Effect of P fertilization and Spraying by Micronutrients on Productivity of Intercropped Maize and Soybean and Competitive Relationships under Different Farming Systems

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ABSTRACT: A field trial was performed at the farm Sakha ARS, ARC, Egypt, throughout the 2020 and 2021 seasons to study the influence of P fertilization levels (15.5 and 23.25 kg P_2O_5/fed) in addition spraying by micronutrients (without, spraying with 400 g Zn/200 Liter water/fed, 400 g Mn /200 Liter water/fed and 400 g Zn + 400 g Mn /200 Liter water/fed) on the productivity of intercropped maize and soybean under different farm systems (expressed as plowing treatments, *i.e.* ,using chisel plow once, tiller plow once and chisel plow once beside tiller plow once) as well as competitive relationships and economic evaluation. Using chisel plow once beside tiller plow once significantly increased earliness characters, growth characters and yield and yield attributes of maize as well as soybean traitsand resulted in the superior values of all these characters in each one season. Increasing phosphorus fertilizer levels to 23.25 kg P_2O_5/fed produced the superior values of earliness characters, growth characters and yield and yield attributes of maize as well as soybean characters in each season. Foliar spraying intercropped maize and soybean twice with the combination of Zn and Mn at 400 g Zn + 400 g Mn /200 Liter water/fed produced the superior values of earliness characters, growth characters and yield and yield attributes of maize as well as soybean characters in each season. It can be concluded that the maximum land equivalent ratio (LER), total income and net return were obtained from intercropping maize and soybean with 50 % of its pure stand and using chisel plow once beside tiller plow once and fertilizing with 23.25 kg P_2O_5/fed in Addition to foliar spraying intercropped maize and soybean twice after 30 and 60 DFS with the combination of Zn and Mn at 400 g Zn + 400 g Mn /200 Liter water /fedunder the environmental conditions of Kafr El-Sheikh Governorate, Egypt.

Keywords: Maize, soybean, intercropping, plowing treatment, P fertilization levels, foliar sprying , micronutrients, competitive relationships, Economic evaluations.

INTRODUCTION

Intercropping of legumes as soybean and cereals as maize has been well recognized as one manner of sustainable agricultural cropping models global (**Du et al., 2018**).

Maize (*Zeamays* L.) is looked one of the truly valuable strategic cereal food crops in Egypt and also in the world. It has great nutritional value containing about 10 % moisture74 % total carbohydrate,4.9 % protein, 7.4 % oil, 3.7 % fiber, and 4.1 % ash(**Khalifa, 2019).**In Egypt, accordioning to **FAO (2021),** total planted area was2.368 million feddan, producing 7.450 million ton and average production of maize is 22.47ardab/fed in 2019 season.

Soybean is deemed a legume plant, that can fix atmospheric N when appropriatelynodulated , and therefore is a smaller amount dependent relative for growth on supplies of N from the soil **(Flynn and Idowu, 2015)**. **Rashwan and Zen El- Dein (2017)** detailed that increasing N level from 80 to 100 and up to 120 kg /fad increased count of branches for each plant, count of pods for each plant, seed yield for each plant and for each fad of soybean as well as total LER (land equivalent ratio) and aggressivity were improved with the increment in N level of maize intercropped with soybean especially with submission of 120 kg N /fed, while the lowest one was attained with 80 kg N/fed.

Plowing has been an important aspect of technological development in the evolution of agriculture, in particular in food production. The objectives of plowing the soil include seedbed preparation, water and soil conservation and weed control. Plowing has various physical, chemical and biological effects on the soil both beneficial and degrading, depending on the appropriate methods used.

Moschler el al (1975) reported comparative residual nutrient elements in 30cm soil layer on corn grown in the field by no- tillage and conventional tillage methods. Corn grown by limestone and fertilizer. The data on redidualfertility were obtained by repeated in green house cropping without lime or fertilizer followed by testing the soil for Hp and acid extricable nutrient elements.

Bedeer and Ragheb (1993) reported that planting maize under reduced till system led to a significant increase in grain yield and the economic return**.** The grain yield was significantly increased by planting maize under conventional till.

The physical consequences such as aggregate constancy, infiltration level, soil and water conservation, in particular, have direct influence on soil productivity and yield sustainability, which lead to an enhanced nutrient uptake and better yield of crops (**Arif*et al.*, 2007**).**Ahmad *et al.* (2010)** pointed out that tillage operation with the same implement over several years may lead to compacted layer in field soil. Plowing at the same depth year after year reinforce the plow pan development, so use of different tillage implements may be the only solution to breakup this pan. **Ozpinar (2010)** found that shallow tillage produced grain yield as much as Moldboard plough. On the other hand, **Khaliq*et al.* (2012)** stated that the influence of deep tillage on corn fodder yield was non-significant. **Anjum et al. (2019)** showed that maize hybrid sown under deep tillage gave maximum net income, grain yield, count of grains/ear, 1000-grain weight, plant height and ear length, while the lowest grain yield, count of grains for each ear, 1000-grain weight, plant height and ear length were obtained from the zero tillage. **Bongominet al. (2020)** reported that conventional tillage practice had a higher mean maize grain yield for each hectare and plant height compared to minimum tillage. **Ramadhan (2021)** showed that deep tillage provides greater agronomic benefits and productivity of maize compared to conventional tillage and reduced tillage. The most probable reasons for the reduced tillage yield depression may be related to the generally lower yield components and Because of increased weed density. In addition to reduced tillage, deep tillage and conventional tillage decreased the bulk density.

Phosphorus fertilizer is second only to N fertilizer in importance as an essential crop nutrient. An satisfactory supply of accessible P in soil is coupled with increased root growth, which means roots can explore more soil for nutrients and moisture(**Marschner, 1995**).**Khalifa et al (2002)**found that application of P fertilizer increased grain yield and ear height ,leaf area, ear length and diameter at Nub aria and Sakha .Grain yield significantly increased by 4.6 and 3.4 % and 16.2 and 7.2 % as P increased from zero to 15 and from 15 to 30 kg p_2O_5/fad. **Alias et al. (2003)** found that maximum values of leaf area for each plant, count of grains for each cob, 1000- grains weight and grain yield were observed at 125 kg P ha^{-1}.**Onasanya et al (2009).**noticed that the application rate of 120 kg N / ha+40 kg P /ha significantly increased grain yield /ha .**Ahmad et al. (2019)** stated that maximum grains for each ear, thousand grain weight, biological and grain yield were produced when ammonium phosphate was applied at 90 kg/ha. **Ray et al. (2020)** showed that application of 125% recommended dose of phosphorus fertilizer resulted in the maximum grain and storw yield with 124.5 and 91.2% increase over the control (without phosphorus fertilizer), respectively.

Although the micronutrients needed in small-scale quantities that are as valuable as macronutrients in completion of life cycle of this crop. The role of micronutrients in regulation of plant growth and yield is established. Utilization of micronutrients like zinc and manganese can enhance and increase productivity of maize (**Ghazvineh and Yousefi, 2012**).**Salem and El-Gizawy (2012)** revealed that spraying by micronutrient (Zn + Mn + Fe) in the form of EDTA. The EDTA compounds of the of solutions containing 85 mg nutrient /L gave the superior values of ears/plant, grains/ear, 100-grain weight and grain yield. **Hoda et al (2014)**noticed that the superior values of plant height (249cm) were obtained by the application of mixture treatment (Fe +Zn +Mn. Followed by Zn and Fe (245 and 244 cm).The response of maize plant to Fe , Zn and Mn may be due to the improvement roles of these elements in enzymes activation and hormones regulation in metabolism of carbohydrates, proteins and auxins and also in multiple processes development of division and differentiation of cells .**Tahir and Yasin (2016)** showed that foliar application of 250 m l / micronutrients mixture at stem elongation stage significantly improved plant height, ear length, count of grains/rows, ear weight, 1000-grain weight, grain yield, biological yield, harvest index, grain protein and grain oil contents. **El- Metwally et al. (2019)**indicated that the maximum maize grain, protein, carbohydrates and oil yields were recorded with foliar application of micronutrients. **Mustafa and Rasul (2020)**revealed that foliar application with some micronutrients significantly affected grain yield of maize and uptake of applied micronutrients by maize grains.

This study intended to resolve the influence of farm systems (expressed as plowing treatments) P fertilization and spraying by micronutrients on productivity of intercropped maize and soybean as well as increase land usage ratio and farmers' total income under Kafr El-Sheikh Governorate conditions.

MATERIALS AND METHODS

A field trial was performed at Sakha A R S Farm, ARC, Egypt, throughout the two summer growing seasons of 2020 and2021,to study the influence of P fertilization and spraying by micronutrients on the productivity competitive relationships and economic evaluation of intercropped maize cv single cross 131 and soybean cv Giza 111 under three tillage systems .The preceding winter crop was sugar beet (*Beta vulgaris* var. *sassharifera* L .)in the first season and Egyptian Clover (*Trifolium alexandrium* L.) in the second season.

The soil sample were randomly taken from (0-30)before soil preparation .Then particle size distribution and chemical analyses were coned by the method described by **Page et al (1982),**and the results are revealed in Table 1.

Seed of maize cv . Single Cross 131andsoybean cultivar cv . Giza 111were kindly provided by Maize and food legume Research sections, respectively, FCRI, ARC, Giza, Egypt.

A split-split plot layout with three repetitions was used . Main-plots were allocated to three tillage systems (chisel plow , tiller plow and chisel plow followed by tiller) ;sub-s to phosphorus fertilizer levels (15.5 and 23.25 kg $^{p}{}_{2}{}^{o}{}_{5}$ /fed) and sub- sub-plots to foliar sparing of maize and soybean with chested micronutrients (Zn , Mn , Zn + Mn , and water as control) .the chisel plow and tiller plow carried out one single pass .Each chelated zinc (Zn) Each and chelated manganese (Mn) solution were sprayed a concentration of 400 g /L after 30 and 60 days from sowing .The experimental field was plowed harrowed , ridged , and divided into sub-sub plot , Each measuring 22.4 m^2Each sub sub plot consisted of 8 ridges 70 cm apart and 4 m long .The used system of maize –soybean intercropping was 2:2 .Sowing took place for maize and soybean on 24 and 27 May in the 2020 and 2021 seasons , respectively . Seeds of the hybrid maize cv single cross 131 were sown on one side of ridge in hill 25 cm apart at to 2-3 seeds for each hill and thinned to one plant for each hill 25 after sowing .Seed of soybean cv Giza 111 were sown on two sides of a ridge in hills 20 cm apart at 4-5 seeds for each hill and thinned to two plants for each hill 15 days after sowing . Solo maize and soybean were sown as the Ministry of Agriculture recommendations to calculate competitive relationships and net return

Table 1. The soil analysis of the experimental sites throughout the 2020 and 2021 growing seasons.

Properties		2020season	2021season
A: particle size distribution :			
Sand %		9.72	9.73
Silt %		30.24	29.99
Clay %		60.04	60.28
Texture		Clayey	Clayey
B: Chemical analysis:			
pH		7.85	7.90
EC ds/m^2		2.90	2.85
Organic matter (g kg^{-1})		11.7	10.8
Total N %		0.13	0.12
Total carbonate %		6.24	6.23
CEC meq/100 g soil		41.34	41.52
SP %		78.35	78.48
SAR		4.55	4.64
Available mg/kg	N	27.00	26.40
	P	8.85	8.65
	K	245.70	265.00
Soluble cationsmeq/L	ZN	6.30	6.10
	Mn	14.22	13.69
	Ca++	6.36	6.35
	Mg^{++}	6.46	5.81
	Na^{+}	10.20	9.99
	K^{+}	0.45	0.46
Soluble anions meq/L	CO_3^{--}	0.00	0.00
	HCO_3^{-}	4.60	4.46
	CL^{-}	9.55	8.85
	SO_4^{--}	10.20	9.32

The other agricultural practices for maize and soybean were done as recommended. Harvesting was accomplished for maize and soybean onSeptember25thand 28thin the first and second seasons respectively.

Recorded data:

1. Maize characters:

Five guarded plants if maize were randomly taken from each sub- sub plat at

90 days from sowing (DAS) to estimate the plant height (cm) and ear leaf area (cm^2). At harvesting,10 maize plants from each sub –sub plot were taken to determine ear length (cm), count of rows/ear, count of grains/row, ear weight (g), ear grains weight (g), shelling percentage (%),and 100-grain weight (g).Maize plants of the 2 inner ridge of each sub –sub plot at 15.5 % moisture content ,then converted to ardab for each feddan (ardab = 140 kg)

2. Soybean characters:

At harvest time, five guarded plants of soybean were randomly taken from each sub-sub plot to determine ;plant height (cm), count of branches/plant, count of seeds/pod, count of seeds/plant and 100-seed weight (g).Soybean plants of the 2 inner ridges of each sub –sub plot was harvested to determine seed yield for each plot and converted to t /feddan.

2. **Competitive relationships:**
3. **a- Land equivalent ratio (LER)**was determined according to the following formula described by **Willey and Rao (1980)**:

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Y_{aa} and Y_{bb} were a pure stand of the crop, a (maize) and b(soybean), respectively. Yab is the intercrop yield of a crop, and Yba is the intercrop yield ofb crop.

b- Aggressivity (Ag)was calculated according to **Mc-Gilchrist (1965)** as the following formula:

- For crop (a),

$$A_{ab} = \frac{Y_{ab}}{Y_{aa}\ x\ Z_{ab}} - \frac{Y_{ba}}{Y_{bb}\ x\ Z_{ba}}$$

- for crop (b),

$$A_{ba} = \frac{Y_{ba}}{Y_{bb}\ x\ Z_{ba}} - \frac{Y_{ab}}{Y_{aa}\ x\ Z_{ab}}$$

Where:

A_{ab} = aggressivety value for the component a (maize).

A_{ba} = Aggressivety value for the component b(soybean).

Y_{ab} is the intercrop yield of maize, Z_{ab} is the percentage of the area occupied by soybean.

c-Relative crowding coefficient (RCC) or K was calculated according to **De-Wit (1960)** as follows:

K = Kab × Kba

$$Kab = \frac{Yab\ x\ Zba}{(Yaa - Yab)Zab} \qquad Kba = \frac{Yba\ x\ Zab}{(Ybb - Yba)Zba}$$

Where: a is maize, and b is soybean, respectively. Z_{ab} is the percentage of the area occupied by maize, and Z_{ba} is the percentage of the area occupied by soybean.

4. Net return:

Gross return from each treatment was calculated in Egyptian pounds (L.E.) according to the Ministry of Agriculture and Lands Reclamation, Economic Affairs Sector, Agricultural Statistics. Where market prices of maize grains were560and 700 L.E. /ardab and soybean seed were 8 and 10 L.E./kg in 2020 and 2021seasons, respectively.

Net return = Total income – Total costs

Feddan.(L.E.) = Gross return – Total costs

The obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split-split plot design as published by **Gomez and Gomez (1984)** using the "MSTAT-C" software package. In addition, treatment means were compared by using least significant difference (LSD) method at 5 % level of probability as described by **Snedecor and Cochran (1980)**.

RESULTS AND DISCUSSIONS

1. Plowing treatments effects:

Data presented in Tables2, 3,4, 5and 6 revealed that all studied characters of maize *i.e.* Growth characters (plant height and ear leaf area) and yield and its attributes (ear length, count of rows/ear, count of grains/row, ear weight, ear grains weight, 100-grain weight and grain yield/fed) as well as soybean characters i.e. plant height ,count of branches /plant ,count of seed / pod , count of seeds /plant , 100-seed weight and seed yield /fed were significantly affected by studied farm systems expressed as plowing treatments (using chisel plow once, using tiller plow once and using chisel plow once beside tiller plow once), except shelling percentage in each season. Data revealed that using chisel plow once beside tiller plow once significantly, increased growth characters and yield and yield attributes of maize as well as soybean characters which resulted in the superior values of all these characters in each season. Using tiller plow once came second after using chisel plow once beside tiller plow once concerning its effect on maize, and soybean growth characters in each season. The lowest values of maize, and soybean growth characters were obtained by using chisel plow once in each season.

These results are mainly due to plowing beneficial effects on physical (aggregate-stability, infiltration rate, soil and water conservation), chemical and biological, soil properties which have direct influence on soil productivity and yield sustainability, which lead to an enhanced nutrient uptake and better yield of crops. **Moschler et al(1975) Bedeer and Ragheb(1993) , (Arif*et al.*, 2007**). These results are comparable to those obtained by **Anjum et al. (2019), Bongomin et al. (2020)** and **Ramadhan (2021)**.

2. P fertilization levels effects:

Phosphorus fertilizer levels significantly affected plant height, ear leaf area, ear length, count of rows/ear, count of grains/row, ear weight, ear grains weight, 100-grain weight and grain yield/fed of maize as well as soybean plant height, count of branches/plant, count of seeds/pod, count of seeds/plant, 100-seed weight and seed yield/fed, whereas shelling percentage was not significantly affected in each season as shown in Tables 2, 3, 4, 5 and 6.Increasing phosphorus fertilizer levels to 23.25 kg P_2O_5/fed produced the superior values, growth characters and yield and yield attributes of both maize and in each season. However, fertilizing with the lowest level of phosphorus fertilizer (15.5 kg P_2O_5/fed) recorded the lowest values of earliness characters, growth characters and yield and yield attributes of maize and soybean in each season.

Table 2: Plant height, ear leaf area, ear length, count of rows/ear and count of grains/row of maize intercropped with soybean as affected by plowing treatments, P fertilization levels and spraying by micronutrients as well as their interactions throughout 2020 and 2021 seasons.

Characters	Plant height		Ear leaf area (cm^2)		Ear length (cm)		Count of rows/ear		Count of grains/row	
	2020	**2021**	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**
A. Plowing treatments:										
Chisel plow once	200.8 c	212.8 c	602.2 c	581.7 c	20.56 c	21.43 c	14.25 c	14.65 c	32.17 c	34.24 c
Tiller plow once	212.2 b	222.0 b	637.0 b	675.5b	21.21 b	22.25 b	15.89 b	16.28 b	34.97 b	37.44 b
Chisel plow once + tiller plow once	222.6 a	228.0 a	735.8 a	775.9 a	22.20 a	23.16 a	17.02 a	17.41 a	40.10 a	41.88 a
F- test at 5 %	*	*	*	*	*	*	*	*	*	*
B. P fertilization levels:										
23.25 kg P_2O_5/fed	215.0 a	222.4 a	664.1 a	692.8 a	21.50 a	22.21 a	15.94 a	16.34 a	36.13 a	38.53 a
15.5 kg P_2O_5/fed	208.8 b	219.5 b	652.6 b	662.5 b	21.15 b	22.35 b	15.50 b	15.89 b	35.36 b	37.17 b
F- test at 5 %	*	*	*	*	*	NS	*	*	*	*
C. Spraying by micronutrients:										
Without	200.0 d	206.3 d	590.4 d	613.7d	19.31 d	20.36 d	14.51 d	14.91 d	33.16 d	34.61 d
Zn at 400 g/fed	217.6 b	225.8 b	659.0 b	676.8 b	22.35 b	23.33 b	16.22 b	16.62 b	36.63 b	39.38 b
Mn at 400 g/fed	207.8 c	216.5 c	620.9 c	643.6 c	20.41 c	21.04 c	15.35 c	15.73 c	34.08 c	36.77 c
Zn at 400 g + Mnat 400 g/fed	222.2 a	235.3 a	763.1a	776.6 a	23.22 a	24.38 a	16.81 a	17.20 a	39.10 a	40.66 a
F-test at 5 %	*	*	*	*	*	*	*	*	*	*
Solo maize	221.0	230.0	896.7	896.2	21.30	22.40	16.80	17.20	38.40	40.60

Table 3: Ear weight, ear grains weight, shelling percentage, 100-grain weight and grain yield/fed of maize intercropped with soybean as affected by plowing treatments, P fertilization levels and spraying by micronutrients as well as their interactions throughout 2020 and 2021 seasons.

Characters	Ear weight (g)		Ear grains weight (g)		Shelling (%)		100-grain weight (g)		Grain yield (ardab)/fed)	
Treatments	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
A. Plowing treatments:										
Chisel plow once	261.7 c	267.9 c	211.4 c	217.6 c	79.47 c	80.32 c	35.74 c	36.12 c	18.01 c	18.33 c
Tiller plow once	273.2 b	278.4 b	217.4 b	223.5 b	80.35 b	81.11 b	37.18 b	37.20 b	18.74 b	19.07 b
Chisel plow once + tiller plow once	279.6 a	284.8 a	229.0 a	235.1 a	81.82 a	82.49 a	37.72 a	38.41 a	19.17 a	19.54 a
F – test at 5 %	*	*	*	*	*	*	*	*	*	*
B. P fertilization levels:										
23.25 kg P_2O_5/fed	274.3 a	280.5 a	222.1 a	228.3 a	80.64	81.42	37.36	37.34	18.86 a	19.21 a
15.5 kg P_2O_5/fed	268.7 b	273.6 b	216.4 b	222.4 b	80.44	81.20	36.39	37.14	18.42 b	18.76 b
F-test at 5%	*	*	*	*	*	*	*	*	*	*
C. Spraying by micronutrients:										
Without	251.2 d	256.5 d	199.3 d	205.3 d	79.17 c	80.02 b	35.43 d	35.44 d	17.22 d	17.61 d
Zn at 400 g/fed	277.4 b	284.1 b	227.3 b	233.3 b	81.38 b	82.22 a	37.50 b	38.15 b	19.13 b	19.48 b
Mn at 400 g/fed	259.8 c	265.4 c	205.8 c	212.1 c	79.31 c	80.05 b	35.85 c	35.97 c	17.83 c	18.13 c
Zn at 400 g + Mn at 400 g/fed	297.5 a	302.2 a	244.7 a	250.7 a	82.32 a	82.95 a	38.73 a	39.42a	20.38 a	20.71 a
F- test at 5 %	*	*	*	*	*	*	*	*	*	*
Solo maize	**215.0**	**225.0**	**170.0**	**176.0**	**79.06**	**79.99**	**37.37**	**37.97**	**29.47**	**30.17**

Table 4: Plant height, ear length, count of grains/row, 100-grain weight (g) and grain yield (ardab/fed) of maize intercropped with soybean as affected by the interaction among plowing treatments, P fertilization levels and spraying by micronutrients throughout 2020 and 2021 seasons.

Characters			**Plant height (cm)**		**Ear length (cm)**		**Count of grains/row**		**100-grain weight (g)**		**Grain yield (ardab/fed)**	
Plowing treatments	**P levels**	**Spraying by micronutrients**	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Chisel plow once	23.25 kg P_2O_5/fed	Without	191.0	201.6	19.33	19.40	30.53	31.40	35.13	35.70	16.57	17.03
		Zn at 400 g/fed	214.3	224.0	21.20	22.63	33.60	36.13	37.36	37.33	18.74	19.08
		Mn at 400 g/fed	201.0	211.0	20.50	20.60	30.66	34.63	35.33	33.93	17.47	17.82
		Zn + Mn	211.0	231.0	22.56	23.66	36.46	37.96	38.36	38.63	19.68	19.92
	15.5 kg P_2O_5/fed	Without	184.6	194.0	18.50	19.10	28.40	30.60	34.16	34.76	16.50	16.84
		Zn at 400 g/fed	201.0	212.0	21.23	22.33	32.60	35.10	35.43	36.70	18.40	18.74
		Mn at 400 g/fed	192.0	201.0	19.23	20.33	29.60	32.10	33.51	34.35	17.13	17.30
		Zn + Mn	212.0	228.3	21.96	23.40	35.53	36.03	36.61	37.55	19.61	19.95
Tiller plow once	23.25 kg P_2O_5/fed	Without	203.0	205.0	19.20	20.30	33.40	32.93	36.18	36.78	17.36	17.71
		Zn at 400 g/fed	220.3	231.0	22.40	23.50	36.40	39.93	38.46	38.40	19.52	19.86
		Mn at 400 g/fed	212.0	221.0	20.83	21.23	34.40	37.26	36.45	34.71	18.17	18.51
		Zn + Mn	223.0	238.0	23.36	24.20	38.40	41.46	39.53	39.46	20.45	20.80
	15.5 kg P_2O_5/fed	Without	194.3	206.0	18.36	20.56	32.40	34.30	35.23	35.83	17.09	17.44
		Zn at 400 g/fed	216.0	226.0	22.36	23.43	35.23	38.63	37.5	37.80	18.97	19.31
		Mn at 400 g/fed	200.3	219.0	19.43	20.43	32.40	34.93	35.5	35.43	17.65	17.89
		Zn + Mn	223.0	230.3	23.23	24.33	37.16	40.10	38.6	39.20	20.39	20.73
Chisel plow once + tiller plow once	23.25 kg P_2O_5/fed	Without	214.0	211.0	20.13	21.23	37.40	40.23	36.4	36.33	18.17	18.51
		Zn at 400 g/fed	229.0	231.0	23.43	23.53	40.40	44.26	38.76	39.26	19.88	20.22
		Mn at 400 g/fed	221.0	224.0	21.16	21.26	38.26	41.76	36.73	37.00	18.62	18.97
		Zn + Mn	235.0	244.0	24.36	25.46	43.66	44.46	39.67	41.06	21.37	21.71
	15.5 kg P_2O_5/fed	Without	213.0	220.3	20.36	21.56	36.86	38.20	35.5	36.43	17.64	18.17
		Zn at 400 g/fed	225.3	231.0	23.46	24.56	41.60	42.26	37.48	39.41	19.31	19.65
		Mn at 400 g/fed	221.0	223.0	21.30	22.40	39.20	39.93	37.61	37.21	17.94	18.28
		Zn + Mn	229.3	240.3	23.86	25.26	43.40	43.93	39.6	40.60	20.80	21.14
LSD at 5 %			1.6	1.4	0.48	0.47	0.50	0.58	0.41	0.48	0.90	0.88

Table 5: Plant height, count of branches/plant, count of seeds/pod, count of seeds/plant, 100-seed weight and seed yield/fed of soybean intercropped with maize as affected by plowing treatments, P fertilization levels and spraying by micronutrients as well as their interactions throughout 2020 and 2021 seasons.

Characters / Treatments	Plant height (cm)		Count of branches/plant		Count of seeds/pod		Count of seeds/plant		100-seed weight (g)		Seed yield (t/fed)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
A. Plowing treatments:												
Chisel plow once	91.7 b	100.3c	3.12 a	4.12 b	1.80 b	2.11b	34.54c	35.66c	13.33c	14.28b	0.630c	0.775c
Tiller plow once	91.8 b	106.2b	3.91ab	4.91ab	1.76 b	2.12 b	36.62b	38.41b	13.57b	14.58a	0.735b	0.861b
Chisel plow once + tiller plow once	98.5 a	107.0a	4.66 a	5.45 a	1.90 a	3.67 a	38.12a	40.41a	13.67a	14.64a	0.849a	0.964a
F-test at 5 %	*	*	*	*	*	*	*	*	*	*	*	*
B. P fertilization levels:												
23.25 kg P_2O_5/fed	94.7 a	105.1a	4.11 a	4.97 a	1.87	2.64	36.66a	38.47a	13.60a	14.58a	0.776a	0.883a
15.5 kg P_2O_5/fed	93.3 b	103.9b	3.69 b	4.69 b	1.77	2.63	36.19b	37.86b	13.45b	14.42b	0.700b	0.850b
F-test at 5%	*	*	*	*	NS	NS	*	*	*	*	*	*
C. Spraying by micronutrients:												
Without	84.8 d	95.8 c	2.88 d	3.88 c	1.46 d	1.80 d	33.11d	34.50d	12.81c	13.80c	0.557d	0.654d
Zn at 400 g/fed	90.6 c	103.8b	4.16 b	5.05 b	2.00 b	2.04 b	36.94b	39.66b	14.06a	15.06a	0.811b	0.946b
Mnat 400 g/fed	97.3 b	104.6b	3.50 c	4.33 c	1.67 c	1.97 c	34.00c	36.77c	13.02b	14.01b	0.674c	0.820c
Zn at 400 g + Mn at 400 g/fed	103.2a	113.8a	5.05 a	6.05 a	2.15 a	4.71 a	41.66a	41.72a	14.20a	15.12a	0.910a	1.047a
F-test at 5 %	*	*	*	*	*	*	*	*	*	*	*	*
Solo soybean	**108.67**	**113.67**	**4.00**	**5.00**	**1.80**	**2.00**	**40.67**	**42.67**	**13.48**	**14.49**	**1.375**	**1.474**

Table 6: Plant height, count of seeds/plant and seed yield/fed of soybean intercropped with maize as affected by the interaction among plowing treatments, P fertilization levels and spraying by micronutrients throughout 2020 and 2021 seasons.

Characters			**Plant height (cm)**		**Count of seeds/plant**		**Seed yield (t/fed)**	
Plowing treatments	**P levels**	**Spraying by micronutrients**	2020	2021	2020	2021	2020	2021
Chisel plow once	23.25 kg P_2O_5/fed	Without	85.00	89.66	32.66	32.66	0.472	0.582
		Zn at 400 g/fed	87.00	100.66	35.33	36.66	0.736	0.805
		Mn at 400 g/fed	93.00	104.33	33.00	34.66	0.587	0.851
		Zn + Mn	98.66	108.66	38.33	40.33	0.882	1.010
	15.5 kg P_2O_5/fed	Without	82.00	92.66	31.00	31.00	0.430	0.566
		Zn at 400 g/fed	91.00	95.33	35.33	35.66	0.665	0.765
		Mnat 400 g/fed	96.00	101.00	30.33	32.66	0.523	0.642
		Zn + Mn	101.00	110.00	40.33	41.66	0.746	0.980
Tiller plow once	23.25 kg P_2O_5/fed	Without	84.00	98.00	33.33	34.66	0.594	0.559
		Zn at 400 g/fed	92.00	103.66	36.33	40.33	0.811	1.014
		Mn at 400 g/fed	99.00	108.66	33.66	37.00	0.710	0.847
		Zn + Mn	102.66	112.66	41.00	41.66	0.922	1.057
	15.5 kg P_2O_5/fed	Without	81.00	96.33	32.66	34.66	0.539	0.629
		Zn at 400 g/fed	85.00	106.00	38.00	41.33	0.779	0.970
		Mn at 400 g/fed	91.66	109.00	35.33	37.66	0.627	0.770
		Zn + Mn	98.66	115.00	42.66	40.00	0.902	1.039
Chisel plow once + tiller plow once	23.25 kg P_2O_5/fed	Without	86.00	100.33	34.33	36.66	0.712	0.764
		Zn at 400 g/fed	91.66	112.33	38.00	43.00	0.990	1.074
		Mn at 400 g/fed	99.00	103.33	35.66	40.33	0.846	0.966
		Zn + Mn	114.00	118.66	44.33	43.66	1.056	1.130
	15.5 kg P_2O_5/fed	Without	91.00	97.66	34.66	37.33	0.598	0.823
		Zn at 400 g/fed	97.00	105.00	38.66	41.00	0.888	1.047
		Mn at 400 g/fed	105.00	101.00	36.00	38.33	0.750	0.845
		Zn + Mn	104.00	118.00	43.33	43.00	0.949	1.065
LSD at 5 %			1.75	1.84	1.18	1.11	0.072	0.064

These results may be due to the role of phosphorus in plant nutrition growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division. Also, phosphorus compounds are involved in the transfer and storage of energy within plants. In addition, energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds such as ATP and ADP for later use in growth and reproduction. An adequate supply of available P in soil is associated with increased root growth, which means roots can explore more soil for nutrients and moisture (**Marschner, 1995**similar results were obtained by . **Khalifa et al (2002)** , **Alias et al. (2003),Onasanya et al (2009), Ahmad et al. (2019) and Ray et al. (2020)**.

3. Spraying by micronutrients effects:

Concerning effect of spraying by micronutrients *i.e.* without spraying) (control treatment), spraying with chelated zinc (Zn), chelated manganese (Mn) and the combination of Zn and Mn, it had significant effect on maize growth characters (plant height and ear leaf area) and yield and yield attributes (ear length, count of rows/ear, count of grains/row, ear weight, ear grains weight, 100-grain weight and grain yield/fed) as well as soybean characters (plant height, count of branches/plant, count of seeds/pod, count of seeds/plant, 100-seed weight and seed yield/fed) in each season as shown in Tables 2, 3, 4, 5 and 6.Foliar spraying intercropped maize and soybean twice after 30 and 60 days from sowing with the combination of Zn and Mn at the rate of 400 g Zn + 400 g Mn/200 Liter water/fed produced the superior values of growth characters and yield and yield attributes of maize and soybean in each season. The second best treatment was foliar spraying intercropped maize and soybean twice with 400 g Zn/200 Liter water/fed, followed by foliar spraying intercropped maize and soybean twice with 400 g Mn/200 Liter water/fed in each season. While, the lowest values of growth characters and yield and yield attributes of maize and soybean were obtained from control treatment (without spraying micronutrients) in each season.

These increases in growth characters and yield and yield attributes of maize as well as soybeans a result of foliar application with micronutrients (Zn and Mn) may be due to its role in carbohydrate metabolism and reproductive phase of the plants along with photosynthesis and various enzymatic activities, which stimulate vegetative growth, hence increasing yield attributes and finally grain yield of maize and seed yield of soybean. This result coincided with those obtained by**Hoda et al (2014)** , **Tahir and Yasin (2016), El-Metwally et al. (2019) and Mustafa and Rasul (2020)**.

4. Interactions effects:

There are many significant interaction effects among plowing treatments, P fertilization levels and spraying by micronutrients on most of studied characters of maize intercropped with soybean in each season as shown in Tables 4 and 6. We present only the significant triple interaction among plowing treatments, P fertilization levels and spraying by micronutrients on all studied characters of maize intercropped with soybean in each season.

The interaction among plowing treatments, P fertilization levels and spraying by micronutrients significantly influenced plant height, ear length, count of grains/row, 100-grain weight and grain yield/fed of maize intercropped with soybean and plant height, count of seeds/plant and seed yield/fed of soybean intercropped with maize in each season as shown from results in Table 4 and 6.

The recommended treatment that produced the superior values of plant height, ear length, count of grains/row, 100-grain weight and grain yield/fed of maize intercropped with soybean and plant height, count of seeds/plant and seed yield/fed of soybean intercropped with maize in each season was using chisel plow once beside tiller plow once and fertilizing with 23.25 kg P_2O_5/fed in addition to foliar spraying intercropped maize and soybean twice after 30 and 60 days from sowing with the combination of Zn and Mn at 400 g Zn + 400 g Mn /200 Liter water/fed as illustrated in Tables 4 and 6. This treatment followed by using chisel plow once beside tiller plow once and fertilizing with 15.5 kg P_2O_5/fed additionally spraying intercropped maize and soybean with the combination of Zn and Mn at 400 g Zn + 400 g Mn /200 Liter water/fed without significant differences between them in most cases in each season. On the other hand, the lowest values of plant height, ear length, count of grains/row, 100-grain weight and grain yield/fed of maize intercropped with soybean and plant height, count of seeds/plant and seed yield/fed of soybean intercropped with maize were resulted from control treatment of three studied factors (using chisel plow once, fertilizing with 15.5 kg P_2O_5/fed without foliar spraying plants with micronutrients) in each season.

5. Competitive relationships:

(a) Land equivalent ratio:

Data in Table 7 showed that all treatments of the interaction among plowing treatments, P fertilization levels and spraying by micronutrients of maize intercropped with soybean raised land productivity compared with planting of maize and soybean in pure stand in each season. In each season, the best treatment included was using chisel plow once beside tiller plow once and fertilizing with 23.25 kg P_2O_5/fed in addition to foliar spraying intercropped maize and soybean twice after 30 and 60 days from sowing with the combination of Zn and Mn at 400 g Zn + 400 g Mn /200 Liter water/fed, where this treatment increases land usage by 50% in the first and49% in the second seasons. Simultaneously, the lowest treatment was using chisel plow once and fertilizing with 15.5 kg P_2O_5 /fed without spraying by Zn or Mn. This treatment decreased land productivity by 13% in the first and 6% in the second season. Thus, it is evident that maize was the better contributor in LER in all treatments in each season.

(b) Aggressivity (A):

Data presented in Table 7 revealed that maize is dominated crop in 22 treatments in the first season and 13 treatments in the second season due to the interaction among plowing treatments, P fertilization levels and spraying by micronutrient sand soybean was dominated crop in 2treatment in the first season and11 treatments out of 24 in the second season. It is evident that a maize crop had higher competitive abilities compared with soybean. where, maize was planted by 50 % of its pure stand and soybean was intercropped with maize by 50 % of its pure stand.

(c) Relative crowding coefficient (RCC):

Data in Table 7 showed that the interaction among the three factors under study (plowing treatments, P fertilization levels and spraying by micronutrients) achieved yield advantageous in all treatments in each season. The superior yield advantage was recorded by using chisel plow once beside tiller plow once and fertilizing with 23.25 kg P_2O_5/fed in addition to foliar spraying intercropped maize and soybean twice after 30 and 60 days from sowing with the combination of Zn and Mn at 400 g Zn + 400 g Mn /200 Liter water/fed (8.73 and 8.43) in the first and second seasons, respectively. On the other hand, the lowest yield advantage was showed with treatment of using chisel plow once, fertilizing with 15.5 kg P_2O_5/fed without foliar spraying plants with micronutrients (0.58 and 0.79) in the first and second seasons, respectively.

Table 7: Land equivalent ratio (LER), aggressivity (Ag) and relative crowding coefficient (RCC) of intercropping maize with soybean as affected by the interaction among plowing treatments, P fertilization levels and spraying by micronutrients throughout 2020 and 2021 seasons.

Characters			**LER**			**Ag**		**RCC**			**LER**			**Ag**		**RCC**		
Plowing treatments	**P levels**	**Spraying by micronutrients**	Lm	Ls	LER	Ag m	Ag s	K m	K s	K	Lm	Ls	LER	Ag m	Ag s	K m	K s	K
			2020 season								**2021 season**							
Chisel plow once	23.25 kg P_2O_5/fed	Without	0.56	0.34	0.90	+0.44	-0.44	1.28	0.52	0.67	0.56	0.39	0.95	+0.34	-0.34	1.30	0.65	0.85
		Zn at 400 g/fed	0.64	0.54	1.18	+0.20	-0.20	1.75	1.15	2.01	0.63	0.55	1.18	+0.17	-0.17	1.72	1.20	2.07
		Mn at 400 g/fed	0.59	0.43	1.02	+0.33	-0.33	1.46	0.74	1.08	0.59	0.58	1.17	+0.03	-0.03	1.44	1.37	1.97
		Zn + Mn	0.67	0.64	1.31	+0.05	-0.05	2.01	1.79	3.60	0.66	0.69	1.35	-0.05	+0.05	1.94	2.18	4.23
	15.5 kg P_2O_5/fed	Without	0.56	0.31	0.87	+0.49	-0.49	1.27	0.46	0.58	0.56	0.38	0.94	+0.35	-0.35	1.26	0.62	0.79
		Zn at 400 g/fed	0.62	0.48	1.10	+0.28	-0.28	1.66	0.94	1.56	0.62	0.52	1.14	+0.20	-0.20	1.64	1.08	1.77
		Mn at 400 g/fed	0.58	0.38	0.96	+0.40	-0.40	1.39	0.61	0.85	0.57	0.44	1.01	+0.28	-0.28	1.34	0.77	1.04
		Zn + Mn	0.67	0.54	1.21	+0.25	-0.25	1.99	1.19	2.36	0.66	0.66	1.32	-0.04	+0.04	1.95	1.98	3.87
Tiller plow once	23.25 kg P_2O_5/fed	Without	0.59	0.43	1.02	+0.31	-0.31	1.43	0.76	1.09	0.59	0.38	0.97	+0.42	-0.42	1.42	0.61	0.87
		Zn at 400 g/fed	0.66	0.59	1.25	+0.15	-0.15	1.96	1.44	2.82	0.66	0.69	1.35	-0.06	+0.06	1.93	2.20	4.25
		Mn at 400 g/fed	0.62	0.52	1.14	+0.20	-0.20	1.61	1.07	1.72	0.61	0.57	1.18	+0.08	-0.08	1.59	1.35	2.14
		Zn + Mn	0.69	0.67	1.36	+0.05	-0.05	2.27	2.04	4.61	0.69	0.72	1.41	-0.06	+0.06	2.22	2.53	5.63
	15.5 kg P_2O_5/fed	Without	0.58	0.39	0.97	+0.38	-0.38	1.38	0.64	0.89	0.58	0.43	1.01	+0.30	-0.30	1.37	0.74	1.02
		Zn at 400 g/fed	0.64	0.57	1.21	+0.15	-0.15	1.81	1.31	2.36	0.64	0.66	1.30	-0.04	+0.04	1.78	1.92	3.42
		Mn at 400 g/fed	0.60	0.46	1.06	+0.29	-0.29	1.49	0.84	1.25	0.59	0.52	1.11	+0.14	-0.14	1.46	1.09	1.59
		Zn + Mn	0.69	0.66	1.35	+0.07	-0.07	2.25	1.91	4.28	0.69	0.70	1.39	-0.04	+0.04	2.20	2.39	5.25
Chisel plow once + tiller plow once	23.25 kg P_2O_5/fed	Without	0.62	0.52	1.14	+0.20	-0.20	1.61	1.07	1.73	0.61	0.52	1.13	+0.19	-0.19	1.59	1.08	1.71
		Zn at 400 g/fed	0.67	0.72	1.39	-0.09	+0.09	2.07	2.57	5.33	0.67	0.73	1.40	-0.12	+0.12	2.03	2.69	5.46
		Mn at 400 g/fed	0.63	0.62	1.25	+0.03	-0.03	1.72	1.60	2.74	0.63	0.66	1.29	-0.05	+0.05	1.69	1.90	3.22
		Zn + Mn	0.73	0.77	1.50	-0.09	+0.09	2.64	3.31	8.73	0.72	0.77	1.49	-0.09	+0.09	2.57	3.28	8.43
	15.5 kg P_2O_5/fed	Without	0.60	0.43	1.03	+0.33	-0.33	1.49	0.77	1.15	0.60	0.56	1.16	+0.09	-0.09	1.51	1.26	1.91
		Zn at 400 g/fed	0.66	0.65	1.31	+0.03	-0.03	1.90	1.82	3.47	0.65	0.71	1.36	-0.12	+0.12	1.87	2.45	4.58
		Mn at 400 g/fed	0.61	0.55	1.16	+0.13	-0.13	1.56	1.20	1.87	0.61	0.57	1.18	+0.07	-0.07	1.54	1.34	2.07
		Zn + Mn	0.71	0.69	1.40	+0.02	-0.02	2.40	2.23	5.34	0.70	0.72	1.42	-0.01	+0.01	2.34	2.60	6.10

m = maize, s = soybean.

Net return:

Data presented in Table 8 revealed that most treatments of the interaction among plowing treatments, P fertilization levels and spraying by micronutrients exceeded total income and net return compared to cultivating maize or soybean alone in each season. The superior values of total income (20415.2 and 26497.0 LE) and net return (12545.2 and 17407.0 LE) were achieved when using chisel plow once beside tiller plow once and fertilizing with 23.25 kg P_2O_5/fed in addition to foliar spraying intercropped maize and soybean twice after 30 and 60 days from sowing with the combination of Zn and Mn at 400 g Zn + 400 g Mn /200 Liter water / fedin the first and second seasons, respectively. On the other hand, the lowest values of total income (12680.0 and 17448.0 LE) and net return (5510.0 and 9078.0 LE) were obtained using chisel plow once, fertilizing with 15.5 kg P_2O_5/fed without foliar spraying plants with micronutrients in each season.

Table 8: Effect of the interaction among plowing treatments, P fertilization levels and spraying by micronutrients on economic evaluation of maize intercropped with soybean throughout 2020 and 2021 seasons.

Plowing treatments	P levels	Spraying by micronutrients	Actual maize grain yield (ardab)/fed (LE)	Actual soybean seed yield (t/fed) (LE)	Total income (LE)	Total cost (LE)	Net return (LE)	Actual maize grain yield (ardab/fed (LE)	Actual soybean seed yield (t/fed) (LE)	Total income (LE)	Total cost (LE)	Net return (LE)
			2020 season					**2021 season**				
Chisel plow once	23.25 kg P_2O_5/fed	Without	9279.2	3776.0	13055.2	7250.0	5805.2	11921.0	5820.0	17741.0	8450.0	9291.0
		Zn at 400 g/fed	10494.4	5888.0	16382.4	7310.0	9072.4	13356.0	8050.0	21406.0	8515.0	12891.0
		Mn at 400 g/fed	9783.2	4696.0	14479.2	7330.0	7149.2	12474.0	8510.0	20984.0	8540.0	12444.0
		Zn + Mn	11020.8	7056.0	18076.8	7470.0	10606.8	13944.0	10100.0	24044.0	8690.0	15354.0
	15.5 kg P_2O_5/fed	Without	9240.0	3440.0	12680.0	7170.0	5510.0	11788.0	5660.0	17448.0	8370.0	9078.0
		Zn at 400 g/fed	10304.0	5320.0	15624.0	7230.0	8394.0	13118.0	7650.0	20768.0	8435.0	12333.0
		Mnat 400 g/fed	9592.8	4184.0	13776.8	7250.0	6526.8	12110.0	6420.0	18530.0	8460.0	10070.0
		Zn + Mn	10981.6	5968.0	16949.6	7390.0	9559.6	13965.0	9800.0	23765.0	8610.0	15155.0
Tiller plow once	23.25 kg P_2O_5/fed	Without	9721.6	4752.0	14473.6	7450.0	7023.6	12397.0	5590.0	17987.0	8650.0	9337.0
		Zn at 400 g/fed	10931.2	6488.0	17419.2	7510.0	9909.2	13902.0	10140.0	24042.0	8715.0	15327.0
		Mn at 400 g/fed	10175.2	5680.0	15855.2	7530.0	8325.2	12957.0	8470.0	21427.0	8740.0	12687.0
		Zn + Mn	11452.0	7376.0	18828.0	7670.0	11158.0	14560.0	10570.0	25130.0	8890.0	16240.0
	15.5 kg P_2O_5/fed	Without	9570.4	4312.0	13882.4	7370.0	6512.4	12208.0	6290.0	18498.0	8570.0	9928.0
		Zn at 400 g/fed	10623.2	6232.0	16855.2	7430.0	9425.2	13517.0	9700.0	23217.0	8635.0	14582.0
		Mnat 400 g/fed	9884.0	5016.0	14900.0	7450.0	7450.0	12523.0	7700.0	20223.0	8660.0	11563.0
		Zn + Mn	11418.4	7216.0	18634.4	7590.0	11044.4	14511.0	10390.0	24901.0	8810.0	16091.0
Chisel plow once + tiller plow once	23.25 kg P_2O_5/fed	Without	10175.2	5696.0	15871.2	7650.0	8221.2	12957.0	7640.0	20597.0	8850.0	11747.0
		Zn at 400 g/fed	11132.8	7920.0	19052.8	7710.0	11342.8	14154.0	10740.0	24894.0	8915.0	15979.0
		Mn at 400 g/fed	10427.2	6768.0	17195.2	7730.0	9465.2	13279.0	9660.0	22939.0	8940.0	13999.0
		Zn + Mn	11967.2	8448.0	20415.2	7870.0	12545.2	15197.0	11300.0	26497.0	9090.0	17407.0
	15.5 kg P_2O_5/fed	Without	9878.4	4784.0	14662.4	7570.0	7092.4	12719.0	8230.0	20949.0	8770.0	12179.0
		Zn at 400 g/fed	10813.6	7104.0	17917.6	7630.0	10287.6	13755.0	10470.0	24225.0	8835.0	15390.0
		Mn at 400 g/fed	10046.4	6000.0	16046.4	7650.0	8396.4	12796.0	8450.0	21246.0	8860.0	12386.0
		Zn + Mn	11648.0	7592.0	19240.0	7790.0	11450.0	14798.0	10650.0	25448.0	9010.0	16438.0
Solo maize			16503.2	-	16503.2	8500.0	8003.2	21119.0	-	21119.0	9500.0	11619.0
Solo soybean			-	11000.0	11000.0	4000.0	7000.0	-	14740.0	14740.0	4200.0	8340.0

CONCLUSION

It can be concluded that the maximum land equivalent ratio (LER), total income and net return were obtained from intercropping maize and soybean with 50.0 % of its pure stand using chisel plow once beside tiller plow once and fertilizing with 23.25 kg P_2O_5/fed in addition to foliar spraying intercropped maize and soybean twice after 30 and 60 days from sowing with the combination of Zn and Mnat 400 g Zn + 400 g Mn/200 Liter water/fedun the environmental conditions of Kafr El-Sheikh Governorate, Egypt.

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الملخص العربي

تأثير التسميد الفوسفاتى والرش الورقى بالعناصر الصغرى على إنتاجية الذرة الشامية وفول الصويا المحملين والعلاقات التنافسية تحت نظم مزرعية مختلفة

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في مزرعة محطة البحوث الزراعية بسخا ، مركز البحوث الزراعية ، مصر ، أجريت تجربتان حقليتان خلال موسمي 2020 و 2021 لدراسة تأثيرطرق االخدمة و مستويات التسميد الفوسفاتي والرش الورقى بالعناصر الصغرى نفذت التجربة فى تصميم القطع المنشقة مرتين فى ثلاثة مكرارات ووضعت فى القطع الرئسية طرق الخدمة وهى استخدام المحراث الحفار مرة واحدة ، واستخدام المحراث العميق مرة واحدة واستخدام المحراث الحفار مرة واحدة بالإضافة إلى استخدام المحراث العميق مرة واحدة وفى القطع الشقية الاولى مستويات التسميد الفوسفاتى (15.5 و 23.25 كجم بو$_2$أ$_5$ / فدان) فى القطع الشقية الثانية الرش الورقى بالعناصر الصغرى (بدون ، الرش بـ 400 جرام زنك في 200 لتر ماءللفدان ، الرش 400 جرام منجنيز في200 لتر ماء للفدان والرش ب400 جرام زنك + 400 جرام منجنيز في 200 لتر ماء للفدان) بالإضافة إلى العلاقات التنافسية والعائد النقدى . أدى استخدام المحراث الحفار مرة واحدة بالإضافة إلى استخدام المحراث العميق مرة واحدة إلى زيادة معنوية في صفات التبكير وصفات النمو والمحصول ومكوناته لمحصول الذرة الشامية وأيضاً جميع صفات فول الصويا والحصول على أعلى القيم لجميع الصفات المدروسة في كلا الموسمين. أدت زيادة مستويات السماد الفوسفاتى إلى 23.25 كجم بو$_2$أ$_5$ / فدان إلى الحصول على أعلى القيم لصفات التبكير وصفات النمو والمحصول ومكوناته لمحصول الذرة الشامية وأيضاً جميع صفات فول الصويا في كلا الموسمين. أدى الرش الورقي لنباتات الذرة الشامية المحملة مع فول الصويا مرتين بمخليط من الزنك والمنجنيز بمعدل 400 جم زنك + 400 جم منجنيز في 200 لتر ماء للفدان للحصول على أعلى القيم لصفات التبكير وصفات النمو والمحصول ومكوناته لمحصول الذرة الشامية وأيضاً جميع صفات فول الصويا في كلا الموسمين.

من النتائج المتحصل عليها فى هذه الدراسة يمكن استنتاج أنه عند تحميل فول الصويا مع الذرة الشامية بنسبة 50 % لكل منهم أن أقصى معامل لإستغلال الأرض (LER) وإجمالي الدخل وصافى العائد النقدى لكل من الذرة الشامية وفول الصويا نتج من استخدام المحراث الحفار مرة واحدة مع إلى استخدام المحراث العميق مرة واحدة أيضاً والتسميد بـ 23.25 كجم بو$_2$أ$_5$ / فدان بالإضافة إلى الرش الورقي لنباتات الذرة الشامية وفول الصويا المحملين مرتين بمخلوط من الزنك والمنجنيز بمعدل 400 جم زنك + 400 جم منجنيز في 200 لتر ماء للفدان تحت الظروف البيئية لمحافظة كفر الشيخ ، مصر. فى كلا الموسمين.