gh	5.959f	5.839b	14.10b	12.70b
	Sakha 95	3.131d	6.506f	4.086e	11.74e	10.69g
	Giza 171	3.084e	6.808bc	5.833a-c	11.21h	10.20k
75 kg N fed.$^{-1}$	Shandawel 1	3.320b	7.060ab	5.955ab	11.39f	10.37j
	Misr 2	3.199c	6.933a-c	5.839a-c	12.19d	11.33d
	Misr 3	3.125d	6.458c	5.844ab	14.53a	13.54a
	Sakha 95	3.392a	7.007ab	5.850ab	12.29d	111.42c
	Giza 171	3.341b	7.248a	6.232a	11.72e	10.89f
F test		**	**	**	**	**

***,** significant, highly significant**

3- The effect of interaction between micronutrient treatment and wheat cultivars:

Figures (2 and 3) illustrate that the interaction between micronutrient treatments and wheat cultivars had a ($p < 0.001$) effect on grain yield in the 2020/21 season and on protein percentage in both the 2019/20 and 2020/21 seasons. Sakha 95, with M2 treatment, achieved the highest grain yield, recording 3.234 tons fed.$^{-1}$ in the 2020/21 season.

Among the different treatments, Misr 3 treated with micronutrient M2 recorded the highest protein percentages of (12.64 and 10.94%) in both seasons, respectively. Surpassing the values obtained with other treatments and cultivars. These findings indicate that the combination of Misr 3 wheat cultivar with micronutrient treatment M2 led to the highest protein content in the grains, suggesting a potential beneficial effect of this specific combination on the nutritional quality of the wheat crop. This information can be valuable for farmers and researchers in selecting appropriate micronutrients treatments and wheat cultivars to enhance the protein % of grains, which can have implications for both food security and the nutritional value of wheat-based products.

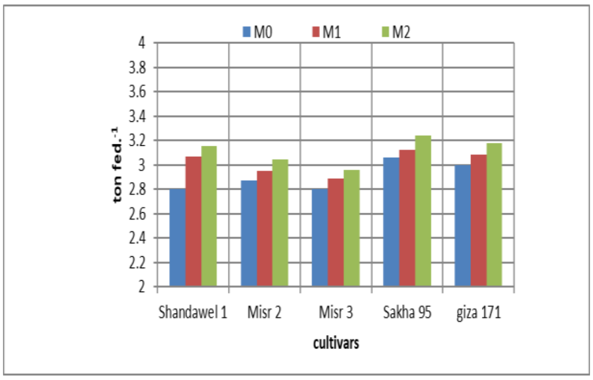


Fig. 2. Means of grain yield as affected by foliar micronutrients and wheat cultivars in the second season.

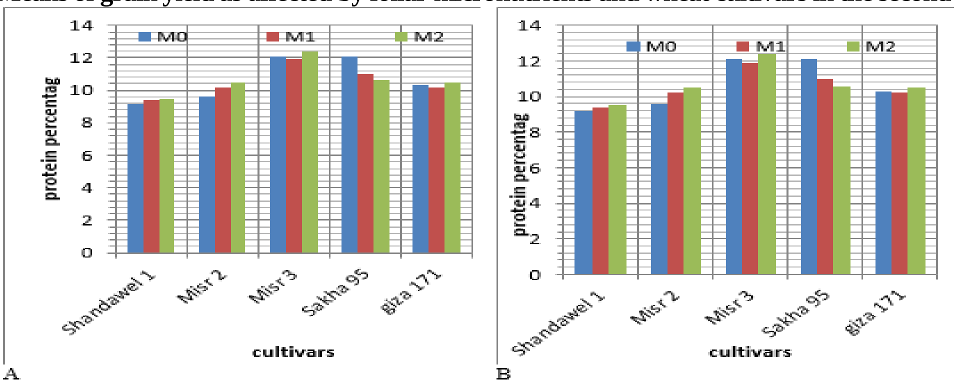


Fig. 3.Means of crude protein %, as affected by foliar micronutrients and wheat cultivars in 2019/20 (A) and 2020/21 (B).

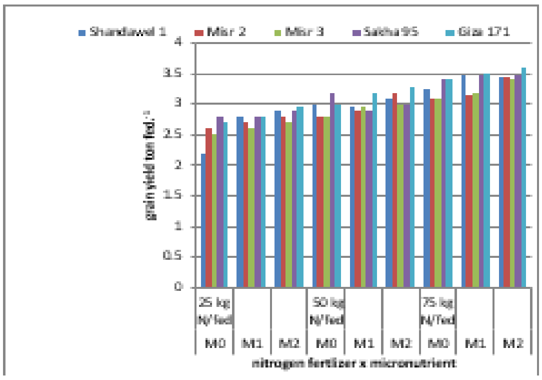
4-The interaction between Urea fertilizer, micronutrients and wheat cultivars:

Figure (4) reveals that the interaction between Urea fertilizer levels, micronutrient treatments, and wheat cultivars had a ($p > 0.001$) effect on grain yield in the 2020/21 season and on protein percentage in the same season. Among the various treatments, Sakha 95, with 75 kg N fed.$^{-1}$ and M2 treatment, achieved the highest grain yield of (3.467 tons fed.$^{-}$

[1]) Misr 3, with the same Urea level and M2 micronutrient treatment, recorded the highest protein percentage of 13.74% in the 2020/21 season, surpassing all other treatments.

Overall, the data indicated that increasing both Urea fertilizer level and the application of micronutrient treatments led to an increase in grain yield and protein percentage for all cultivars under study. This suggests that a combination of optimal Urea fertilizer level and micronutrient application can enhance both grain yield and protein content in wheat across various cultivars.

These findings are crucial for understanding the factors affecting grain yield and protein content in wheat. They can inform the development of targeted agricultural practices to improve protein quality in wheat crops. Moreover, the results emphasize the importance of considering interactions between multiple factors, such as Urea fertilizer, micronutrients and wheat cultivars, in optimizing protein content and overall crop yield.



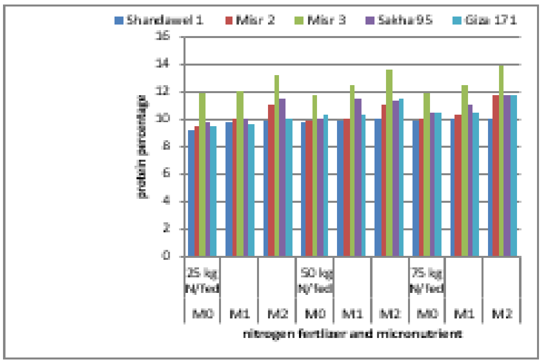


Fig. 4.Effect of interaction between Urea levels, micronutrients and wheat cultivars on grain yield in the second season. (A) and on protein content in the second season(B).

Discussion

From our results Urea fertilizer affected significantly on all studies trait in 2019/20 and 2020/21 growing seasons. Increases Urea levels increased vegetative growth, yield and yield components. Urea fertilization has a significant impact on promoting vegetative growth in plants. This leads to an extended period of growth and development, including delayed maturity, as observed in previous studies Ibrahim *et al.,* (2014), Kandil *et al.,* (2016) Faizy *et al.,* (2017). The application of Urea fertilizer to plants affects the supply of photosynthesis during the critical reproductive phase, contributing to the delay in crop maturity. Furthermore, the availability of nitrogen and micronutrients in the early stages of a plant's life plays a crucial role in building the necessary components for robust growth, particularly in roots and vegetables. This availability of essential nutrients aids in efficient nutrient absorption, reducing plant stress and supporting both vegetative and fruiting growth. Additionally, nitrogen contributes to cell division and multiplication, which ultimately results in increased plant height.

By examining how Urea fertilization and micronutrient availability influence plant growth and development, farmers and agronomists can optimize agricultural practices to enhance crop productivity and overall plant health. Proper nutrient management can lead to healthier plants with improved vegetative growth and better fruiting, ultimately increasing agricultural yields.

The tillering capacity of the plant is influenced by a combination of its genotype and environmental conditions. Additionally, the availability of nitrogen plays a crucial role in promoting the exposure of spikelets, which results in an increased number of grains and ultimately leads to higher yields per plant.

Nitrogen management is indeed a critical aspect of crop production. By increasing nitrogen levels in the soil, the availability of this essential nutrient to wheat plants is enhanced. This, in turn, contributes to improved plant structure and function, leading to better grain weight and overall crop performance.

The present study aligns with findings from Ibrahim *et al.,* (2014), who reported a significant increase in grain and straw yield with higher nitrogen rates (75, 100 and 125 kg N / $fed.^{-1}$). These results are consistent with observations by Nemat *et al.,* (2013), Mandic *et al.,* (2015) and Faizy *et al.,* (2017). Additionally, Solomon and Anjulo (2017), El-Hag and Alaa (2017) and Litke *et al.,* (2018) found that increasing nitrogen rates generally improved yield and its components.

As a major macronutrient, nitrogen is essential for various physiological processes in plants, and its proper management is vital for achieving optimal crop productivity. By ensuring adequate nitrogen supply, farmers can enhance the growth, development, and yield potential of their crops. Effective nitrogen management practices are key to successful and sustainable crop production.

Trace elements, or micronutrients, are vital for plant growth and physiological functions, particularly during vegetative growth and cell division. They are crucial for various metabolic processes and aid in nutrient uptake from the soil. The application of a foliar combination of micronutrients, including Cu, Fe, Mn and Zn, positively affects plant height, spike count, number of grains per spike, and total grain weight (TGW). This is consistent with findings from previous studies by Cakmak (2008), Zeidan *et al.,* (2010), Mekkei and El-Haggan (2014) and Zain *et al.,* (2015).

Incorporating micronutrients into wheat farming practices can significantly enhance crop growth, development, and yield, proving to be a valuable component of agricultural management.

Similar conclusions were drawn by Chaudry *et al.,* (2007), Khan *et al.,* (2010), Zeidan *et al.,* (2010), Nadim *et al.,* (2012), Raza *et al.,* (2014)and Mekkei and El-Haggan (2014), who reported increased grain yield in wheat with the application of Fe and B, either alone or in combination with other micronutrients.

Moreover, the foliar application of micronutrients such as Cu, Fe, Mn and Zn has demonstrated promising improvements in yield parameters, including the number of spikelets spike^{-1}, grain yield, and straw yield, as noted by Mekkei and El-Haggan (2014). Arif *et al.,* (2006) recommended applying foliar sprays of a nutrient solution at various growth stages of wheat, combined with partial doses of N and P, to boost yield and yield components. Additionally, Khan *et al.,* (2009) reported a 31.6% increase in wheat grain yield with the addition of 5 kg Zn per hectare, which also enhanced spike number, spike length, plant height, biological yield and total grain weight (TGW).

Several studies, including Mekkei and Eman (2014), Gomaa *et al*., (2015) and Faizy *et al*., (2017) have recorded the significant effects of micronutrient spraying on wheat grain yields and its components.

Overall, these findings collectively emphasize the importance of micronutrient management and foliar application strategies in optimizing wheat yield and improving various yield components. The application of specific micronutrient combinations or individual micronutrients at appropriate growth stages can contribute to enhanced crop productivity.

The variation among wheat cultivars can be attributed to the interaction between genetic and environmental factors, as supported by El Hag (2016) and Kandil *et al*., (2016). Studies by Sing & Singh (2013), Mandic *et al.,* (2015), El Hag (2016), Kandil *et al.,* (2016), El-Hag and Alaa (2017), Solomon and Anjulo (2017) , El Hag-Dalia (2023) and El Hag-Dalia *et al.,* (2024) have also demonstrated that yield and its components are influenced by the genetic makeup of cultivars and their response to varying nitrogen levels. Tayyar and Kemalgül (2008) found notable differences among wheat cultivars for key traits, such as yield, protein content, gluten content, and gluten index. Similarly, Makawi *et al.,* (2013) and Tawfeuk and Gomaa (2017) observed significant variation in protein content among genotypes. Additionally, Mallick *et al.,* (2013), Kaya and Akcura (2014), Ivanova *et al.,* (2013) and Karaman (2020) reported significant differences in protein percentage, sugar, and fat content among wheat cultivars. Hussein *et al.,* (2010) and Mut *et al.,* (2018) also noted significant variations in protein percentage among different genotypes.

Overall, these studies highlight the role of both genetic factors and environmental conditions in influencing wheat yield and its components, including protein content. The genetic variability among wheat cultivars underscores the importance of selecting appropriate genotypes for specific environmental conditions to optimize crop performance.

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استجابة انتاجية بعض أصناف قمح الخبز للتسميد النيتروجيني باليوريا واضافة بعض العناصر الصغرى في شمال الدلتا بمصر

داليا عبدربه الحاج

قسم المحاصيل - كليه الزراعة – جامعه كفر الشيخ-مصر

الملخص

أجريت تجربة حقلية بكلية الزراعة جامعة كفر الشيخ بمصر خلال موسمي النمو 2020/2019 و 2021/2020 لدراسة تأثير معدل التسميد النيتروجيني باليوريا وبعض العناصر الصغرى على إنتاجية القمح (*Triticum aestivum* L.) بشمال الدلتا. تم في هذه التجربة استخدام تصميم القطع المنشقة مرتين في قطاعات كاملة العشوائية RCBD في ثلاث مكررات. اشتملت التجربة على التسميد باليوريا في ثلاث معدلات (25 و 50 و 75 كجم نيتروجين / فدان) اضافة أرضية في القطع الرئيسية وتم تخصيص الرش الورقي لأسمدة المغذيات الدقيقة المختلطة (Fe، Mn، Zn، Cu) في القطع الشقية الأولى وخمسة أصناف من القمح. وهى: شندويل 1 ومصر 2 ومصر 3 وسخا 95 وجيزة 171 في القطع الشقية الثانية. أظهرت نتائج هذه الدراسة زيادة معنوية مع التسميد بمعدل 75 كجم نيتروجين/ فدان في كل من عدد الأيام حتى الطرد (100.4 يوم) والنضج (147.3 يوم)، ارتفاع النبات (91.4سم) ، عدد الأشطاء الخصبة (265)، وزن الألف حبة (45.3جرام) ، عدد الحبوب / السنبلة (64.5 حبة) ،المحصول البيولوجي (9.809 طن/فدان)،محصول الحبوب (3.622 طن/ فدان)، محصول القش (6.748 طن/فدان) والبروتين (13.51%). ومع أعلى معدل للأسمدة النيتروجينية والمغذيات الدقيقة M2 زادت جميع الصفات باستثناء عدد الاشطاء الخصبة.كما تفوق الصنف جيزة 171 حيث سجل اكثر عدد من الايام من الزراعة حتى الطرد والنضج الفسيولوجي، محصول الحبوب والقش وكل مكونات المحصول. وسجل سخا 95 أعلى قيم لمحصول الحبوب والقش والمحصول البيولوجي. وتفوق الصنف مصر 3 في نسبة البروتين٪. وكان التفاعل بين السماد النيتروجيني باليوريا مع الأصناف معنوياً ، وقد سجل الصنف جيزة 171 وسخا 95 أعلى قيم لمحصول الحبوب ومكوناتها وجودة الحبوب.بزيادة كل من التسميد المعدني والرش بالعناصر الصغرى زاد من انتاجية الأصناف بصفه عامة.