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EFFECT OF PRECEDING CROPS AND FOLIAR MICRONUTRIENTS APPLICATIONS ON YIELD AND YIELD COMPONENTS OF BREAD WHEAT UNDER SANDY SOIL CONDITIONS

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ABSTRACT: Two field experiments were conducted during 2016/2017 and 2017/2018 seasons at the experimental farm of the Agricultural Research Station, Agric. Res. Center, Ismailia Governorate, Egypt (Lat. 30° 35' 30" N, Long. 32° 14' 50" E, 10 m ASL), to evaluate the effect of fallow (control), clover and fodder maize as a preceding crops and foliar application of some micronutrients on yield and yield components of wheat cv. Gemmiza 11. The experimental design was split plot with three replications. Main plots were allocated by preceding crops and sub plots were occupied by three micronutrients salts $FeSO_4$, $ZnSO_4$ and $MnSO_4$, in seven combinations of micronutrients foliar application T1: (Fe +Zn + Mn), T2: (Fe +Zn), T3: (Fe + Mn), T4: Fe, T5: (Zn + Mn), T6: Zn and T7: Mn. Micronutrients were sprayed three times at 30, 60 and 90 days after sowing. Results showed that wheat significantly affected by the preceding summer crops. Clover as a preceding crop left good residual effect on wheat plant which gave the highest values for all studied characters *e.g.* plant height, number of spikes/m^2, No. of spikelets/spike, No. of grains/spike, 1000 grain weight and grain yield as well as straw and grain contents from Fe, Mn and Zn in the two seasons. With respect to micronutrients, the results showed that the differences between these treatments had significant effect on each of plant height, number of spikes/m^2, No. of spikelets/spike, No. of grains/spike, 1000 grain weight and grain yield. The foliar application of mixture nutrients (Fe + Mn + Zn) produced the highest values of yield and its components during both seasons. Moreover, the foliar spray of Fe, Mn and Zn (alone or together and all three nutrients) has significant effect on wheat straw and grain-Fe, Mn and Zn concentration during the two seasons. Also, the results indicated that the interaction between preceding crops and micronutrients treatments had insignificant effect on all studied characters, except 1000 grain weight in the first season and number of spikelets/spike in the second one. In conclusion growing wheat following to clover and foliar application by mixture of Fe+Mn+Zn produced the maximum net income valued 2186 and 2098 LE.fad^{-1} during two seasons, respectively, compared to the other treatments.

Key words: Wheat, preceding crop, mironutrients.

INTRODUCTION

Wheat (*Triticum aestivum*, L.) is one of the most important cereal crops in terms of area and production. Also, wheat is considered as the first leading cereal crop in the world, due to its position as a staple food for the majority of the world population. In Egypt, wheat is the most important food crop and provides almost 35% of the total food calories of the Egyptian people. Increasing wheat productivity in sandy soils is one of the main targets due to its short supply which mandated importing about 50% of the needed wheat, taking into account the climate

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change, the gap is expected to increase in the future (**Ouda *et al.,* 2017**).

Sandy soils are known to be poor in macro and micronutrients especially available nitrogen due to their low content of organic matter. Therefore, appropriate wheat positioning in cropping sequence under efficient management practices may facilitate better utilization of growth resources to enhance growth features. Several investigators showed that leguminous crops are the best precursors for all soil and productivity of wheat. The net benefits of legumes are often equivalent to the addition of 50-100 kg N per ha as fertilizer (**Phoomthaisong *et al.,* 2003**), especially N deficiency is one of the major yield limiting factors for cereals (**Shah *et al.,* 2003**). Inclusion of legumes increases soil fertility and consequently the productivity of succeeding cereal crops (**Ghosh *et al*., 2007**). Less N uptake by legumes plants increased the N uptake by the following non-legume enhancing photosynthesis to increase photo assimilates translocation to plant different sinks and, in turn, enhancing yield and yield attributes (**Khalil *et al.,* 2011**). Also, **Kumar and Sharma (2000)** reported that growing of a legume crop in the previous season affect the growth and development of wheat. Growing wheat after peas or fahl-berseem and/or soybean increaseing, plant height, number of spikes/m^2, spike length, weight of grains/spike and 1000-grain weight as well as grain yield fad.$^{-1}$ compared with wheat grown after fodder maize or maize (**Abou-Kerisha, 1998; Seif El-Nasr and Zahran, 1998; Badr, 1999**). Wheat cultivated after legumes has significantly higher grain and straw yields and net income than after cereal crop (**Abou-Kerisha *et al.,* 2008; Gangaiah *et al.,* 2012**). **Maadi *et al.* (2012)** found that species of preceding crops significantly affect wheat yield and its attributes and grain legumes such as mung bean might help to maximize wheat yield in a crop rotation system. Fahl berseem as preceding crops for wheat gave significantly higher grain yield compared with fodder maize. Similarly, the highest grain yield and net income after fahl berseem, (2.959, 2.980 ton and 5422, 5414 LE) in the 1st and 2nd seasons, respectively (**El-Mehy *et al*., 2014**).

It is perceived that micronutrients play a pivotal role in the yield improvement (**Rehm and Sims, 2006**). These micronutrients help in chlorophyll formation, nucleic acid, protein synthesis and play an active role in several enzymatic activities of photosynthesis as well as respiration (**Reddy, 2004**). **Chaudry *et al.* (2007)** stated that micronutrients (Zn, Fe, B) significantly increased the wheat yield over control when applied singley or in combination with each other. **Zain *et al*. (2015)** found that foliar application of micronutrients substantially improved each of plant height, spike length, No. of spikelets/spike, No. of grains/spike, grain and biological as well as harvest index of wheat. Among treatments, foliar application of $FeSO_4$ + $ZnSO_4$ + $MnSO_4$ remained comparatively better regarding yield related attributes of wheat. Also, **Aziz *et al.* (2019)** showed the effectiveness of foliar feeding for growth and yield parameters, compared to the control without foliar feeding, foliar application of wheat crop increased tillering ability, spike length and grain yield. Therefore, foliar feeding of micronutrients could be an effective approach to enrich wheat grains with essential nutrients for correcting malnutrition. The foliar application of Fe +Zn + Mn treatments had significantly increased crop in two growing seasons. However the interaction of varieties and Fe + Zn + Mn foliar application showed a significant impact on some traits compared to the control. The highest values of all these studied traits were obtained by applying Fe + Zn + Mn as a foliar spray **Abdel-Motagally *et al.* (2016)**.

The aim of this study was to evaluate the effect of fallow (control), clover and fodder maize as preceding crops as well as the effect of some micronutrients on yield and yield components of wheat cv. Gemmiza 11.

MATERIALS AND METHODS

Site Description

Two field experiments were carried out at Ismailia Agricultural Experiments and Research Station, ARC, Ismailia Governorate (Lat. 30° 35' 30" N, Long. 32° 14' 50" E, 10 m ASL), under sprinkler irrigation system during 2016/ 2017 and 2017/2018 seasons. The experimental soil was sandy in texture. Physical properties and chemical analysis of the experimental soil sites (0-30 cm depth) are stated in Table 1 according to standard methods described by **Piper (1950) and Jackson (1973)**. DTPA-extractable Fe, Mn and Zn were measured in soil

Table 1. Some physical and chemical properties of the experimental soil in the two seasons of investigation (2016/2017 and 2017/2018)

Property	First season 2016/2017	Second season 2017/2018	Property	First season 2016/2017	Second season 2017/2018
Physical analysis			**Chemical properties**		
Coarse sand (%)	74.60	72.50	pH	7.86	7.90
Fine sand (%)	19.50	19.65	EC dsm^{-1}	0.95	1.04
Silt (%)	2.45	3.50	OM %	0.42	0.53
Clay (%)	3.45	4.35	Ca CO_3 %	1.95	2.13
Texture	Sandy	Sandy			
			Chemical properties		
Soluble cations (mmolic l^{-1})			**Soluble anions (mmolic l^{-1})**		
Ca^{2+}	4.30	4.39	CO_3^{2-}	-	-
Mg^{2+}	1.82	1.90	HCO_3^-	2.15	2.28
Na^+	2.43	2.51	Cl-	2.65	2.75
K^+	0.95	1.60	SO_4^{2-}	4.70	5.37
Available NPK (ppm)			**DTPA-extractable (mg kg^{-1})**		
N	18.21	21.32	Fe	1.76	1.82
P	4.85	5.78	Mn	1.44	1.45
K	63.45	73.20	Zn	0.37	0.50

sample taken at the ripeness stage using an atomic absorption spectrophotometer as described by **Page *et al.* (1982)**. Samples of the plant were dried at 70^0C for 50 hr., and digested using concentrated sulfuric and perchloric acid combination, (1:1 $H_2SO_4/HClO_4$) **Chapman and Pratt (1961)**. Fe, Mn and Zn were measured in straw and grain sample taken at the ripeness stage using an atomic absorption spectrophotometer according to **Page *et al.* (1982)**.

The experimental design was split plot design with three replications, preceding crops were assigned to the main plots, while seven micronutrient treatments were allotted in subplots. The area of each experimental sub plot was 17.5 m^2 (5 m in length and 3.5 m in width). This experiment included twenty one treatments which were the combinations of three preceding crops and seven treatments of micronutrients foliar application.

A- Preceding crops of wheat were as follows:

[1]- Fallow (control), [2]- Egyptian clover (Fahl) and [3]- Fodder maize.

B- Micronutrients foliar applications of wheat plants were as follow:

T1: (Fe +Zn + Mn) 3.36 +4.20 +3.36 kg $fad.^{-1}$, T2: (Fe +Zn) 3.36 +4.20 kg $fad.^{-1}$,

T3: (Fe + Mn) 3.36 +3.36 kg $fad.^{-1}$, T4: Fe 3.36 kg $fad.^{-1}$, T5: (Zn + Mn) 4.20 + 3.36 kg $fad.^{-1}$, T6: Zn 4.20 kg $fad.^{-1}$, T7: Mn 3.36 kg fad^{-1}

Seven treatments from only micronutrient (Fe, Zn and Mn) and combinations using 500 mg l^{-1} for each with EDTA, 11% were carried out on the plants at 30, 60 and 90 days after sowing. Spraying plants with tube well water at a level for one spray 1.12, 1.12 and 1.40 kg fad.$^{-1}$ from $FeSO_4$, $MnSO_4$ and $ZnSO_4$, respectively.

In both growing seasons, all preceding crops were established following peanut (cv Giza 5). Peanut was growing on 15th April and harvested on 1st September in the two growing seasons. After peanut harvesting, the experimental area was divided to three main plots to occupy by fodder maize, Egyptian clover and fallow (control). Fodder maize and Egyptian clover were sown on 10th September and harvested on 10th November in both growing seasons. In the two growing seasons, peanut and clover seeds were inoculated by *Bradyrhizobium* and R*hizobium trifolii*, respectively, before seeding it. All preceding summer crops were given their convention cultural practices. Wheat (cv. Gemmiza 11) was planted on 15th November, meanwhile harvesting was done on 10th April in both seasons. Phosphorus fertilizer was added at a level of 100 kg fad^{-1} as mono calcium superphosphate (15.5% P_2O_5) during soil preparation. Nitrogen was applied at a level of 100 kg fad.$^{-1}$ as ammonium nitrate (33.5% N) in 4 equal doses every two weeks. Potassium fertilizer was applied at a level of 48 kg fad.$^{-1}$ as potassium sulphate (48% K_2O) at tillering and botting stage. All other cultural practices of growing wheat crop at Ismailia Governorate were followed as commendation.

At harvest, 1 m^2 portion at the center of each wheat sub plot was sampled. From these samples, number of spikes/ m ^{2} and grain yield Ardab fad^{-1} (Ardab= 150kg and fad = 4200 m^2) were determined. Plant height in cm, No. of spikelets/spike, No. of grains/spike and 1000 grain weight (g) were measured from 10 plants in each sub plots.

To calculate the net return of the different experimental treatments, the following market prices with Egyptian currency (LE) were used: 420 LE/ardab for grain wheat, (Bulletin of The Agriculture Statistics, 2016/2017).

Statistical Analysis

Data obtained from each trail were subjected to analysis of variance (ANOVA) using the software of split plot design as described by **Snedecor and Cochran (1981)**. Means of treatments were compared using the least significant differences (LSD) developed by **Waller and Duncan (1969)** at 5% level.

RESULTS AND DISCUSSION

Effect of Preceding Crops on Yield Components and Grain Yield of Wheat

Effect of preceding crops on yield components

Results in Tables 2 and 3 and Fig. 1 clearly indicate that plant height, number of spikes/m^2, No. of spikelets/spike, No. of grains/spike and 1000 grain weight of wheat cv. Gemmiza 11 were significantly effected by the preceding crops and that was true in 2016/2017 and 2017/2018 seasons. All studied yield attributes of wheat (No. of spikes/m^2, No. of spikelets/ spike, No. of grains/spike and 1000 grain weight) achieved the highest values when wheat plants grown after Egyptian clover (354.95, 19.18, 45.73 and 45.18 g in the first season and 351.29, 19.31, 45.00 and 41.66 g in the second season, respectively). While, cultivated wheat following fodder maize produced the lowest values of the previous mentioned traits. It is observed that fahl berseem was used as trap crop to capture left over N from the soil after peanut uprooting and improved total count of rhizobia that increased available soil N content and soil fertility as well as increased availability of micronutrients for wheat plant, as shown from chemical analysis of straw and grain wheat (Tables 4 and 5). These results are in the same context with those reported by **Baldwin (2006)** who mentioned that from 40 to 75 percent of the total N contained in a legume cover crop is available in the soil for subsequent crops, depending on environmental conditions. Less N uptake by legumes plants increased the N uptake by the following non-legume enhancing photosynthesis to increase photo assimilates translocation to different plant sinks and, in turn, enhancing yield and yield attributes (**Khalil *et al.,* 2011**). These results are in accordance with those obtained by **Seif El-Nasr and Zahran (1998), Siadat *et al.* (2011), Gangaiah *et al.* (2012) and El-Mehy *et al.* (2014)**.

Effect of preceding crops on grain yield

Results illustrated in Tables 2 and 3 and Fig. 1 indicate that the preceding crops significantly affected on grain yield of wheat in both growing

Table 2. Effect of preceding crops and foliar application of some micronutrients on yield and yield components of wheat in 2016/2017 season

Man effect and interaction	Plant height (cm)	No. of spikes/ m^2	No. of spikelets/ spike	No. of grains/ spike	1000 grain weight (g)	Grain yield (ardab/ fad.)	Straw yield (ton/fad.)
Preceding crop (P)	**First season 2016/2017**						
Fallow	91.30 b	347.90 b	18.46 b	44.55 b	44.27 b	17.08 b	1.944 ab
Fahl clover	92.77 a	354.95 a	19.18 a	45.73 a	45.18 a	18.18 a	2.059a
Fodder maize	89.72 c	341.33 c	17.70 c	44.34 b	42.01 c	15.98 c	1.749 b
LSD 0.05	0.33	1.00	0.26	0.22	0.06	0.11	0.12
Micronutrients (M)							
Fe+Zn+Mn	92.14 a	353.67 a	18.71 a	46.04 a	44.22 a	17.64 a	1.979 a
Fe +Zn	91.66 b	352.22 ab	18.63 ab	45.24 b	44.10 b	17.49 ab	1.961a
Fe +Mn	91.56 b	350.11 ab	18.45 bc	45.14 bc	43.92 c	17.37 bc	1.948ab
Fe	91.53 b	349.22 b	18.71 a	45.06 c	43.82 c	17.16 c	1.924b
Zn +Mn	91.07 c	344.44 c	18.38 cd	44.27 d	43.67 d	16.76 d	1.891c
Zn	90.74 c	344.33 c	18.22 de	44.30 d	43.64 d	16.71 d	1.879c
Mn	90.16 d	342.44 c	18.02 e	44.06 e	43.30 e	16.42 e	1.842d
LSD 0.05	0.35	4.41	0.22	0.15	0.12	0.28	0.04
Interaction PxM	NS	NS	NS	NS	*	NS	NS

Where: * and NS refers to significant at 0.5 and not significant, respectively.

Table 3. Effect of preceding crops and foliar application of some micronutrients on yield and yield components of wheat in 2017/2018 season

Man effect and interaction	Plant height (cm)	No. of spikes/ m^2	No. of spikelets/ spike	No. of grains/ spike	1000 grain weight (g)	Grain yield (ardab/ fad.)	Straw yield (ton/fad.)
Preceding crop (P)	**Second season 2017/2018**						
Fallow	91.89 b	345.43 b	18.59 b	44.02 b	40.66 b	16.51 b	1.822b
Fahl clover	94.46 a	351.29 a	19.31 a	45.00 a	41.66 a	17.68 a	2.010a
Fodder maize	89.28 c	330.62 c	17.62 c	42.81 c	39.40 c	15.66 c	1.769bc
LSD 0.05	0.28	1.68	0.097	0.25	0.13	0.11	0.11
Micronutrients (M)							
Fe+Zn+Mn	93.47 a	355.44 a	18.82 a	44.28 a	41.63 a	17.51 a	1.956 a
Fe +Zn	92.74 b	349.44 b	18.68 b	44.22 a	41.22 b	17.17 b	1.933a
Fe +Mn	92.54 b	344.89 c	18.63 bc	44.34 a	40.80 c	17.04 c	1.923a
Fe	92.02 c	346.55 bc	18.53 c	44.01 b	40.57 d	16.97 c	1.911a
Zn +Mn	90.45 e	337.89 d	18.32 d	43.71 c	39.92 ef	16.07 d	1.853ab
Zn	90.92 d	333.67 e	18.38 d	43.63 c	40.07 e	15.95 e	1.838b
Mn	90.99 d	329.22 f	18.19 e	43.42 d	39.80 f	15.65 f	1.763c
LSD 0.05	0.20	3.06	0.11	0.21	0.18	0.14	0.10
Interaction PxM	*	*	NS	*	*	*	NS

Where: * and NS refers to significant at 0.5 and not significant, respectively.

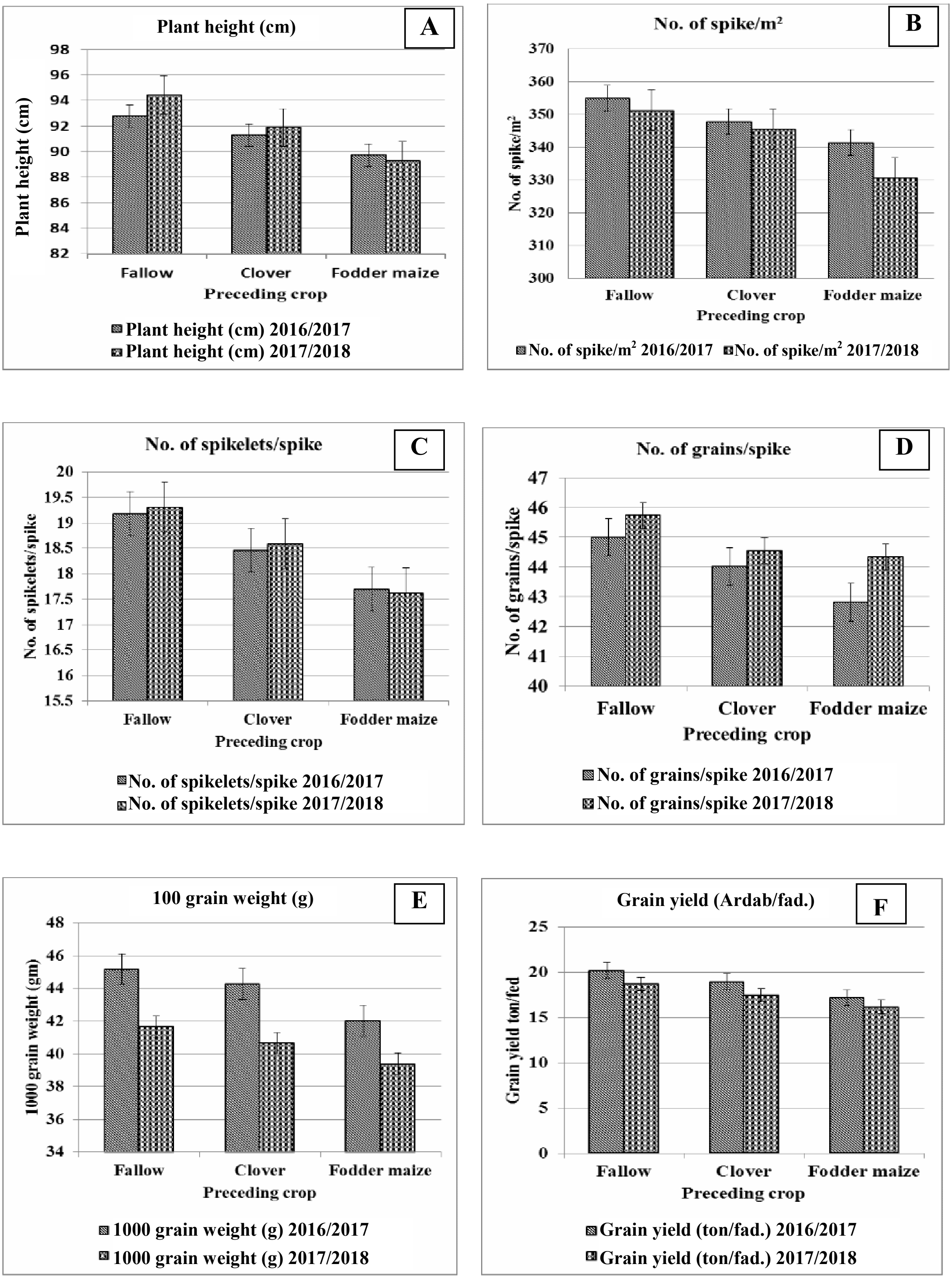

Fig. 1. Effect of preceding crop on plant height (A), No.of spike/m^2 (B), No. of spikletes/spike (C), No. of grains/spike (D), 1000 grain weight (E) and grain yield ardab/fad (F) of wheat in 2016/2017 and 2017/2018 seasons

seasons and had the same trend of yield components. The highest average grain yield were 18.18 and 17.68 Ardab/fad., when wheat grown after fahl clover followed by wheat grown after fallow (17.08 and 16.51 Ardab/ fad.), while the lowest values were recorded when wheat was sown after fodder maize (15.98 and 15.66 Ardab/fad.) during 1st and 2nd seasons, respectively. Grain yield/fad., of wheat plants grown after clover surpassed those grown after fallow and fodder maize by 6.44 and 13.76% in the first season and by 7.09 and 12.90% in the second one, respectively. Similarly, growing wheat following fahl clover significantly increased straw yield by 5.92 and 17.72% in 2016/2017 and by 10.32 and 13.62% in 2017/2018 season, respectively. This superiority of wheat grown after fahl clover may be attributed to the highest values of most of yield components such as spike length, number of spikes/plant. That indicated that growing fahl clover following peanut during the transition period season can immobilize soil N (fixing by peanut) in the plant biomass in addition to adding N from the atmosphere and reduced N losses by both leaching and denitrification (**Pandey *et al.,* 2008**), increased avialbility of micronutrients. Inclusion of legumes increases soil fertility and consequently the productivity of succeeding cereal crops (**Ghosh *et al*., 2007**). Results are in agreement with those obtained by **Seif El-Nasr and Zahran (1998), Abou-Kerisha (1998), Badr (1999), Siadat *et al.* (2011), Gangaiah *et al.* (2012), Maadi *et al.* (2012) and El-Mehy *et al.* (2014)**.

Effect of Micronutrients on Yield Components and Grain Yield of Wheat

Effect of micronutrients on yield components

Results in Table 2 and 3 show that plant height (cm), number of spikes/m^2, No. of spikelets/spike, No. of grains/spike and 1000 grain weight (g) of wheat plant significantly increased due to the foliar application of mixed three micronutrients (Fe, Zn and Mn). These results are true in 2016/2017 and 2017/2018 seasons. The highest value for each of these traits was obtained when mixed spray of the three micronutrients (Fe + Mn + Zn) was conducted together and that was true in the two growing seasons. The lowest value for each of these traits was achieved from individual application of Mn or Zn followed by application of Mn +Zn. Iron has a structural role in chlorophyll, energy transfer within the plant and enters in root cells. This in turn, may be leads to an increase in yield components of wheat plants. These results are in agreement with **Reddy (2004), Chaudry *et al.* (2007), Zain *et al.* (2015) and Aziz *et al.* (2019)**. This increase may be taken place mainly due to the additional availability of micronutrients of wheat plants. In this respect, **Grewal *et al.* (1997)** reported that wheat production increased with application of Zn and boron. In this context, **Gueins *et al.* (2003)** reported significant increase in number of grains/spike and 1000-grain weight of wheat due to foliar application of boron and zinc. **Chaudry *et al.* (2007)** reported that micronutrients (Zn and Fe) significantly increased the wheat yield over control. Also, **Chowdhury *et al.* (2008)** revealed that application of micronutrients (soil + foliar) was the best method to increase grain yield of wheat. Therefore, by supplying plants with micronutrients, either through soil application, foliar spray or side dressing, the quality and yield of crops is improved (**Malakouti, 2008**).

Effect of micronutrients on grain yield

Mixed foliar application of Fe, Zn and Mn had significant increase in grain yield and that was true in the both growing seasons (Tables 2 and 3). Obvious significant increases were recorded for grain yield with foliar mixture application of micronutrients (Fe + Zn + Mn) over than the individual Fe, Zn and Mn by 2.80, 5.57 and 7.43% in the first seasons and 3.18, 9.78 and 11.88% in the second season, respectively. This increase may be attributed to the additional availability of micronutrients of wheat plants. In this respect, **Grewal *et al.* (1997)** reported that wheat production increased with application of Zn and boron. In this context, **Gueins *et al.* (2003)** reported significant increase in number of grains/spike and 1000-grain weight of wheat due to foliar application of boron and zinc.

In both seasons, straw yield behaved the same trend of grain yield/fad., due to micronutrients foliar application. Applying mixed of Fe + Zn + Mn micronutrients significantly increased straw yield ton/fad., comparative to individual spray of Fe, Zn and Mn by 2.86, 5.32 and 7.44% and were 2.35, 6.42 and 10.95% in the first and the second seasons, respectively. These results are in accordance with those obtained by **Chaudry *et al.* (2007)** who reported that micronutrients (Zn and Fe) significantly increased the wheat yield over control. Also, **Chowdhury *et al.* (2008)** revealed that application of micronutrients (soil + foliar) was the best method to increase grain yield of wheat. Therefore, by supplying plants with micronutrients, either through soil application, foliar spray or side dressing, the quality and yield of crops is improved (**Malakouti, 2008**).

Chemical Composition of Straw and Grain Wheat (Fe, Mn and Zn)

Results in Tables 4 and 5 show that growing wheat after peanut/clover produced the highest micronutrients concentration in straw and grain, were Fe (147.4 and 121.0 mg kg^{-1}), Mn (22.5 and 18.7 mg kg^{-1}), and Zn (31.6 and 25.9 mg kg^{-1}) in the first season 2016/2017, whereas in the second season (2017/2018) were Fe (168.0 and 125.7 mg kg^{-1}), Mn (29.1 and 23.1 mg kg^{-1}), and Zn (34.9 and 30.5 mg kg^{-1}), respectively. While the lowest values of these traits were obtained by growing wheat following peanut/ fallow in both seasons. These results indicated that clover as preceding crops left good residual effect on wheat components (grain and straw) which gave the highest concentration of micronutrients (Fe, Zn and Mn).

With respect to foliar application by micronutrients, results indicated that the highest values of micronutrients concentration in straw and grain were Fe (228.6 and 246.6mg kg^{-1}), Mn (34.3 and 29.7 mg kg^{-1}), and Zn (44.5 and 39.3mgkg^{-1}) respectively, while in the second season were Fe (292.1 and 202.8mg kg^{-1}), Mn (40.0 and 35.8mg kg^{-1}), and Zn (48.3 and 42.4mgkg^{-1}) respectively obtained by the foliar spray Fe + Mn + Zn treatment. It is worth to noting that, Zn spray positively effect on Fe and Zn content in wheat straw and grain but negatively effect on Mn content in wheat. The effect of application these micronutrients may be attributed to the essential role of them in the biological processes *via* their functions in enzymes activities in plants. These results are in an agreement with those obtained by **Assaf *et al.* (2007), Maralian (2009) and Yangx *et al.* (2016)**.

Interaction Effect

Results in Table 6 reveal that interaction effect between preceding crops and micronutrients application had significant effect on plant height, No. of spikes/m^2, No. of grains/ spike and grain yield ardab fad^{-1} only in the second season and 1000 grain weight in both seasons, while No. of spikelets/spike, straw yield/fad., and Fe, Mn and Zn concentration of straw and grain were insignificantly affected in both seasons. The micronutrients contents of wheat grain and shoot significant affected by foliar application of micronutrients and the highest values of the mentioned traits were achieved when growing wheat after clover and applied mixture of micronutrient (Fe + Zn + Mn), whereas the lowest values of these traits were obtained by growing wheat after fodder maize and foliar application by Mn lonely. These results were expected since growing fahl clover as a preceding crop improved soil fertility, which increased growth, yield components and grain yield of wheat. Similarly, supplying plants with micronutrients, foliar spray, the quality and yield of crops is improved. Similar results are obtained by **Malakouti (2008), Maralian (2009) and Yangx *et al.* (2016)**.

Economic Evaluation

Results tabulated in Table 7 show that total and net incomes of grain and straw yields markedly increased when growing wheat after clover in both seasons. The highest total and net incomes (8922 and 1868 LE $fad.^{-1}$) in the first and (8629 and 1625 LE $fad.^{-1}$) in the second season, respectively, were obtained by including clover as a preceding crop of wheat. Growing clover in transition period between peanut and wheat increased net income of wheat by 40.03 and 53.74% comparison to fallow. This indicated that the vital role of legumes in increases soil fertility and consequently the productivity of succeeding cereal crops. This result supported by **El-Mehy *et al.* (2014)** they found that Fahl berseem as preceding crops for wheat recorded

Table 4. Effect of preceding crop and foliar application of some micronutrients on Fe, Mn and Zn concentration (mg kg^{-1}) of wheat straw grown on a sandy soil in the two growing seasons

Man effect and interaction	First season 2016/2017			Second season 2017/2018		
	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})
Preceding crop (P)						
Fallow	125.2	20.1	22.3	130.6	25.5	26.8
Fahl clover	147.4	22.5	31.6	168.0	29.1	34.9
Fodder maize	123.8	19.4	20.5	128.5	21.4	24.5
LSD 0.05	9.7	1.3	3.1	7.6	1.4	2.1
Micronutrients (M)						
Fe+Zn+Mn	228.6	34.3	44.5	292.1	40.0	48.3
Fe +Zn	175.8	23.2	38.7	199.5	28.3	45.0
Fe +Mn	192.7	31.2	29.8	215.3	38.1	29.3
Fe	168.5	23.5	21.5	196.5	26.8	24.9
Zn +Mn	153.4	27.0	37.2	189.0	34.5	40.7
Zn	132.2	21.4	35.8	147.9	24.5	44.3
Mn	145.5	29.2	20.3	161.2	35.2	23.8
Man	141.9	25.18	30.22	182.9	30.34	34.25
LSD 0.05	19.8	4.6	5.2	22.5	5.8	7.1
Interaction						
P x M	20.1	3.5	5.4	12.6	4.2	6.3

Where: * and NS refers to significant at 0.5 and not significant, respectively.

Table 5. Effect of preceding crop and foliar application of some micronutrients on Fe, Mn and Zn concentration (mg kg^{-1}) of wheat grain grown on a sandy soil in the two growing seasons

Man effect and interaction	First season 2016/2017			Second season 2017/2018		
	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})
Preceding crop (P)						
Fallow	105.7	15.8	15.5	109.6	19.7	21.3
Clover	121.0	18.7	25.9	125.7	23.1	30.5
Fodder maize	101.6	14.6	14.8	106.5	17.0	33.4
LSD 0.05	8.4	1.3	2.3	9.0	1.6	1.7
Micronutrients (M)						
Fe+Zn+Mn	246.6	29.7	39.3	202.8	35.8	42.4
Fe +Zn	162.3	18.1	34.5	169.2	22.6	38.7
Fe +Mn	168.0	26.9	16.3	175.1	33.2	24.5
Fe	164.5	17.7	16.4	170.0	21.7	19.8
Zn +Mn	131.4	23.8	32.6	134.1	30.0	37.0
Zn	114.5	16.5	31.2	118.0	20.7	34.6
Mn	117.5	25.4	16.0	124.4	32.1	21.3
Mean	143.3	20.72	24.25	143.5	25.57	29.35
LSD 0.05	18.1	2.6	6.4	17.3	4.2	6.0
Interaction						
P x M	19.7	3.1	5.2	25.6	4.7	3.4

Where: * and NS refers to significant at 0.5 and not significant, respectively.

Table 6. Effect of the interaction between preceding crops and foliar application of some micronutrients on wheat traits in the two growing seasons

Mixture micronutrient	First season 2016/2017			Second season 2017/2018		
	Preceding crop					
	Fallow	Clover	Fodder maize	Fallow	Clover	Fodder maize
				Plant height (cm)		
Fe+Zn+Mn	92.20	93.63	90.60	93.06	96.02	91.32
Fe +Zn	91.60	93.20	90.17	92.54	95.73	89.93
Fe +Mn	91.80	92.90	89.97	92.09	95.41	90.12
Fe	91.17	92.93	90.50	92.03	95.11	88.93
Zn +Mn	91.10	92.53	89.57	90.42	92.62	88.32
Zn	91.07	92.40	88.77	91.51	93.24	88.00
Mn	90.17	91.80	88.50	91.54	93.09	88.33
LSD 0.05		**NS**			**0.35**	
				No. of spikes/m^2		
Fe+Zn+Mn	354.33	361.33	345.33	357.67	360.00	348.67
Fe +Zn	351.67	359.00	346.00	352.33	357.67	338.33
Fe +Mn	349.00	355.00	346.33	350.00	353.67	331.00
Fe	345.67	359.67	342.33	348.33	354.67	336.67
Zn +Mn	342.67	352.00	338.67	340.33	349.33	324.00
Zn	346.33	349.00	337.67	337.01	342.70	321.34
Mn	345.67	348.67	333.00	332.33	341.00	314.33
LSD 0.05		**NS**			**5.30**	
				No. of grains/spike		
Fe +Zn+Mn	44.37	45.47	43.00	46.03	46.77	45.33
Fe +Zn	44.27	45.37	43.03	44.67	46.43	44.63
Fe +Mn	44.30	45.43	43.30	44.50	46.40	44.53
Fe	44.10	45.03	42.90	44.77	46.03	44.37
Zn +Mn	43.73	44.83	42.57	43.97	44.73	44.10
Zn	43.77	44.60	42.53	44.12	45.04	43.75
Mn	43.63	44.27	42.37	43.80	44.70	43.67
LSD 0.05		**NS**			**0.25**	

Table 6. Cont. Effect of interaction between preceding crops and foliar application of some micronutrients on wheat traits in the two growing seasons

Mixture micronutrient	Preceding crop					
	1000 grain weight (g)					
Fe+Zn+Mn	44.36	45.46	43.00	41.80	42.66	40.43
Fe +Zn	44.26	45.36	43.03	41.16	42.50	40.00
Fe +Mn	44.30	45.43	43.30	40.66	41.86	39.86
Fe	44.10	45.03	42.90	40.46	41.83	39.40
Zn +Mn	43.73	44.83	42.56	40.26	41.03	38.46
Zn	43.76	44.60	42.53	40.10	41.03	39.06
Mn	43.63	44.26	42.36	40.13	40.70	38.56
LSD 0.05		**0.21**			**0.31**	
	Grain yield (Ardab $fad.^{-1}$)					
Fe+Zn+Mn	17.65	18.83	16.44	17.54	18.69	16.30
Fe +Zn	17.49	18.62	16.37	17.20	18.28	16.05
Fe +Mn	17.24	18.40	16.48	16.81	18.25	16.07
Fe	17.01	18.40	16.08	16.75	18.15	15.99
Zn +Mn	16.67	17.92	15.69	15.96	17.07	15.17
Zn	16.83	17.67	15.62	15.79	16.76	15.31
Mn	16.67	17.43	15.17	15.54	16.52	14.89
LSD 0.05		**NS**			**0.27**	
	Straw yield (Ton $fad.^{-1}$)					
Fe+Zn+Mn	2.002	2.133	1.800	1.948	2.084	1.837
Fe +Zn	1.981	2.110	1.794	1.934	2.049	1.816
Fe +Mn	1.953	2.084	1.807	1.919	2.067	1.783
Fe	1.925	2.084	1.763	1.860	2.049	1.824
Zn +Mn	1.921	2.029	1.721	1.848	1.962	1.749
Zn	1.940	2.001	1.696	1.865	1.942	1.706
Mn	1.888	1.974	1.663	1.798	1.914	1.667
LSD 0.05		**NS**			**NS**	

Table 7. Net income (LE fad.$^{-1}$) of grain wheat as affected by the interaction of a preceding crops and foliar application of some micronutrients in both growing seasons

Mixture micronutrient	First season 2016/2017				Second season 2017/2018			
	Total income (LE/fad.)							
	Fallow	Clover	Fodder maize	Mean	Fallow	Clover	Fodder maize	Mean
Fe+Zn+Mn	8664	9240	8028	**8644**	8584	9152	7992	**8576**
Fe +Zn	8582	9139	7993	**8571**	8430	8958	7873	**8420**
Fe +Mn	8462	9028	8048	**8513**	8258	8956	7863	**8359**
Fe	8347	9028	7853	**8409**	8195	8905	7857	**8319**
Zn +Mn	8202	8794	7663	**8219**	7859	8397	7465	**7907**
Zn	8282	8670	7619	**8190**	7799	8253	7495	**7849**
Mn	8180	8555	7407	**8048**	7652	8136	7294	**7694**
Mean	**8388**	**8922**	**7802**		**8111**	**8679**	**7691**	
Treatments	Net income (LE/fad.)							
	Fallow	Clover	Fodder maize	Mean	Fallow	Clover	Fodder maize	Mean
Fe+Zn+Mn	1610	2186	974	**1590**	1530	2098	938	**1522**
Fe +Zn	1528	2085	939	**1517**	1376	1904	819	**1366**
Fe +Mn	1408	1974	994	**1459**	1204	1902	809	**1305**
Fe	1293	1974	799	**1355**	1141	1851	803	**1265**
Zn +Mn	1148	1740	609	**1165**	805	1343	411	**853**
Zn	1228	1616	565	**1136**	745	1199	441	**795**
Mn	1126	1501	353	**994**	598	1082	240	**640**
Mean	**1334**	**1868**	**748**		**1057**	**1625**	**637**	

On ardab of grain wheat was 420 LE, ton of straw was 660 LE and cost of wheat was 7054 LE/fad., in 2016/2017 seasons (**Bulletin of Statistical, 2016**).

the highest grain yield and net income (2.959, 2.980 ton/fad., and 5422, 5414 LE/fad.) in the 1st and 2nd seasons, respectively.

Total and net income values had markedly varied by foliar application of different micronutrient treatments as shown in same Table. The highest total and net income were detected when spray wheat plants by mixture micronutrients of (Fe+Zn+Mn), which were (8644 and 1590 LE fad.$^{-1}$) and (8576 and 1522 LE fad.$^{-1)}$, respectively, in the first and second seasons. Whereas the lowest values of total and net income (8048 and 994 and 7694 and 640 LE fad.$^{-1}$) were achieved by application of Mn separately in the first and in the second seasons, respectively. This result may be attributed to increased photosynthetic and growth development due to integrated three micronutrients. **Zain *et al.* (2015)** found that foliar application of $FeSO_4$ + $ZnSO_4$ + $MnSO_4$ remained comparatively better regarding yield related attributes of wheat.

Accordingly, the best treatment achieved the highest net income when growing wheat plant following clover as a preceding crop and foliar application by Fe + Zn + Mn mixed, being 2186 and 2098 LE fad.$^{-1}$ in 2016/2017 and 2017/2018 seasons, respectively.

Conclusion

Under sandy soil conditions, growing fahl clover, following peanut, during the transition period season of succeeding wheat and foliar application of Fe+Zn+Mn mixed at a rate of 500 mg L^{-1} in thrice times, increases growth, yield and yield attributes of wheat as well as maximizing total and net income in both seasons. Fe, Mn and Zn concentration of wheat straw and grain can be increased by foliar Fe, Mn and Zn application on potentially Fe, Mn and Zn deficient in sandy soil, and effect occurred in wheat straw and grain when spraying Fe and Mn application improved the bioavailability of these micronutrients and increased wheat productivity.

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تأثير المحصول السابق والعناصر الصغرى على المحصول ومكوناته لقمح الخبز تحت ظروف الأراضى الرملية

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أجريت تجربتين حقليتين فى محطة بحوث الإسماعيلية، محافظة الإسماعيلية، مصر خلال موسمى النمو ٢٠١٧/٢٠١٦ و ٢٠١٧/ ٢٠١٨ لدراسة تأثير البور أو البرسيم الفحل والدراوة كمحصول سابق للقمح والمزروعة خلال الفترة البينية لحصاد الفول السودانى وزراعة القمح فى ١٥ نوفمبر لكلا الموسمين والرش بالعناصر الصغرى على محصول القمح ومكوناته ومحتوى القش والحبوب من العناصر الصغرى حديد، زنك ومنجنيز وكذلك تقييم العائد الأقتصاد الناتج من معاملات الدراسة المختلفة، واشتملت الدراسة على سبعة معاملات من الرش الورقى للعناصر الصغرى ناتجة من التوافيق المتبادلة هى: T1: (Fe +Zn + Mn), T2: (Fe +Zn), T3: (Fe + Mn), T4: Fe, T5: (Zn + Mn), T6: Zn and T7: Mn وتم الرش على ثلاث فترات بعد ٣٠ ، ٦٠ و ٩٠ يوم من الزراعة بمعدل ٥٠٠ مللجم/لتر، استخدم تصميم القطع المنشقة مرة واحدة فى ثلاث مكررات، وكانت أهم النتائج المتحصل عليها: أثرت المعاملات السابقة معنويا على جميع صفات القمح المدروسة، أدى الأثر المتبقى الجيد للبرسيم كمحصول سابق إلى زيادة صفات ارتفاع النبات، عدد السنابل/م^2، عدد السنيبلات/سنبلة، عدد الحبوب/السنبلة، وزن ١٠٠٠ حبة، حصول الحبوب والقش/فدان، محتوى القش والحبوب من العناصر الصغرى فى كلا الموسمين مقارنة بالبور والدراوة، أدى الرش بالعناصر الصغرى إلى زيادة معنويه فى صفات ارتفاع النبات، عدد السنابل/م^2، عدد السنيبلات/سنبلة، عدد الحبوب/السنبلة ، وزن ١٠٠٠ حبة ومحصول الحبوب والقش/فدان، الرش بمخلوط الثلاث عناصر (حديد + زنك + منجنيز) حقق أعلى القيم من محصول القمح ومكوناته فى كلا الموسمين. أدى الرش بعنصر الحديد والزنك والمنجنيز منفردة أو فى مخلوط إلى زيادة محتوى القش والحبوب من العناصر الصغرى (حديد، زنك، منجنيز)، أدى الرش بالعناصر الصغرى (حديد + منجنيز+ زنك) إلى زيادة معنوية فى محتوى القش والحبوب من عنصر الحديد، المنجنيز والزنك سواء تم إضافة العنصر بمفردة أو مع العنصرين الآخرين، كما وجد أن هناك تأثير سلبى لعنصر الزنك على عنصر المنجنيز وكان أعلى تركيز من الثلاثة عناصر فى المعاملة التى تم فيها إضافة الحديد+ المنجنيز+ الزنك رشا، كان للتفاعل بين المحاصيل السابقة والرش بالعناصر الصغرى تأثير غير معنوى على جميع الصفات فى كلا الموسمين، ماعدا وزن ال١٠٠٠ حبة فى الموسم الأول وارتفاع النبات، عدد السنابل/م^2، عدد الحبوب/سنبلة، محصول حبوب/فدان فى الموسم التانى، أدى زراعة القمح عقب الفول السودانى ثم برسيم والرش بمخلوط العناصر الصغرى حديد + زنك + منجنيز بمعدل ٥٠٠ ملليجم/لتر إلى تحقيق أعلى صافى دخل ٢١٨٦ و٢٠٩٨ جنية/فدان مقارنة بالمعاملات الأخرى فى كلا الموسمين على التوالى، ويمكن التوصية بزراعة البرسيم كمحصول تحريش فى الفترة البينية بين حصاد الموسم الصيفي (الفول السودانى) وزراعة المحصول الشتوى (القمح) والرش بمخلوط العناصر الصغرى (حديد + زنك + منجنيز) أدى إلى زيادة محصول القمح ومكوناتة ومحتوى الحبوب والقش من العناصر الصغرى بالإضافة إلى زيادة إجمالى وصافى دخل المزارع مقارنة بالمعاملات الاخرى.

المحكمـــــون:

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