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Integrated effect of some bio and chemical fertilization treatments on wheat growth and yield under sandy soil conditions

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Abstract : Two field experiments were established in 2012/2013 and 2013/2014 winter seasons at the Research and Production Station, National Research Centre, El-Nubaria Province, El-Behira Governorate, Egypt. The study aimed to investigate the impact of biofertilization with Azolla 2 L/fed. or Mycorrhiza 1 kg/fed. in combination with foliar application with KNO_3 or $Mg(NO_3)_2$ at (5 g/L) on growth, pigmentation and yield of wheat grown under sandy soil conditions. Results indicated that bio inoculant treatments significantly affected photosynthetic pigments content, growth and yield characters compared with the control treatment, with superiority to Mycorrhiza over Azolla. The results also indicated that foliar application with either KNO_3 or $Mg(NO_3)_2$ significantly enhance all the previous characters as compared with control treatment (tap water). Foliar applied KNO_3 produced the highest values for plant height (cm), grain yield (tons/fed), straw yield (tons/fed), 1000 grains weight (g) and crude protein (%). As for photosynthetic pigments content, $Mg(NO_3)_2$ surpass KNO_3. Moreover, either bio inoculant or foliar application treatments significantly affected the N, P, K and Mg content of wheat grains. The combined treatment of mycorrhiza and KNO_3 recorded the highest values for growth, yield and its components, as well as the percentage of N, P and K, while the highest photosynthetic pigments content and Mg content were recorded in plants treated with mycorrhiza and sprayed with $Mg(NO_3)_2$. Such results emphasize that biofertilization is not a substitute but a partial supplement for the recommended NPK mineral fertilizers which could be ascribed partially to the increased mobility of fixed nutrients like P in the soil or fixing more N which reflected directly on most growth and yield characters of wheat in sandy soils.
Key wards: wheat, Azolla, Mycorrhiza, foliar application of K or Mg, growth, photosynthesis, productivity.

Introduction

Wheat (*Triticum aestivum* L.) considered as the main cereal crop in the world and in Egypt. It represents the main source of food for more than one third of the world population, in Egypt wheat provides 37% of the total calories for the people and 40% of the protein in the Egyptian diet (Ministry of Agriculture Statistic Year Book, 2015). It is also represent a major source of straw for animal feeding.

Under Egyptian conditions a great attention is being devoted at the National Research Centre to reduce the high rates of mineral fertilizers by using biofortified farming system[1,2,3]. Beneficial role of biofertilizers are evident to rationalize the use of mineral fertilizers and add an effective mean for sustainable cultivation of the desert, less environmental pollution, diminishing farming expenses, enhancing crop productivity by providing them with a readily nutritive elements and growth promoting substances[4]. Mycorrhizal fungi is one of the soil organisms that create hyphae to connect between soil and host plant root systems[5]. Arbuscular Mycorrhizae (AM) fungi assist plants to get water and nutrients from the soil, and in turn, the plant provides the fungus with relatively constant and direct access to carbohydrates[6]. Many investigators have shown a substantial increase in growth and yield of wheat plant in reclaimed sandy soils[7,3].

Azolla is a good source of biofertilizer and green manure having a wide distribution. Ability of *Azolla-Anabaena* system to fix nitrogen from the environment at faster rates, makes it a suitable agronomic choice under tropical conditions[8]. Nitrogen fixation potential of the *Azolla-Anabaena* system has been estimated to be 1.1 kg N ha^{-1} day^{-1}. Azolla has multifaceted uses and has gained considerable importance in the recent times as biofertilizer and green manure as well as poultry feed and cattle fodder[9].

Potassium is principle macronutrients. It considered as the most abundant cation in the cells of higher plants. It is essential for plants because, it help in enzymes activation, protein synthesis and photosynthesis process[10]. Further, it minimize the loss of soil moisture by reducing the transpiration and increasing the retention of water in plants tissues. [11] added that potassium plays an important role in plant metabolism, improves the quality of the crops, because it helps in grain filling and increase kernel weight, strengthens straw, increases disease resistance and helps the plant to mitigate abiotic stress[12]. Also, [13] indicated the importance of K under sandy soil conditions for vegetables.

Magnesium is a macronutrient which acts as a catalyst in many oxidation, reduction reactions inside the plant tissues, as well as it may increase crop adaptation to drought[14]. In this concern [15] stated that foliar spraying with magnesium sulphate significantly enhance net assimilation rates, seed yield and crude protein % of bean plants. Studies indicate that 15 to 30% of the total magnesium in plants is associated with the chlorophyll molecule[16]. [17] concluded that the Magnesium fertilization as foliar application tended to increase grain, straw yield and 1000-kernel weight, number of grains/spike and grain content of Mg, P, K, and crude protein.

The objective of this work is to evaluate the effect of inoculation with Azolla or Mycorrhiza and foliar spraying with KNO_3 and Mg $(NO_3)_2$ on growth, photosynthetic pigments content, yield and yield components as well as nutrients content of wheat plants grown under new reclaimed sandy soil.

Materials and Methods

Two field experiments were performed at the Agricultural Production and Research Station, National Research Centre, Nubaria Province, Behaira Governorate, Egypt, during the two successive winter seasons of 2012/2013 and 2013/2014. The surface soil sample (0-30 depth) of the experimental area was subjected to laboratory analysis to determine some of its physical and chemical properties according to the method described by[18] in Table (1).

Table (1): Mechanical and chemical analyses of the experimental soil (2012/2013 and 2013/2014 seasons).

Mechanical analysis:	2012/2013	2013/2014
Sand %	92.3	90.1
Silt %	3.1	4.3
Clay %	4.6	5.6
Chemical analysis:	2012/2013	2013/2014
CaCo3 %	1.3	1.5
Organic matter %	0.3	0.3
EC. mmhos/cm^2	0.3	0.3
pH	7.4	7.2
Soluble N (ppm)	8.0	8.2
Available P (ppm)	3.0	3.4
Available K (ppm)	19.8	20.2

The experimental design was split plots design with four replicates. Three biofertilizer treatments (control, Azolla 2 L/fed. or Mycorrhiza 1 kg/fed.) were assigned to the main plots, while the three foliar treatments were randomly distributed in the sub plots (tap water, KNO_3 5 g/L or $Mg(NO_3)_2$ 5 g/L). Wheat grains (60 kg/fed.) *Triticum aestivum* L. cv. Sakha 94 were planted on 14*th* and 16*th* November in 2012 and 2013 in both seasons, respectively. Biofertilier treatments were applied either by drilling on wheat grains prior to grain covering for mycorrhiza at 1kg/fed once before the first irrigation was applied while for Azola, it was carried out by foliar spraying at 2 L/fed twice before the 1*st* and second irrigation. Phosphorus fertilizer was added before sowing at the rate of 31 kg P_2O_5/fed as calcium superphosphate (15.5% P_2O_5), while potassium was added at the rate of 24 kg K_2SO_4 /fed as potassium sulphate (48% K_2SO_4), nitrogen fertilizer was applied at the rate of 75 Kg N/fed in the form of ammonium nitrate (33.5% N) in three equal doses at, 20 days after sowing, tillering, and heading stages. Sprinkler irrigation system was applied every 5 days. The solutions of the macronutrients were sprayed two times, after 40 days from sowing and 15 days later at the rate of (5 g/L) KNO_3 or (5 g/L) Mg $(NO_3)_2$ in additions to tap water as control treatment. The normal agronomic practices of growing wheat were practiced till harvest as recommended by wheat Research Department A.R.C., Giza. At 90 days from sowing. Plant samples were taken from each treatment (0.25 m^2) to record the following characters: plant height (cm), number of spikes/m^2, blades area (cm^2/m^2), flag leaf area (cm^2) and dry weight of plants (g/m^2). Photosynthetic pigments content were determined according to[19].

At harvest, the two central rows were harvested and the following characters were recorded: number of grains/spike, dry weight of grains/spike (g), 1000 grains weight (g), grain yield (tons/fed), straw yield (tons/fed), biological yield (tons/fed), harvest index (economical yield/biological yield * 100). Total nitrogen was determined following the micro Kjieldhl method according to [20] and then total N content was multiplied by 5.75 to obtain the protein content in grain. Phosphorus was measured calorimetrically by vanadate molybdate yellow method[21]. Potassium and was measured by flame photometer according to[22]. Magnesium was also determined according to[20]. The obtained data were subjected to the proper statistical analysis according to[23]. Since the trends were similar in both seasons, the homogenty test was carried out according to Partlet's test and the combined analysis of the data was applied according to[23]. Treatment means were compared using LSD test at 5% level.

Results and Discussion

1.1. Effect of fertilization with Azolla or Mycorrhiza on growth characters of wheat.

It is clear also from Table (2), that plant height (cm), number of spikes, dry weight of spikes (g/m^2), dry weight of blades (g/m^2), flag leaf area (cm^2) and dry weight of plant (g/m^2) at 90 days from sowing were significantly affected with addition of Azolla or Mycorrhiza except blades area cm^2 /m^2. Addition of Mycorrhiza greatly increased most growth characters of wheat plants as compared to Azolla but there was no significant between Azolla and Mycorrhiza on all growth characters. Such effect may be due to that mycorrhiza increases the surface areas of plant root systems, which facilitate uptake of nutrients and water[24]. In addition, biofertilizer inoculation in soil improves soil biota and minimizes the sole use of chemical fertilizers[25]. Similar results were obtained by [2, 7] who revealed that the biotreatments produced significant increments in all growth characters under study. Moreover, [26] stated that, Mycorrhiza can improve plant growth by up taking P and help to absorb N, K, Ca, S, Cu, and Zn.

Table (2): Effect of fertilization of Azolla or Mycorrhiza on some growth characters of wheat.

Organic treatment	Plant height cm	Number of spikes/m^2	Dry weight of spikes g/m^2	Blades area cm^2/m^2	Dry weight of blades g/m^2	Flag leaf area cm^2	Dry weight of plants g/m^2
Control	83.7	326.2	394.4	56590.5	299.2	41.9	1007.6
Azolla	87.4	340.4	412.8	58026.1	313.4	43.2	1035.3
Mycorrhiza	88.8	358.1	424.0	58913.3	316.0	43.7	1050.7
LSD at 5%	4.6	19.3	21.2	ns	16.3	2.2	ns

1.2. Effect of foliar application with KNO_3 or Mg $(NO_3)_2$ on growth of wheat.

Data in Table (3) showed that, foliar application of either Mg or K positively enhanced all the studied growth characters in comparing with control treatment, However, K surpass Mg in all the studied growth characters. This increase in growth due to potassium application could be due to its role in improving physical, chemical and biological condition of soil, its direct effect attributed due to its metabolic activity in plant growth. These results are in agreement with [27] who stated that the increase in grain number/spike by foliar feeding with K may be due to increase in number of spikelets. In this concern, many researcher proved that potassium played a key role in the osmotic adjustment (stomatal opening) of plants under water stress and yield may be improved due to foliar feeding with potassium[28].

Table (3): Effect foliar application of KNO_3 or Mg $(NO_3)_2$ on growth of wheat.

Foliar application treatment	Plant height cm	Number of spikes/m^2	Dry weight of spikes g/m^2	Blades area cm^2/m^2	Dry weight of blades g/m^2	Flag leaf area cm^2	Dry weight of plants g/m^2
Tap water	81.5	323.3	388.3	55943.5	293.4	40.0	989.0
$Mg(NO_3)_2$	87.0	340.2	413.7	57821.5	310.6	42.9	1028.8
KNO_3	91.4	361.3	429.2	59764.9	324.5	45.8	1075.8
LSD at 5%	5.2	20.3	19.5	301.3	17.3	2.3	45.6

1.3. Interaction effect of biofertization and foliar treatments on growth of wheat.

Data presented in Table (4) show the combined effect between biofertilization treatments with Azolla or Mycorrhiza and foliar application treatments with KNO_3 or Mg $(NO_3)_2$, on growth of wheat. Data showed that, the highest values for all growth characters were recorded in plants treated with Mycorrhiza and sprayed with KNO_3. On the contrary, Plant without biofertilization and sprayed with tap water recorded the lowest values for all growth characters. Similar results were obtained by [29] who stated that, biofertilzation and foliar potassium application significantly affect plant growth. This significant increase in all growth characters could be attributed to the positive impact of the combined effect of the bioinoculants and the foliar applied macronutrients

Table (4): Interaction effect of biofertization and foliar treatments on growth of wheat.

Organic treatment	Foliar application	Plant height cm	Number of spikes/m^2	Dry weight of spikes g/m^2	Blades area cm^2/m^2	Dry weight of blades g/m^2	Flag leaf area cm^2	Dry weight of plants g/m^2
Control (without)	Tap water	78.3	314.3	378.5	55487.6	288.3	39.1	977.6
	$Mg(NO_3)_2$	85.6	325.6	398.3	56777.4	301.2	42.6	1017.8
	KNO_3	87.1	338.8	406.5	57506.6	308.0	44.0	1027.3
Azolla	Tap water	82.5	316.5	384.2	55521.7	291.5	40.4	986.9
	$Mg(NO_3)_2$	87.2	339.3	417.3	57983.7	318.3	43.2	1028.7
	KNO_3	92.6	365.5	436.8	60572.9	330.2	45.9	1090.3
Mycorrhiza	Tap water	83.6	339.1	402.1	56821.0	300.2	40.6	1002.6
	$Mg(NO_3)_2$	88.2	355.6	425.6	58703.4	312.4	43.0	1040.0
	KNO_3	94.6	379.5	444.3	61215.3	335.3	47.5	1109.7
LSD at 5%		9.3	38.8	41.4	546.1	33.5	4.5	98.3

2.1. Effect of fertilization with Azolla or Mycorrhiza on photosynthetic pigments content.

Data in Fig. (1) showed that either Azolla or Mycorrhiza significantly affected the content of chl. a, b and carotenoids as compared with control treatment. However, Chl. a + Chl. b and Chl.a + Chl. b / Carotenoids features took similar trend. Similar results were recorded by [30]. In this concern, [31] stated that, Mycorrhiza fungi enhance photosynthetic pigments and photosynthesis of host plants because it cause better mineral nutrition, as they cause chlorophyll organs of plant to grow by absorbing adequate carbon, producing nutrients to plant and increasing efficiency of photosynthesis. [32] proved that azolla positively affected photosynthetic pigments content of *Beta vulgaris.*

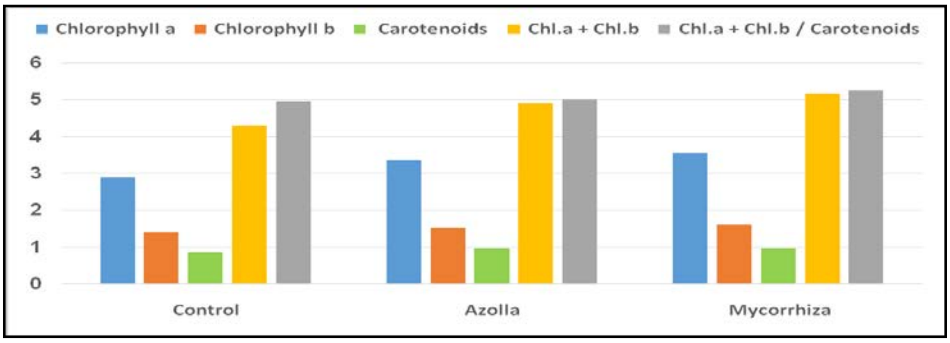

Fig. (1): Effect of fertilization with Azolla or Mycorrhiza on photosynthetic pigments content.

(LSD 5%: 0.23)

2.2. Effect of foliar application of KNO_3 or Mg $(NO_3)_2$ on photosynthetic pigments content.

Data presented in Fig. (2) revealed that foliar application with KNO_3 or Mg $(NO_3)_2$, positively affected photosynthetic pigments content, with superiority to Mg $(NO_3)_2$ over all the other treatments. Similar results were obtained by[33]. Such increase in photosynthetic pigments content in the leaves of plants may be attributed to the enhancing effect of Mg on chlorophyll accumulation through the useful importance of magnesium for photosynthesis, net assimilation and transpiration rates[34]. On the other hand, foliar application of K was less effective than Mg on chlorophyll content.

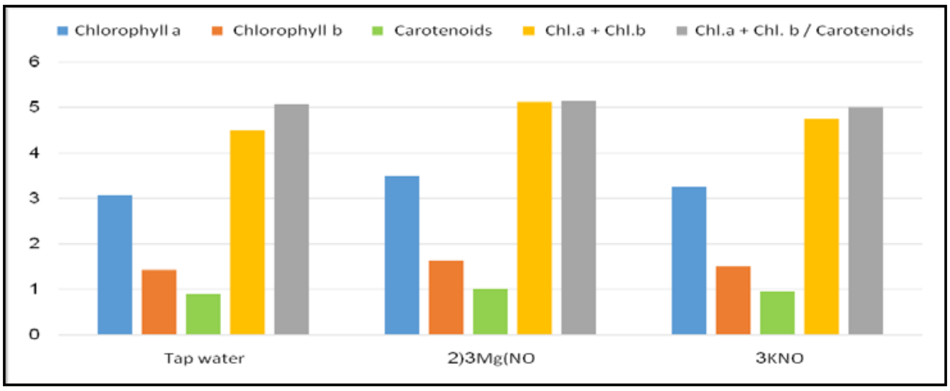

Fig. (2): Effect of treatment with KNO_3 or Mg $(NO_3)_2$ on photosynthetic pigments content.

(LSD 5%: 0.27)

2.3. Interaction effect of biofertization and foliar treatments on photosynthetic pigments content.

Data in Fig. (3) showed that the highest values of chl. a, chl. b and carotenoids as well as Chl. a + Chl. b and Chl. a + Chl. b / Carotenoids were recorded in plants treated with Mycorrhiza and sprayed with Mg $(NO_3)_2$. This could be due to the individual effect of either Mycorrhiza or Mg $(NO_3)_2$. On the other hand, the least values of photosynthetic pigments content, were recorded in plants did not received biofertilizers and sprayed with tap water, Similar results were recorded by [33,3].

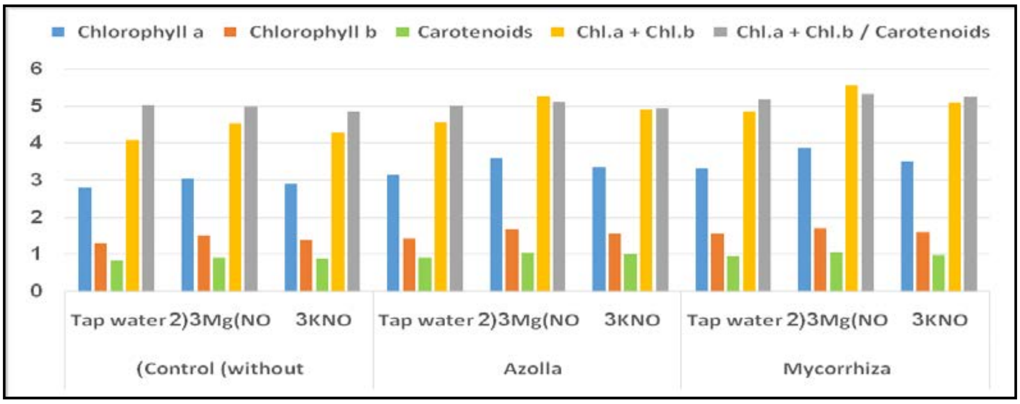

Fig. (3): Interaction effect of biofertilization and foliar treatments on photosynthetic pigments content. (LSD 5%: 0.42)

3.1. Effect of fertilization with Azolla or Mycorrhiza on yield, yield attributes and protein content of wheat.

Data in Table (5) showed that, yield and yield attributes of wheat plants, significantly affected by biofertilization treatments. However, plants fertilized with Mycorrhiza surpass plants treated with Azolla. Similar results were obtained by[3]. On the contrary plants fertilized with Azolla produced higher values of protein content in the grains as compared with other treatments. Applications of biofertilizer in agriculture are suggested as a sustainable way of increasing crop yields and economize their production as well[35]. This increment of yield and its components could be due to the positive impact of biofertilizer on plant growth which play important role of assimilation of wheat plants that reflected on enhancing these characters.

Table (5): Effect of fertilization with Azolla or Mycorrhiza on yield, yield attributes and protein content of wheat.

Organic treatment	Number of grains/spike	Dry weight of grains/spike g	1000 grains weight g	Grain yield ton/fed	Straw yield ton/fed	Biological yield ton/fed	Harvest Index	Crude protein %
Control	53.05	2.51	43.87	1.84	2.36	4.2	43.75	12.5
Azolla	55.16	2.64	45.97	1.97	2.53	4.5	43.81	13.99
Mycorrhiza	57.75	2.85	47.76	2.16	2.7	4.86	44.42	13.55
LSD at 5%	2.67	0.15	2.33	0.11	0.13	0.21	2.2	0.69

3.2. Effect of foliar application with KNO_3 or Mg $(NO_3)_2$ on yield, yield attributes and protein content of wheat.

Results presented in Table (6) also indicated that foliar application of either KNO_3 or Mg $(NO_3)_2$, significantly affected number of grains/spike, weight of grains/spike and 1000 grains weight (g) grain yield (tons/fed), straw yield (tons/fed), biological yield (tons/fed), crude protein%. However, harvest index was significant. Similar results were obtained by[36]. These effects may be due to the role of K in formation of proteins, photosynthesis translocation regulation, carbohydrates, and enzyme action, synthesis of nucleic acid, chlorophyll, oxidative, photophospharylation and translocation of solutions[37]. In this concern, [38] stated that, such increase in yield and yield attributes characters, could be due to the role of potassium in increasing the division, cell growth, increasing photosynthesis process, and somewhat lost storage limitations and transport of photosynthesis assimilates into seeds resulting in more grain filling, and consequently, seed weight increases. Moreover, [39] reported that foliar spraying with potassium plays an important role in the growth and development of plants. Also, [36] came to similar conclusion.

Table (6): Effect of foliar application with KNO_3 or Mg $(NO_3)_2$ on yield, yield attributes and protein content of wheat.

Foliar application	Number of grains/spike	Dry weight of grains/spike g	1000 grains weight g	Grain yield ton/fed	Straw yield ton/fed	Biological yield ton/fed	Harvest Index	Crude protein %
Tap water	52.58	2.51	44.02	1.81	2.33	4.14	43.75	12.27
$Mg(NO_3)_2$	55.66	2.69	46.18	1.98	2.52	4.5	43.98	13.61
KNO_3	57.72	2.79	47.4	2.17	2.74	4.91	44.24	14.16
LSD at 5%	2.56	0.13	2.31	0.09	0.11	0.22	NS	0.64

3.3. Interaction effect of biofertization and foliar treatments on yield, yield attributes and protein content of wheat.

Data presented in Table (7) showed the interaction effect between biofertilization with treatments with Azolla or Mycorrhiza and foliar treatments with KNO_3 or Mg $(NO_3)_2$ on yield and yield attributes as well as grain protein% in wheat plant. Data showed that, plants treated with Mycorrhiza and sprayed with KNO_3 recorded the highest values of yield and yield components. However, the highest values for protein in wheat grains were recorded in plants treated with Mycorrhiza and sprayed with Mg $(NO_3)_2$. Similar results were obtained by [29] who showed that, bioinoculation of cluster bean plant with AMF and potassium fertilizer significantly increased pod weight and consequently higher yields over control treatment.

Table (7): Interaction effect of biofertization and foliar treatments on yield, yield attributes and protein content of wheat.

Organic treatment	Foliar application	Number of grains/spike	Dry weight of grains/spike g	1000 grains weight g	Grain yield ton/fed	Straw yield ton/fed	Biological yield ton/fed	Harvest Index	Crude protein %
Control (without)	Tap water	50.32	2.35	42.02	1.66	2.15	3.81	43.57	11.39
	$Mg(NO_3)_2$	53.15	2.51	43.36	1.83	2.35	4.18	43.78	12.71
	KNO_3	55.68	2.66	46.23	2.02	2.58	4.6	43.91	13.4
Azolla	Tap water	52.12	2.51	44.36	1.81	2.33	4.14	43.72	13.11
	$Mg(NO_3)_2$	56.23	2.68	46.54	1.95	2.5	4.45	43.82	14.2
	KNO_3	57.12	2.72	47.02	2.15	2.75	4.9	43.88	14.66
Mycorrhiza	Tap water	55.3	2.68	45.69	1.97	2.51	4.48	43.97	12.31
	$Mg(NO_3)_2$	57.6	2.89	48.65	2.16	2.71	4.87	44.35	13.92
	KNO_3	60.35	2.99	48.94	2.35	2.88	5.23	44.93	14.43
LSD at 5%		3.59	0.26	4.12	0.19	0.28	0.45	ns	1.33

4.1. Effect of fertilization with Azolla or Mycorrhiza on nutrient contents of wheat grains.

Data in Fig. (4) showed significance differences between treatments. However, the highest N content was recorded in plant treated with Azolla. On the other hand, wheat plants treated with Mycorrhiza contained the highest P, K and Mg content. Similar results were obtained by [40]. In this regards, [29] stated that, it might be due to the fact that mycorrhizal inoculation assists the plants to counter photo inhibition and photo destruction of pigments under stressed conditions by increasing the content of carotenoids. The positive effect of Arbuscular mycorrhiza fungi could be attributed to the increase in mineral uptake by increased acquisition of phosphorus and other low mobile mineral nutrients, which reduce the use of fertilizers[41]. They added, they can also break down certain complex minerals and organic substances in the soil and make it available to their hosts.

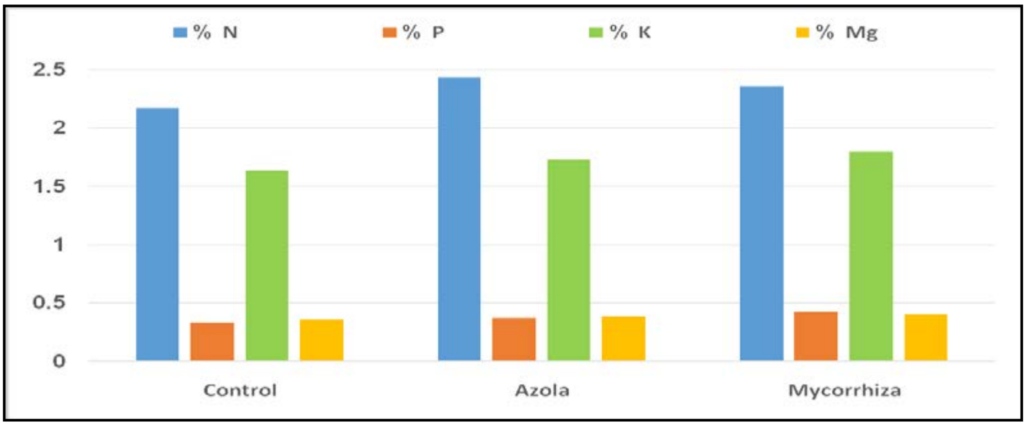

Fig. (4): Effect of fertilization with Azolla or Mycorrhiza on nutrient contents of wheat grains.

(LSD 5%: 0.13)

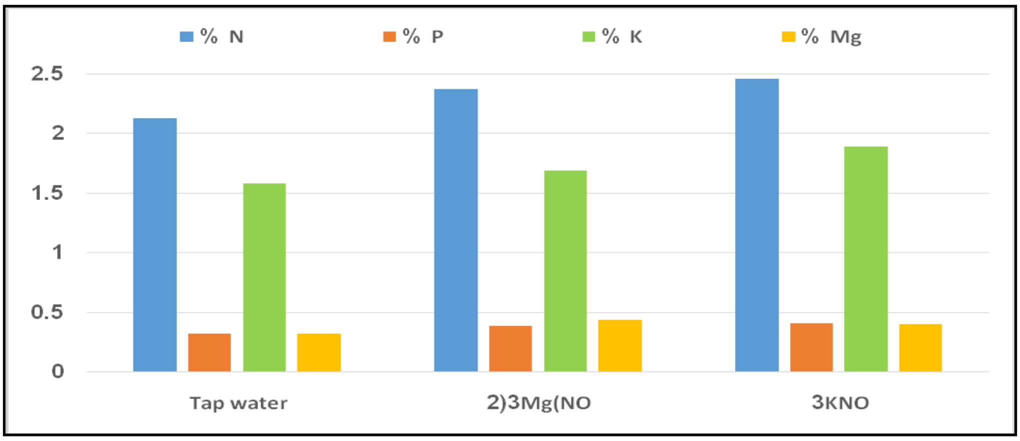

Fig. (5): Effect of foliar application of KNO_3 or Mg $(NO_3)_2$ on nutrient contents of wheat grains.

(LSD 5%: 0.19)

4.2. Effect of foliar application of KNO_3 or Mg $(NO_3)_2$ on nutrient contents of wheat grains.

Data in Fig. (5) showed that, foliar application with either K or Mg, significantly affected content of N, P, K and Mg as compared with control treatment. However, plants sprayed with KNO_3 recorded the highest values of N, P and K, while plants sprayed with Mg $(NO_3)_2$ recorded higher contents of Mg. Such pronounced effect of K on nutrients uptake was confirmed by the findings of [42]. In this respect, [36] stated that, both KNO_3 and Mg $(NO_3)_2$ significantly increased N, P and K content of wheat grains.

4.3. Interaction effect of biofertization and foliar treatments on nutrient contents of wheat grains.

Data presented in Fig. (6) showed that, plants treated with Mycorrhiza and sprayed with KNO_3 recorded the highest content of P and K, while the highest values of N was recorded in plants treated with Azola and sprayed with KNO_3. On the other hand, plants treated with Mycorrhiza and sprayed with Mg $(NO_3)_2$, recorded the highest values of Mg These results are supported by the work of [43] who showed that nutrient uptake of AMF infected plants was higher compared to non-AMF infected plants. Similar results were obtained by [3,36]. In this regards, [44] suggested the synergistic effect of K and Mg nutrients on mycorrhizal development when present in specific concentrations in soil. [45] observed 35% increase in K^+ contents in *Pinus pinaster* mycorrhized by *Hebeloma cylindrosporum* upon two months culturing in K^+ deficiency, suggesting that this fungus plays a vital role in pine adaptation to limiting conditions. Moreover, [46] stated that, K^+ assimilation was increased up to 38% improved in shoots of *Acacia spirorbis* and *Eucalyptus globules* mycorrhized by *Pisolithus albus*.

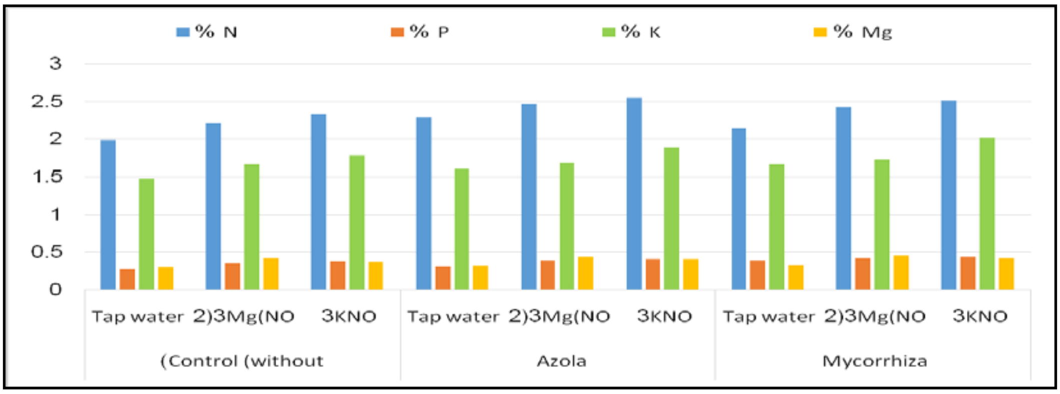

Fig. (6): Interaction effect of biofertization and foliar treatments on nutrient contents of wheat grains. (LSD 5%: 0.23)

Conclusion

Our results showed that fertilization with Mycorrhiza or Azolla had a positive effect on wheat productivity under the circumstance of new reclaimed sandy soil. Azolla can be used as a viable bioinoculant for sustainable crop production and development. Foliar application of K or Mg significantly affected growth and yield components of wheat plants resulting in an improvement in grain quality through the effect on concentration of grain nutrients and protein. Combined application of Mycorrhiza and KNO_3 could be suitable for wheat production in new reclaimed sandy soil. Such results emphasize that biofertilization is not a substitute but a partial supplement for the recommended NPK mineral fertilizers which could be ascribed partially to the increased mobility of fixed nutrients like P in the soil or fixing more N which reflected directly on most growth and yield characters of wheat in sandy soils.

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