International Scientific Organization

International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

Influence of Some Technological Fertilization and Nitrogen Fertilizer Levels on Wheat Grain Yield and Quality

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Abstract

The current work aimed to study the effect of some new technological fertilizers in combination with mineral nitrogen fertilizer levels on wheat yield *(Var. Msr$_1$)* and grain quality in clayey soil. Two field experiments were conducted in a Private Farm, Qutaiyifet El-Aziziya Village, Minya Elqamh District, Sharkia Governorate, Egypt, during the two successive winter seasons of 2021/2022 and 2022/2023. Split plot arrangements replicated three times, within randomized complete block design. The main plots allotted to liquid compound fertilizer (1L fed^{-1}), commercial bio-fertilizers (at the rate of 1 kg fed^{-1} from Cerialine, Phosphourine and Potassiummag) and N, P, K Nano-fertilizer (400-ppm fed^{-1}). While sub plots assigned to five mineral N-fertilizer rates (0.0, 40, 60, 80 and 100 kg fed^{-1}) as Ammonium nitrate. The results revealed that application of liquid compound fertilizer led to a significant increase in grain yield, number of spikes / m^2, straw yield, nitrogen use efficiency, N-uptake of grains and carbohydrates and protein (%) in grains compared to bio and nano fertilizers treatments. Wheat grain yield, number of spikes / m^2, straw yield, as well as protein (%) and carbohydrates (%) in grains showed gradual significant increases with raising mineral nitrogen fertilizer rate from zero up to 100 kg N fed^{-1}. On the other hand, nitrogen use efficiency decreased significantly with increasing N-fertilizer rate up to 100 kg fed^{-1}. Regarding the interaction effect between studied factors, the treatment of liquid compound fertilizer and 100 kg N fed^{-1} was recorded the highest values of most studied characters.

Keywords: Wheat, technology fertilizers, nitrogen fertilization levels.

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1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important staple food crops for more than 35% of the world's population. In Egypt, wheat is considered one of the most important food grain crops, which its grains are used to produce bread and pasta. Livestock breeders also use wheat straw as a basic roughage food for animals. Wheat comes in first place of cereal grains, due to its grain containing 12% protein, 1.72% fat, 69.60% carbohydrate and 27.20% minerals. Egypt area of wheat is estimated by about 3.4 million feddan, with production of 8.9 million ton, while it imports 10 million tons of wheat [1]**.** Increasing productivity can be achieved in several ways, including adding mineral fertilizers and various nutrients for plants to increase grain productivity and grain quality. Nitrogen is the important nutrient for growth and production of common wheat that effects on the plant growth and increases grain yield. Soil N supply must be sufficient for tillering, stem elongation, booting, heading and grain filling, as well as accumulation of proteins in the grains. Nitrogen application increased total grain yield of wheat, biological yield, as well as the percentage of protein and carbohydrates in grains [3,4,5,6]. [7] reported that wheat grain yield showed a significantly increases with increasing nitrogen fertilizer levels (0, 20, 30 and 40 Kg ha^{-1}). Wheat yield were significantly higher about 30% with N and P fertilization over the non-fertilized plots. Protein and gluten contents in wheat grains had the positive affected by N and P fertilizer applications [8]. Many investigators reported that, foliar fertilization at different growing stages of wheat increased grain yield over than the control [9,10,11].

The new technological fertilizers as nanotechnology are one of the recent innovative sciences that have tremendous potential to revolutionize agriculture and allied fields, such as crop production [12,13]**.** Wheat plants showed a significant response to spraying NPK-nano fertilizer, all abovementioned agronomic traits (plant length, number of spikes, straw and grain yield) and chemical composition of grains (protein and carbohydrates) significantly increased with foliar application of NPK-nano fertilizer [14,7]. Bio-fertilizer is a substance, which contains living microorganisms applied to seed, plant surfaces or soil. Bio-fertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus and stimulating plant growth through the synthesis of growth promoting substances. Bio- fertilizers can be expected to reduce the use of chemical fertilizer and pesticides. The micro-organisms in bio-fertilizers restore the soil's natural nutrient cycle and build soil organic matter. Through the use of bio-fertilizers healthy plants could be grown while enhancing the sustainability and the health of soil. Also, bio-fertilizers are eco-friendly organic agro-input and more cost effective than chemical fertilizers. Inoculants are recommended mainly for wheat [15].

This study aims to investigate the effect of modern technological fertilizers and different levels of nitrogen fertilization on yield and grain quality of wheat variety Misr-1 under Egyptian conditions.

2. Materials and Methods

Two field experiments were conducted at a Private Farm, Qutaiyifet El-Aziziya Village, Minya Elqamh District, Sharkia Governorate, Egypt during the two successive winter seasons of 2021/2022 and 2022/2023 using split plot arrangements replicated three times within randomized complete block design. The main plots assigned to three new technological fertilizers plus control treatment as follows:

1- Control treatment (without any technological fertilizers application).
2- Liquid compound fertilizer composed of N 20, P_2O_5 20, K_2O 20, Fe 0.3, Cu 0.5, Mg 5, Zn 0.3, Mn 0.3, S 1, B 0.01and Mo 0.01% at the rate of 1 L fed^{-1}.
3- Three commercial bio-fertilizers, i.e. the first is Cerialine (free-living bacteria fixing nitrogen), the second named Phosphourine (phosphorus dissolving bacteria) and the third is Botassiummag (potassium solubilizing bacteria) at the rate of 1 kg fed^{-1} from each.
4- Nano - fertilizer in liquid form contains N, P, and K at concentrations of 10, 10 and 10 %, respectively at the rate of 400-ppm fed^{-1}.

The sub plots were occupied by five mineral nitrogen fertilizer levels (0.0, 40, 60, 80 and 100 kg N fed^{-1}) as Ammonium nitrate (330 g N kg^{-1}). Wheat seeds (*Triticum aestivum* L.) var. Misr-1 grown broadcasting on a plot size of 3 × 2 m. The recommended rates of phosphorus (7 kg P fed^{-1}) as Ca – superphosphate (68 g P kg^{-1}) and potassium (20 kg K fed^{-1}) as potassium sulphate (400 g K kg^{-1}) were added during soil preparation. Wheat seeds wetted by arabic gum solution and then mixed with bio-fertilizers directly before sowing in rows 20 cm apart on November 12 th in both growing seasons. Both of liquid compound and nano – fertilizer as foliar application was splitted into two equal doses and applied after 45 (tillering stage) and 75 (flowering stage) days from sowing. Nitrogen fertilizer applied in three equal splitting doses and applied after 25, 55 and 85 days from sowing. Land irrigation method was used. The normal agricultural practices for wheat crop were carried out perfectly. Soil samples randomly taken before planting, air – dried, ground to pass through a 2- mm sieve. The principle chemical and physical properties for the studied soil were determined according to the standard methods described in [16,17] as shown in Table 1.

Table (1). Some physical and chemical properties of the experimental sites at 30 cm soil depth (in the two seasons)

Soil fertility characteristic	First Season (2021/2022)	Second Season (2022/2023)
Mechanical analysis		
Sand %	11.02	10.96
Silt %	28.89	25.33
Clay %	60.09	63.71
Soil texture	Clay	Clay
Chemical analysis		
pH (1: 2.5susp.)	7.57	8.03
EC_e (Soil paste at 25°C)	0.92 dS / m	0.97 dS / m
Soil-CEC (cmol kg^{-1}) (Amm. acetate ext.)	45.20	44.80
O.M % (Wakely & Black method)	1.35	1.47
Available N (mg/kg) **(K2SO4 ext.)**	30.01	29.75
Available P (mg/kg) (Olsen ext.)	9.59	9.13
Available K (mg/kg) **(Amm. acetate ext.)**	321	297
Available Zn (mg/kg)	0.27	0.23

Notes:1- Soil analyses were done using representative composite samples.
2- Extraction solution for available N (KCl), P (Na-bicarbonate), K (NH_4-acetate).

One square meter (1m length of 5 central rows) area was harvested in each plot. After harvest, number of spikes m^{-2} were count, grain yield and straw yield were estimated as ton per fedden. Wheat grains N content was determined by wet digestion using the standard methods as reported by [18]. Crude protein content (%) was calculated by multiplying N content × 5.83 according to [19]. Carbohydrates content (%) in grains was determined according to [20]. Nitrogen use efficiency and N-uptake were calculated as the following equations according to the method described by [21] as follows:

$$\text{NUE} = \frac{\text{grain yield (kg/fed)}}{\text{N-applied (kg/fed)}}$$

$$\text{N-uptake} = \frac{\text{N (\%)} \times \text{grain yield (kg/fed)}}{100}$$

The proper statistical analysis of split plot design was used combined analysis was performed for the characters recorded in both seasons. The collected data were statistically analyzed using the Analysis of Variance (ANOVA) to detect significance if any at treatment level. Differences among treatments were judged according to [22]. Using the COSTAT system for windows, version 6:311 (cohort software, Berkeley, CA, USA) [23].

3. Results and Discussion

3.1. Effect of Technological Fertilizers

Data in Tables 2, 3 and 4 show that number of spikes m^{-2} (NS), straw yield (SY), grain yield (GY), carbohydrates and protein (%) in grains, N-uptake by grains and nitrogen use efficiency (NUE) significantly affected by applying new technological fertilizers. Application of liquid compound fertilizer led to a significant increase in grain yield (ton fed^{-1}). These results are true in both growing seasons. This increase compared to control treatment, nano and bio fertilizers amounted to 29.48%, 10.81% and 14.73% respectively, in the combined. Increases in number of spikes m^{-2} and straw yield followed a pattern similar to that of the grain yield. Data also showed that applying liquid compound fertilizer gave the highest values of N-uptake by grains, nitrogen use efficiency, as well as carbohydrates and protein (%) in grains followed by nano and bio fertilizers. As an average, the increments of (2.21, 1.87 & 1.75 %), (27.17, 12.47 & 10.02 %), (16.45, 13.30 & 9.26 %) and (6.56, 5.54 & 4.78 %) for N-uptake by grains, nitrogen use efficiency, carbohydrates and protein (%) in grains due to application of liquid compound, nano and bio fertilizers, respectively compared to control treatment in the combined of both seasons. These significant increases were probably due to content of liquid compound fertilizer on micronutrients, which have the promoting effect on plant growth and productivity throughout raising enzymes activity, enhancing cell physiology and improving photosynthetic process [24]. These finding are in accordance with those obtund by [25,26,27,28,29,14,24].

3.2. Effect of mineral nitrogen fertilizer levels

The results in Table 2 show that NS m^{-2}, SY (ton fed^{-1}) and GY (ton fed^{-1}) markedly affected by N-fertilizer level. As an average, the increments of (6.45, 10.54, 14.40 & 17.14 %), (12.32, 21.53, 29.59 & 33.88 %) and (18.90, 36.61,51.63 & 56.24 %) for spikes m^{-2}, straw yield and wheat grain yield due to application of 40, 60, 80 and 100 kg N fed^{-1}, respectively compared to N fertilizer rate without any addition in the combined. These findings may be due to that nitrogen as a major nutrient for plants enhanced the vegetative growth of wheat plant, increased photosynthetic activity and metabolites required to produce the higher grain yield [7]. These results are in accordance with those by [30,28,31,6,7,32]. In respect to grain quality, data presented in Tables 3 and 4 reveal that gradually raised with N-fertilizer rates from 40, 60, 80 to 100 kg cased a significantly increases of N-uptake (kg fed^{-1}) as well as protein (%) and carbohydrates (%) in wheat grains. The highest N-uptake, carbohydrates and protein percentage (40.75 kg fed^{-1}, 77.35% and 9.24%) with increments of (49.15, 16.26 and 12.63 %), respectively were recorded with applying 100 kg N fed^{-1} as the average of two growing seasons. This result may be due to the enhancement of soil nitrogen availability to the plant with increasing N-fertilizer rate. Concerning the nitrogen use efficiencies, data show that the values of N use efficiency (NUE) significantly decreased with increasing N-fertilizer rate up to 100 kg fed^{-1}. Many researchers have reported that NUE values are usually greater at lower dose of N fertilizer application. This depressed effect may be attributed to the reduction in the rates of increase of grain yield versus the increase in N fertilization rates. This result is agreement with those obtained by [33,34,35].

3.3. The interaction effect

Regarding the interaction effect of the studied factors, the statistical analysis of variance for obtained data clearly indicate that the interaction effect gave a positive response on wheat yield and its components, as well as N-uptake, grains quality and nitrogen use efficiency (figures; 1-7). The best interaction treatment that achieved the highest values of (489.8, 5.32, 3.26, 83.05, 9.44 & 53.96) for spikes number m^{-2}, straw yield, grain yield (ton fad^{-1}), carbohydrates and protein (%) in grains and N-uptake (kg^{-1}) by grains, respectively was (100 kg N fed^{-1} + liquid compound fertilizer at rate of 1L fed^{-1}) in both growing seasons. With respect to N use efficiency, all interaction treatments contained liquid compound fertilizer gave higher values than that contained with nano and/or bio fertilizers. The treatment of (40 kg N fed^{-1} + liquid compound fertilizer at the rate of 1L fed^{-1}) recorded the maximum NUE value of (66.3 kg Y / kg N) which may be due to the reduction in the rates of increase of grain yield versus the increase in N fertilization rates. Fig. (1-7): The interaction effect of some technological fertilizers and nitrogen fertilizer levels on wheat yield and its quality (combined of two seasons).

Table (2). Number of spikes /m^2, Straw yield (ton/fed.) and wheat grain yield (ton/fed.) as affected by some technological fertilizers and nitrogen fertilizer levels in 2021/2022 and 2022/2023 winter seasons and their combined

Characters / Treatments	Number of spikes /m^2			Straw yield (ton/fed.)			Grain yield (ton/fed.)		
	First season 2021/22	Second season 2022/23	Combined	First season 2021/22	Second season 2022/23	Combined	First season 2021/22	Second season 2022/23	Combined
	A-Technological Fertilizers								
Control	440.3 d *	436.5 d	438.4 d	4.493 d	4.260 d	4.377 d	2.275 d	2.189 d	2.232 d
Bio.	457.7 c	450.5 c	454.1 c	4.609 c	4.456 c	4.533 c	2.546 c	2.491 c	2.519 c
Liquid	462.1 a	458.3 a	460.2 a	4.999 a	4.561 a	4.780 a	2.953 a	2.826 a	2.890 a
Nano	459.4 b	456.4 b	457.9 b	4.661 b	4.488 b	4.575 b	2.649 b	2.566 b	2.608 b
LSD (0.05)	0.3592	0.9263	0.6428	0.0122	0.005	0.0086	0.0041	0.0033	0.0037
F .test	**	**	**	**	**	**	**	**	**
	B- Nitrogen Fertilizer Levels (kg/fed.)								
0	413.8 e	411.4 e	412.6 e	3.914 e	3.730 e	3.822 e	1.958 e	1.904 e	1.931 e
40	440.7 d	437.7 d	439.2 d	4.511 d	4.074 d	4.293 d	2.346 d	2.245 d	2.296 d
60	458.6 c	453.6 c	456.1 c	4.779 c	4.510 c	4.645 c	2.688 c	2.588 c	2.638c
80	476.1 b	467.9 b	472.0 b	5.051 b	4.855 b	4.953 b	2.985 b	2.870 b	2.928 b
100	485.2 a	481.3 a	483.3 a	5.197 a	5.036 a	5.117 a	3.051 a	2.983 a	3.017 a
LSD (0.05)	0.4016	1.0357	0.7187	0.0136	0.0056	0.0096	0.0045	0.0037	0.0041
F .test	**	**	**	**	**	**	**	**	**
							C- Interaction		
A*B (F .test)	**	**	**	**	**	**	**	**	**
LSD (0.05)	0.8044	2.0745	1.4395	0.0273	0.0112	0.0193	0.0091	0.0073	0.0082

* Means followed by Unlike Alphabet(s) within a treatment Column and Period are Significantly Different DMRT (p=0.05).

Table (3). carbohydrates and protein percentages in grain as affected by some technological fertilizers and nitrogen fertilizer levels in 2021/2022 and 2022/2023 winter seasons and their combined

Characters / Treatments	Carbohydrates (%)			Protein (%)		
	First season 2021/2022	Second season 2022/2023	Combined	First season 2021/2022	Second season 2022/2023	Combined
A-Technological Fertilizers						
Control	65.89 d *	64.52 d	65.21 d	8.448 d	8.314 d	8.381 d
Bio.	72.17 c	70.38 c	71.28 c	8.850 c	8.727 c	8.789 c
Liquid	76.55 a	75.32 a	75.94 a	9.002 a	8.859 a	8.931 a
Nano	75.24 b	72.52 b	73.88 b	8.914 b	8.788 b	8.846 b
LSD (0.05)	0.0544	0.1333	0.0939	0.0395	0.0286	0.0341
F .test	**	**	**	**	**	**
B- Nitrogen Fertilizers Levels						
0 Kg/fed.	66.70 e	66.36 e	66.53 e	8.284 e	8.121 e	8.203 e
40 Kg/fed.	69.12 d	68.58 d	68.85 d	8.500 d	8.399 d	8.450 d
60 Kg/fed.	71.06 c	70.03 c	70.55 c	8.802 c	8.655 c	8.729 c
80 Kg/fed.	76.05 b	73.17 b	74.61 b	9.138 b	9.001 b	9.070 b
100 Kg/fed.	79.40 a	75.29 a	77.35 a	9.293 a	9.185 a	9.239 a
LSD (0.05)	0.0609	0.1491	0.105	0.0441	0.032	0.0381
F .test	**	**	**	**	**	**
C- Interaction						
A*B (F .test)	**	**	**	**	**	**
LSD (0.05)	0.1219	0.2986	0.2103	0.0884	0.0641	0.0763

*Means followed by Unlike Alphabet(s) within a treatment Column and Period are Significantly Different DMRT (p=0.05).

Table (4). N-uptake (kg/fed) and Nitrogen Use Efficiency Kg Y /kg N as affected by some technological fertilizers and nitrogen levels in 2021/2022 and 2022/2023 winter seasons and their combined

Characters / Treatments	N-uptake (kg/fed)			Nitrogen Use Efficiency kg Y /kg N		
	First season 2021/2022	Second season 2022/2023	Combined	First season 2021/2022	Second season 2022/2023	Combined
A-Technological Fertilizers						
Control	14.215 *	13.544	13.880	30.517	29.305	29.911
Bio.	38.872	37.503	38.188	33.274	32.543	32.908
Liquid	45.813	43.173	44.493	38.986	37.092	38.039
Nano	40.736	38.902	39.819	34.243	33.040	33.641
LSD (0.05)	0.3592	0.9263	0.6428	0.0041	0.0033	0.0037
F .test	**	**	**	**	**	**
B- Nitrogen Fertilizers Levels						
0 Kg/fed.	27.981	26.663	27.322	0.000	0.000	0.000
40 Kg/fed.	29.910	28.432	29.171	58.656	56.131	57.394
60 Kg/fed.	35.091	33.407	34.249	44.804	43.138	43.971
80 Kg/fed.	40.079	37.881	38.980	37.306	35.878	36.592
100 Kg/fed.	41.484	40.020	40.752	30.508	29.828	30.168
LSD (0.05)	0.4016	1.0357	0.7187	0.0045	0.0037	0.0041
F .test	**	**	**	**	**	**
C- Interaction						
A*B (F .test)	**	**	**	**	**	**
LSD (0.05)	0.1219	0.2986	0.2103	0.0884	0.0641	0.0763

*Means followed by Unlike Alphabet(s) within a treatment Column and Period are Significantly Different DMRT (p=0.05).

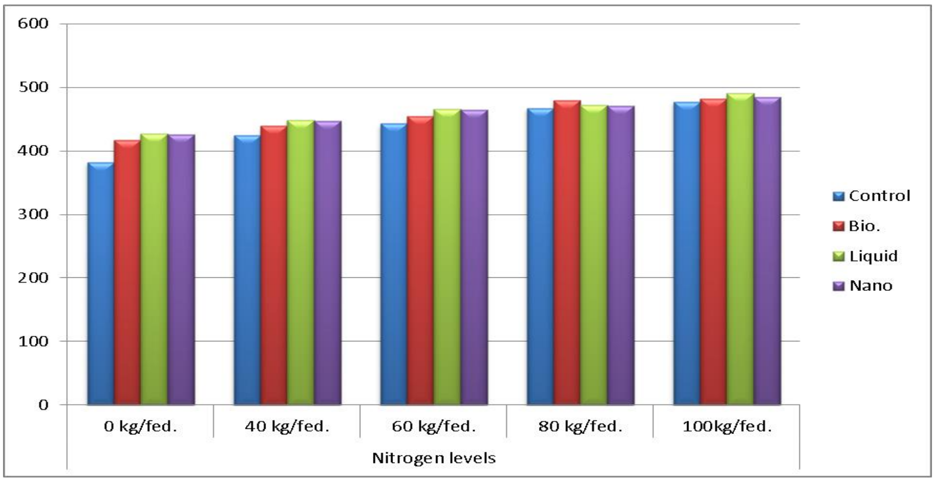

Fig. 1. Number of spikes/m^2

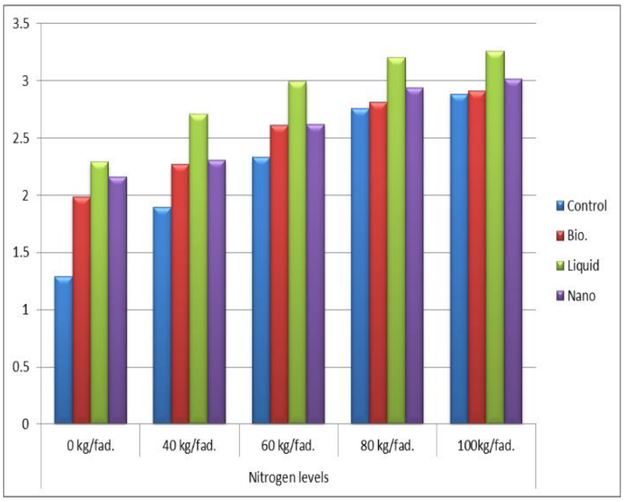

Fig. 2. Grain yield (ton/fed.)

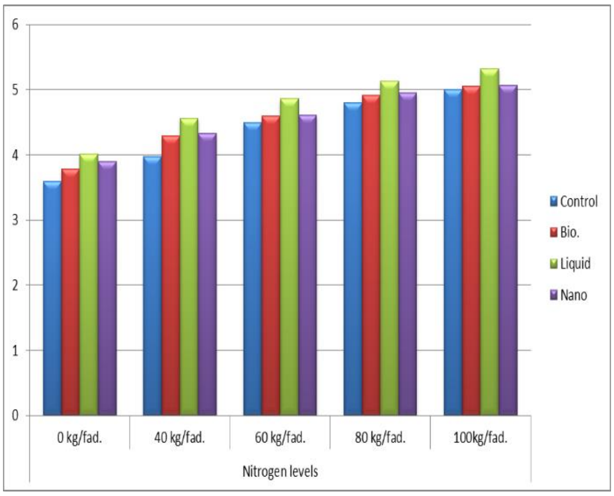

Fig. 3. Straw yield (ton/fed.)

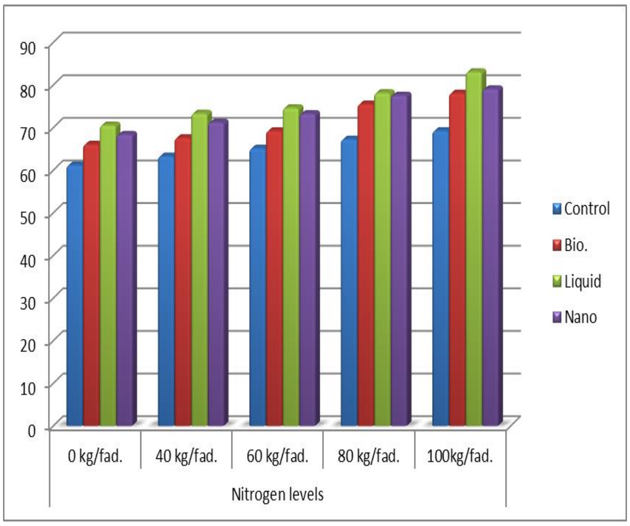

Fig. 4. Carbohydrates (%) in grains

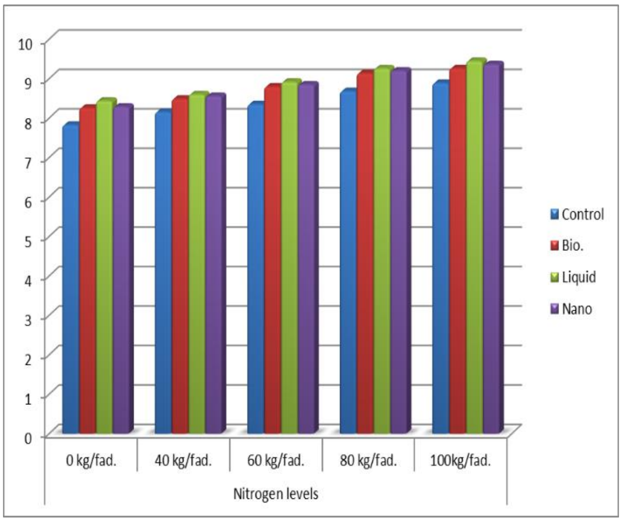

Fig. 5. Protein (%) in grains

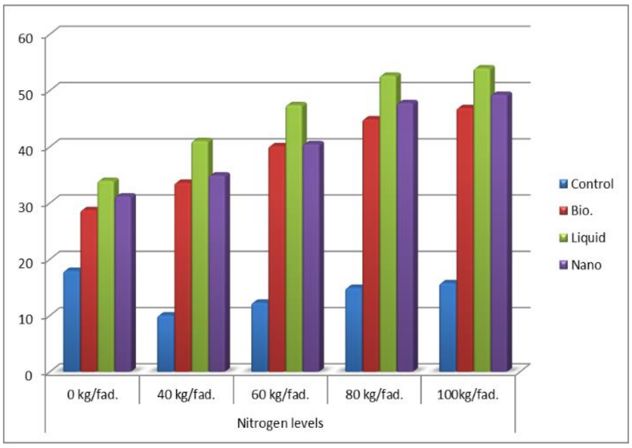

Fig. 6. N-uptake by grains (kg/fad)

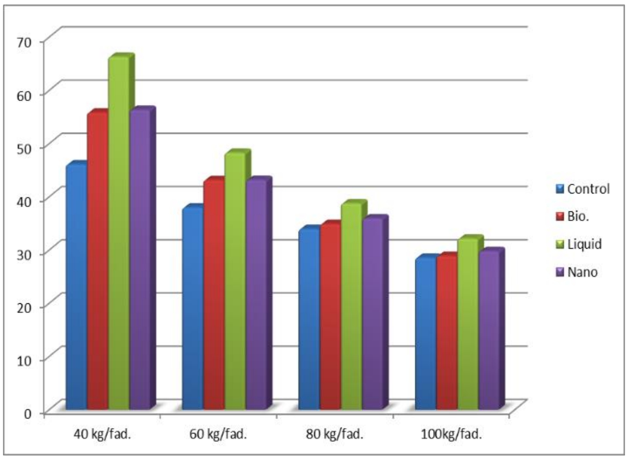

Fig. 7. Nitrogen Use Efficiency Kg Y /kg N

4. Conclusions

The current study demonstrates that applied the diversifying of new technological fertilizers systems improved wheat crop and quality. Liquid compound fertilizer was superior to nano and bio fertilizers in relation to its effect on NS m^{-2}, GY, carbohydrates and protein (%) in grains and N-uptake, as well as NUE. The positive association between improving wheat crop and fertilization by liquid compound fertilizer can be explained based on the importance of micronutrients for the formation and functioning of several enzymes, activity of chlorophyll and growth hormones. Therefore, it can be recommended that the co-addition of the N-fertilizer and liquid compound fertilizer as foliar application under clayey soil conditions, at Sharkia Governorate, Egypt.

References

[1] FAO STAT. (2021). Available online, Food and Agriculture, Organization of the United Nations Resources, Rome, Italy: http://www.Fao. Org/faostat/en/data.

[2] Y. Hussain, S. F. Ullah, G. Akhter & A. Q. Aslam. (2017). Groundwater quality evaluation by electrical resistivity method for optimized tubewell site selection in an ago-stressed Thal Doab Aquifer in Pakistan. Modeling Earth Systems and Environment, 3, 1-9.

[3] F. Belete, N. Dechassa, A. Molla & T. Tana. (2018). Effect of nitrogen fertilizer rates on grain yield and nitrogen uptake and use efficiency of bread wheat (*Triticum aestivum* L.) varieties on the Vertisols of central highlands of Ethiopia. Agric & Food Secur., 7, 78. https://doi.org/10.1186/s40066-018-0231-z

[4] S. Ibraheem. (2018). Influence of different levels of Bio fertilizer EM1 and nitrogen fertilizer on growth traits and yield in wheat. Mesopotamia Journal of Rafidain Agriculture, 46(1), 151-168. (In Arabic).

[5] H. H. F. Al-Jabri. (2020). The contribution of the main stem and stalks to yield and its components for cultivars of soft wheat under the influence of nitrogen fertilization. Masteres thesis, College of Agriculture Al-Muthanna University, Iraq.

[6] E. L. Moursy, S. A. Rasha, A. A. A. Leilah, S. H. Haffez & M. A. Badawi. (2020). Response of Wheat to Mineral Nitrogen Levels and Foliar Application with Alga Extract. *Journal of Plant Production*, *11*(4), 349-354.

[7] M. A. Hussain, O. A. Omer & H. S. Mohammed. (2021). Response yield and some growth parameters of bread wheat to nano and nitrogen fertilizers. Journal of Duhok University, 24(1), 73-81.

[8] P. Rusek, M. Mikos-Szymańska, M. Karsznia, Sienkiewicz-Cholewa & J. U. Igras. (2016). The effectiveness of nitrogen-phosphorus fertilization in winter wheat (Triticum aestivum L.*)* cultivation. Bulgarian Journal of Agricultural Science, 22(5): 752–755.

[9] S. J. Leghari, N. A. Wahocho, G. M. Laghari, A. H. Laghari, G. M. Bhabhan, K. H. Talpur & A. A. Lashari. (2016). Role of nitrogen for plant growth and development: A review. Advances in Environmental Biology, 10(9), 209-219.

[10] W. Jarecki, J. Buczek & D. Bobrecka-Jamro. (2017). Response of spring wheat to different soil and foliar fertilization. Journal of Central European Agriculture. Journal of Central European Agriculture, 18 (2):460-476. DOI: https://doi.org/10.5513/JCEA01/18.2.1919

[11] M. Mikos-Szymańska, M. Borowik, M. Wyzińska & P. Rusek. (2018). Effects of different fertilizer treatments on grain yield and yield components of spring wheat. Research for rural development, 2, 100-106.

[12] N. Scott & H. Chen. (2012). Nano scale science and engineering for agriculture and food systems. Industrial Biotechnology, 8(6), 340-343.

[13] L. M. Batsmanova, L. M. Gonchar, N. Y. Taran & A. A. Okanenko. (2013). Using a colloidal solution of metal nanoparticles as micronutrient fertiliser for cereals. In Proceedings of the International Conference Nano materials: Applications and Properties (No. 2, no. 4, pp. 04NABM14-04NABM14). Sumy State University Publishing.

[14] H. W. Al-Juthery, K. H. Habeeb, F. J. K. Altaee, D. K. AL-Taey & A. R. M. Al-Tawaha. (2018). Effect of foliar application of different sources of nano-fertilizers on growth and yield of wheat. Bio. Sci., Res., (4):3976-3985.

[15] S. C. Dahm, W. B. Derrick & O. C. Uhlenbeck. (1993). Evidence for the role of solvated metal hydroxide in the hammerhead cleavage mechanism. Biochemistry, 32(48), 13040-13045.

[16] D. L. Sparks. (1996). Methods of Soil Analysis", part 3-chemical methods, (2nd Ed.), Agron. 9: A.S.A., Ins., Madison, Wisc., USA.

[17] G. Estefan, R. Sommer & J. Ryan. (2013). Methods of Soil, Plant, and Water Analysis. A manual for the West Asia and North Africa region. Third Edition by International Center for Agricultural Research in the Dry Areas. Box 114/5055, Beirut, Lebanon.

[18] E. D. Westerman. (1990). Soil Testing and Plant Analysis, (3rd Ed.), Monograph No.3, Soc., of Am. Book Series, S.S.A., Ins., Madison, Wisc., USA.

[19] E.W. Ronald, T.E. Acree, E.A. Deckar, M.H. Penner, D.S. Reid, S.J. Schwartz, C. F. Shoemaker, D. Smith & P. Sporns. (2005). "Hand Book of Food Analytical Chemistry" published by John Wiley and Sons, Inc., Hoboken, New Jersey. Published simultaneously in Canada.

[20] M. Dubois, K.A. Gilles, Gilles, J. K. Hamilton, P.T. Rebers & F. Smith. (1956). Colorimetric method for determination of sugars and related substances. Analytical Chemistry, 28(3), 350-356.

[21] M. Naeem, A. A. Ansari & S. S. Gill. (2017). Essential Plant Nutrients: Uptake, Use Efficiency, and Management. (EBook) Library of Congress

Control Number: 2017946075. Springer International Publishing AG 2017.

[22] D.B. Duncan. (1955). Multiple range and multiple F tests. Biometrics, 11(1), 1-42.

[23] C.S.C.P. Costat Statically Computer Program. (2005). Cohort software, copy right (c) 1998 – 2005, PMB320, Monterey, CA, 93940.USA.

[24] Z. P. Stewart, E. L. Paparozzi, C. S. Wortmann, P. K. Jha & C.A. Shapiro. (2021). Effect of foliar micronutrients (B, Mn, Fe, Zn) on maize grain yield, micronutrient recovery, uptake, and partitioning. https://doi.org/10.3390/plants10030528 .

[25] M. Naderi, M. Ketabchi, M. Abbasi & W. Bleck. (2011). Analysis of microstructure and mechanical properties of different high strength carbon steels after hot stamping. Journal of Materials Processing Technology, 211(6), 1117-1125.

[26] M. Mardalipour, H. Zahedi & Y. Sharghi. (2014). Evaluation of nano bio fertilizer efficiency on agronomic traits of spring wheat at different sowing date. In Biological forum (Vol. 6, No. 2, p. 349). Research Trend.

[27] [M. Janmohammadi, T. Amanzadeh, N. Sabaghnla & S. Dashti. (2016). Impact of foliar application of nano micronutrient fertilizers and titanium dioxide nanoparticles on the growth and yield components of barley under supplemental irrigation. Acta agriculturae Slovenica, 107, 265-276.

[28] E. E. Kandil, E. A. Marie & E. A. Marie. (2017). Response of some wheat cultivars to nano-, mineral fertilizers and amino acids foliar application. *Alexandria science exchange journal*, *38*(January-March), 53-68.

[29] H. Abdel-Aziz, M. N. Hasaneen & A. Omar. (2018). Effect of foliar application of nano chitosan NPK fertilizer on the chemical composition of wheat grains. Egyptian Journal of Botany, 58(1), 87-95.

[30] L. Chen, D. Zheng, B. Liu, J. Yang & Q. Jin. (2016). VFDB 2016: hierarchical and refined dataset for big data analysis—10 years on. Nucleic acids research, 44(D1), D694-D697.

[31] C. Dal Cortivo, M. Ferrari, G. Visioli, M. Lauro, F. Fornasier, G. Barion & T. Vamerali. (2020). Effects of seed-applied bio fertilizers on rhizosphere biodiversity and growth of common wheat (*Tritium aestivum* L.) in the field. Frontiers in Plant Science, 11, 513542.

[32] M. M. Awad, A. A. El-Mehy & H. H. Hassan. (2023). Impact of crop sequence and nitrogen fertilization levels on wheat (*Triticum aestivum* L.) productivity in Egypt. Egyptian Journal of Agricultural Research, 101 (1): 83-94.

[33] I. S. M. Mosaad, E. E. E. Khafagy & R. A. El-Dissoky (2013). Effect of mineral, bio and organic nitrogen fertilization on wheat yield and nitrogen utilization efficiency and uptake at northern Delta of Egypt. J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 4 (10): 1101 - 1116.

[34] A. M. G. Ewis. (2019). Evaluation the effect of N mineral fertilization in combination with N bio-fertilizer on barley yield and its components in sandy soil. Journal of Soil Sciences and Agricultural Engineering, Mansoura University, 10 (8):423-433.

[35] T. Godebo, F. Laekemariam & G. Loha. (2021). Nutrient uptake, use efficiency and productivity of bread wheat (*Triticum aestivum* L.) as affected by nitrogen and potassium fertilizer in keddida gamela woreda, Southern Ethiopia. Environmental Systems Research, 10(1), 12.