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Effect of Tillage Depth System and Intercropping Patterns on Solid and Intercropped Soybean with Maize.

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ABSTRACT

Two field experiments were carried out in Gemmeiza Research Station during the two summer successive seasons 2013 and 2014 to investigate the effect of three soil tillage depths *i.e.* 15, 20 and 25 cm and three intercropping patterns *i.e.* P1-100% maize (single cross 128) + 50% soybean (variety Giza 111) in ridges (0.70 m in width) P2- 100% maize + 50 % soybean in beds (1.40 m in width) and soybean was intercropped with maize at the two rows on bed back, whereas maize was planted at both sides of the bed and P3- Pure stands of maize and soybean were planted as recommended for each crop. The experiment was laid out in a strep plot design in three replicates. Results could be summarized as follows: All characters of maize was significant by affected increasing soil tillage depth from 15 up to 20 cm depth except, plant height in first season. On the other hand, maize grain yield recorded the highest value with tillage depth at 20 cm in both seasons. Maize pure stand recorded the highest values of all studied characters followed by planting in beds and the lowest values were obtained, when maize grown in ridges in both seasons, except, plant height behaved opposite trend of these characters. indicated that plant height in the second season, No. of kernels, ear weight^{-1}, 100-kernel weight in the first season and maize grain yield fad^{-1} in both seasons were significantly affected by interaction between plowing depth and intercropping patterns. Also, all soybean characters were significantly affected by tillage systems in both seasons, where, tillage depth at 20 cm gave the highest values, followed by at 25 cm While, 15 cm depth gave the lowest values in both seasons. Whereas soybean pure stand recorded the highest values of yield in both seasons, followed intercropping 100% + 50% soybean on the beds in both seasons. The found that 100-seed weight and seed yield fad^{-1} in both seasons were significantly affected by the interaction between different tillage depth and intercropping patterns. Soil tillage depth at 20 cm and intercropping pattern (100% maize + 50% soybean) on beds recorded the highest values for LER (1.34) and LEC (0.43) in the combined analysis, which showed that intercropping had better grain yield performance when compared to sole cropping. All intercropping patterns were grown in different depths were positive for total income comparative to maize pure stand in combined analysis of both seasons. The highest total income and MAI were achieved with plowing depth at 20 cm in beds (8855.96and 2247.03 L.E. fad^{-1}) and the lowest value was showed with plough at 25 cm in ridge (6426.63 and 126.01L.E.fad). Growing maize and soybean with plowing depth at 20 cm increased total income by 10.26 and 10.70%, while MAI increased by 0.88 and 28.80 % compared with plowing depth 15 and 25 respectively. It could be concluded that tillage at 20 cm depth and intercropping pattern (100% + 50%) maize/soybean planted in beds to obtain the best land usage and total income.

Keywords: Intercropping, tillage depth system**,** maize, Soya bean**.**

INTRODUCTION

Tillage will ensure the adequate moisture and air quantity needed for plant. In addition, the seeded should be as free as possible from weeds and applied fertilizer be incorporated eventually with the soil. So, before sowing seed sit is necessary prepare a suitable seeded for seed germination Abo-Habaga (1992) concluded that decreasing the percentage of less than (0> 50 mm) in the seeded increased the main distance between adjacent seed in raw for a given number of seed per unit area and then the crop yield was increased. Sherif *et al*. (1995) indicated that tillage treatments significantly affected plant height, ear length, stem diameter, ear wt, wt. of grains ear^{-1}, grain yield per plant, 100-grain wt. and grain yield fad^{-1}. Except number of rows ear^{-1} Sahar Sherif *et al*. (2006) indicated that using chisel plough 3 passes decreased the value of mean weight diameter by 33.0%, 27.92% and 31.8% as compared with chisel plough 2 passes for 10, 15 and 20 cm depth, respectively. They added that yield and quality of maize and soybean were significantly increased by using tillage with chisel plough 3 passes either in pure stands as intercrop combination. Ahadiyat and Ranamukhaarachchi (2008) studied three tillage methods (no-conventional and depth tillage) and four cropping patterns. They found that conventional and depth tillage increased yield components of maize compared with no-tillage, but grain yield remained unchanged among cropping patterns.

Hussein *et al*. (2007) investigated depth of plowing on growth, yield and its components of corn. They found that plant heights leaf area index, number of grains ear^{-1}, wt. of 100-grain and grain yield fad^{-1} significantly affected by plowing depth. Also, they added that increasing of plowing depth (0-40 cm) increased the yield of grain. Yugi *et al*. (2011) found that lateral root distance, root dry wt. and dry biomass were greater in maize intercropped than sole maize in all tillage methods. There was insignificant effected on maize grain yield due to tillage and maize intercropped.

Abed Al-Karhi and Ali (2014) reported that conventional tillage led to a significant increase in all quantities of growth and yield of sorghum and grains yield of mung bean compared minimum tillage and zero-tillage. They added that LERs were increased by conventional tillage than other tillage treatments.

Intercropping, is one type of a multiple cropping system. It is recommended to be used in many parts of the world for food or fibers productions, because of its overall high productivity, effective control of pests and diseases, good ecological services and economic profitability. In an intercropping system, there are often two or more crop species grown in the same field for a certain period of time, even though the crops are not necessarily sown or harvested simultaneously (Thierfelder *et al*., 2012 and Wu and BZ 2014). Many investigators studied the effect of intercropping of maize with soybean. El-Douby *et al*. (1996) concluded that the highest maize grain yield was obtained when (4:2) soybean/ maize intercropping applied. Whereas, the highest soybean yield was produced with (2 maizes:4 soybean) maize /soybean. They added that intercropping increased LER values by 19 and 23% as compared maize alone the first and second seasons, respectively. El-Douby and Allam (2001) found that growth, ear characters and grain yield fad^{-1}, of maize were reduced significantly compared with its pure stand. LER

and RCC were increased in all intercropping patterns. Fathy *et al*. (2008) found that yield and its components of Giza 35 and 111 soybean varieties were reduced by intercropping with maize compared with its pure stands. Meanwhile the reduction in grain yield fad^{-1} of maize valued to 19 and 26.8% than its pure stand. They added that LERs were 1.24 and 1.37 (maize + Giza 35) and 1.12 and 1.12 (maize + Giza 111) in the first and second seasons, respectively. Lamloum and Ewis (2015) reveled that the highest maize grain yield was obtained, when maize was planted on raised-bed, while soybean yield was obtained, when soybean was grown in (2:4) maize/soybean. They added that the maximum of LER (1.53 and 1.48) and RCC (12.77 and 9.38) were observed with raised-beds. The net return showed that intercropping soybean with maize in all intercropping patterns were higher compared with solid maize or solid soybean.

The aim of this study was to obtain the best land usage and total income by applying the best tillage depth and intercropping pattern.

MATERIALS AND METHODS

Two field experiments were carried out at Gemmeiza Agricultural Research station, El-Gharbia governorate, Egypt during 2013 and 2014 seasons to investigate the effect of soil tillage depth and some intercropping patterns for soybean with maize on yield and yield components of both crops. A strip - plot design with three replicates was used, the main strip were allocated for three soil tillage treatments, whereas the sub – strip were devoted for intercropping patterns. The sub-plot area was 21 m^2 (0.7 x 3.0 m x 10 ridges or (1.4 m x 5 beds). The treatments were as follows: Soil tillage depth (the main – strip): - Chisel plough at15,20 and 25 cm (D1, D2 and D3).

Intercropping patterns (the sub strip)**: -**

P1- 100% maize (variety single cross 128) + 50% soybean (variety Giza 111) in ridges (0.70 m in width) and soybean were intercropped with maize at the other side of the ridge, maize was planted at 60 cm between hills and thinned to two plants hill^{-1}, whereas Soybean was thinned to two plants hill^{-1} with distance of 20 cm between hills.

P2- 100% maize +50 % soybean in beds (1.40 m in width) and maize was planted on both sides of the bed at 60 cm between hills and thinned to two plants/hill. Whereas, soybean was planted in two rows on top at 30 cm between rows and thinned to two plants hill^{-1} with distance of 20 cm between hills.

P3- Pure stands of maize and soybean were planted as recommended for each crop, maize was planted at 30 cm between hills and thinned to one plant hill^{-1} and soybean was planted at both sides of the ridge and thinned to two plants hill^{-1} with distance of 20 cm between hills.

Before starting the experiments, physical soil analysis was done where the soil was clay loam in texture had an average pH value of 7.5; 1.3 % organic matter and had 27, 10 and 337 ppm available N, P and K, respectively (averaged over the two seasons for the depth 30 cm of soil depth).

Each plot was fertilized by calcium superphosphate (15.5% $P_2O_{5)}$ at a rate of 150 kg fad^{-1} which was applied during land preparation. Potassium sulphate (48 % K_2O) before the first and second irrigations at a rate of 50 kg fad^{-1} Nitrogen fertilizer as ammonium nitrate (33.5% N) was applied at a rate of 120 kg N fad^{-1}. in equal doses at the first and second irrigations. All agricultural practices as recommended were produced in both seasons,

The preceding winter crop was wheat (*Triticum aestivum* L.) in the two seasons. Soybean was sown on May 20th and 24th through 2013 and 2014 seasons, respectively. Maize was sown on June 7th and 9th through 2013 and 2014 seasons, respectively. The harvest in soybean in the first week and maize in second week in September, respectively. Maize was harvested at physiological maturity while soybean was harvested when the first pod of the plants fully matured. Kernels and seeds were weighted and adjusted to constant moisture of 15.5 % and 12% for both components i.e. cereal and legume crop components respectively and ten plants were taken at random from each sub-plot to estimate growth the following:

Maize: Plant and ear heights (cm), No. of leaves plant^{-1}, leaf area index(LAI), ear length and diameter (cm), number of kernels row^{-1}, number of rows ear^{-1}, 100- kernel weight (g), ear weight (g). Whereas grain yield fad^{-1} from whole sub-plot.

Soybean: Plant height (cm), number of branches and pods plant^{-1}, 100- seed weight (g), Seed and biological yields (ton fad^{-1}).

A- Land use efficiency: In order to assess the land use efficiency, Total Land Equivalent Ratio (Total LER) was suggested by Monzon *et al*., (2014). It was determined according to do as the sum of yield relative i.e. intercrop yields relative to their solid yield. The total LER an accurate assessment of the biological efficiency of the intercropping situation, using the following equation to evaluate and compare the productivity of relay intercropping and mono cropping:

Total LER= (Yab / Yaa) + (Yba / Ybb).

Where, Yaa and Ybb are yields as sole crops of component a (Maize) and component b (soybean) and Yab and Yba are yields as intercrops of a and b, respectively. Values of total LER greater than 1.0 are considered advantages. While, values of total LER less than 1.0 are considered disadvantages.

B- Land equivalent coefficient (LEC):

A measure of interaction concerned with the strength of relationship was calculated thus, LEC=La x Lb. Where, La= partial LER of main crop and Lb= partial LER of intercrop (Aditiloye *et al*., 1983), for a two- crop mixture the minimum expected productivity coefficient (PC) is 25% that is a yield advantage is obtained if LEC exceeds 0.25.

C- Relative crowding coefficient (RCC):

This parameter was proposed according to De-wit (1960) it assumes that mixture treatment forms are placement series. Each series has its own coefficient (K) which gives a measure to indicate that series has produced more, less or equal yield to that expected. Relative crowding coefficient (RCC) was determined according to the following formula: for species (a) in mixture with species (b).

Kab = $\frac{Yab \times Zba}{(yaa-yab)\times zab}$ **Kba** = $\frac{Yba\times Zab}{(Yaa-yba)\times Zba}$

Where: Zab is sown proportion of species a (in a mixture with b) and Zba is sown proportion of species b (in a mixture with a).

If a species has a coefficient less than, equal to, or greater than one, means it has produced less yield, the same yield, or more yield than the "expected", respectively.

The component crop with the higher coefficient is the dominant one. to determine if there is a yield advantage of mixing, the product of the coefficient is formed by multiplying Kab X Kba If K > 1 , there is yield advantage , If K< 1 there a yield disadvantage.

D-Economic evaluation:

Gross return from each treatment was calculated in Egyptian pounds (LE). One ardab of maize (140 kg) = 317 LE and one ton of soybean seed = 4480 LE. In 2013 and 2014, the average Prices were taken from the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Statistics of 2013 and 2014 years.

E- Monetary advantage index (MAI): It suggests that the economic assessment should be in terms of the value of land saved. This could probably be assessed on the basis of the rentable value of this land.MAI was calculated according to formula, suggested by Willey (1979).

MAI=[Economic value of combined intercrops×(LER–1)]LER^{-1}

Statistical analysis: the obtained data were statistically analyzed according to Steel *et al.* (1997), and least significant difference LSD was used to separate the treatment means at 5% level of significance.

RESULTS AND DISCUSSION

First: Maize

A- Soil tillage depth effect:

Results presented in Tables 1 and 2 revealed that all studied characters i.e. No. of leaves plant^{-1}, Leaf area Index (LAI) , ear length and diameter (cm), number of kernels row^{-1}, ear weight (g), 100-kernel weight and maize yield (ardab fad^{-1}) of maize were significantly affected by plowing depth in both seasons except, plant height and No. of rows ear^{-1} were significantly affected in one season out of two and ear height was not significantly affected in both seasons.

Plant height of maize recorded the highest values where maize was planted at 15 cm depth followed by at 20 whereas the lowest value was showed with 25 cm depth in 2nd season. This result may be due to increase the depth gave the big aggregates at 15 or 20 cm depth than 25 cm as well as tillage at deep depth increased the percentage of small soil colds size (less 50 mm) and the value of meat weight diameter (MWD) was decreased by plowing depth (Sherif *et al*., 2006 and Abed Al-Karhi and Ali (2014) plowing depth at 20 cm was recorded the highest values for other growth characters i.e ear height, No. of leaves plant^{-1} and leaf area index (LAI), while, 15 cm depth ranked second whereas, 25 cm showed the lowest values for aforementioned traits in both seasons. This result may be due to the total root length was significantly influenced by tillage depth and the tillage practices conventional tillage had greatest deep tillage intermediate and there was a decrease in root length density as the soil depth increased (Ahadiyat and Ranamukhaarachchi, 2008 and Dube *et al.,* 2014).

Table 1. Plant and ear heights (cm), no. of leaves plant^{-1}, leaf area index(LAI) , ear length and diameter (cm), no. of rows ear^{-1} of maize as affected by soil tillage depth and intercropping patterns in both seasons.

Main effects and interaction	Plant height (cm)		Ear height (cm)		No. of leaves plant^{-1}		Leaf area Index		Ear length (cm)		Ear diameter(cm)		No. of rows ear^{-1}	
	2013	2014	2013	2014	2013	2013	2013	2014	2013	2014	2013	2014	2013	2014
Soil tillage depth														
15 cm(D1)	245.67	247.00	138	132.23	15.28	17.01	5.19	4.13	20.08	19.74	4.30	4.34	13.84	13.91
20 cm(D2)	244.91	240.77	140.12	134.67	16.67	18.21	5.70	4.47	21.89	21.64	4.52	4.48	14.41	14.07
25 cm(D3)	242.12	224.22	137.20	126.67	14.20	14.76	4.65	3.92	19.17	18.57	4.02	4.11	13.02	13.61
F Test	N.S	*	N.S	N.S	*	*	*	*	*	*	*	*	*	N.S
$LSD_{0.05}$	-	3.87	-	-	0.26	0.48	0.39	0.28	0.43	1.71	0.17	0.17	0.31	-
Intercropping patterns														
Pattern(P1)	251.56	245.11	136.68	126.22	15.13	15.97	4.97	4.03	19.87	19.75	4.15	4.14	12.84	13.19
Pattern(P2)	241.57	237.56	138	129.22	15.34	16.61	5.19	4.15	20.32	19.89	4.29	4.31	13.81	13.92
Pattern(P3)	239.57	229.33	140.64	138.12	15.66	17.40	5.37	4.35	20.94	20.30	4.40	4.48	14.63	14.48
F Test	*	*	*	*	*	*	*	*	*	N.S	*	*	*	*
$LSD_{0.05}$	5.61	2.87	0.62	3.94	0.27	0.30	0.31	0.21	0.38	N.S	0.12	0.12	0.42	0.31
Interaction(D×P):	N.S	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Whereas: Soil tillage depth 15, 20 and 25 cm (D1, D2 and D3)

Pattern (P1) refers to 100% maize + 50% soybean in ridges (0.70 m in width) and soybean were intercropped with maize at the other side of the ridge, Pattern (P2) refers to 100% maize +50 % soybean in beds (1.40 m in width) and maize was intercropped at the both sides of the bed, Pattern (P3) refers to pure stands of maize.

Ear characters, i.e., ear length and diameter (cm), No. of rows ear^{-1}, No. of kernels/row, ear weight^{-1} (gm) and 100-kernel weight (gm) behaved the same trend of other growth characters as shown in Tables 1 and 2. Where, revealed that plowing at 20 cm depth was superior to other plowing depths followed by 15 and 25 cm indicated the lowest values for these characters in both seasons. These results may be due to the reflecting of other growth characters. Similar results were obtained by Hussein *et al*. (2007) and Al-jabori and Al-jabori (2015). The grain yield of maize fad^{-1} grown in plowing 20 cm depth gave the highest yield (20.12 and 19.94) followed by 15 cm (17.95 and 17.85) and the lowest value was showed with 25 cm (17.57 and 16.64 ardab fad^{-1}.) in the first and

second seasons, respectively. There was a decrease in root length density as the soil depth increased. These results were related to growth were obtained by Sherif *et al.* (1995), Abed Al -Karhi and Ali (2014) and Al-jabori and Al-jabori (2015).

B- Intercropping patterns effect:

Results presented in Tables 1 and 2 indicated that some growth, yield and yield components of maize were significantly affected by intercropping patterns in both seasons except ear length in second season (2014). There were significant differences ($P < 0.05$) in maize traits. The intercropping pattern (100% maize + 50% soybean) in ridges, maize achieved the highest plant height with mean (251.56 and 245.11cm) followed by intercropping pattern (100% + 50%) in beds (241.58 and 237.56 cm) and simultaneously maize alone gave the lowest value (239.57 and 229.33 cm) in the first and this result may be due to the effect of intra -specific competition among maize plants and Inter-specific competition between maize and soybean plants either in ridges or in beds with 50% soybean plants. Opposite results were obtained with Lamloum and Ewis (2015).

Table 2. Number of kernels row^{-1}, ear kernels weight (g), 100-kernel weight and maize yield (ardab fad^{-1}) as affected by soil tillage depth and intercropping patterns in both seasons.

Main effects	No. of kernels row^{-1}		Ear weight (g)		100 -kernel weight (g)		Maize yield (ardab fad^{-1})	
and interaction	2013	2014	2013	2014	2013	2014	2013	2014
Soil tillage depth								
15 cm(D1)	38.68	38.55	220.42	215.03	34.45	32.59	17.95	17.85
20 cm(D2)	40.79	40.77	227.05	219.84	36.63	33.88	20.12	19.94
25 cm(D3)	37.31	37.53	207.49	222.36	30.76	30.90	17.57	16.64
F test	*	*	*	*	*	*	*	*
$LSD_{0.05}$	0.61	0.24	2.89	2.34	0.63	0.78	1.53	1.11
Intercropping patterns								
Pattern(P1)	37.53	35.89	211.89	218.11	32.68	30.74	15.20	16.68
Pattern(P2)	38.28	39.63	219.15	209.44	33.79	32.52	17.82	17.71
Pattern(P3)	40.97	41.34	223.91	229.68	35.37	34.11	22.62	20.04
F test	*	*	*	*	*	*	*	*
$LSD_{0.05}$	0.60	0.49	1.87	1.79	0.42	0.62	0.74	1.03
Interaction (D×P):	*	N.S	*	N.S	*	N.S	*	*

Whereas: Soil tillage depth 15, 20 and 25 cm (D1, D2 and D3)

Pattern (P1) refers to 100% maize + 50% soybean in ridges (0.70 m in width) and soybean were intercropped with maize at the other side of the ridge, Pattern (P2) refers to 100% maize +50 % soybean in beds (1.40 m in width) and maize was intercropped at the both sides of the bed, Pattern (P3) refers to pure stands of maize.

Some growth characters i.e ear length (cm), No. of leaves plant^{-1} and leaf area index (LAI) were significantly affected by intercropping patterns in both seasons (Table 1). It is quite evident that planting maize as a pure stand significantly increased in aforementioned traits in both seasons followed by intercropping patterns on beds and ridges, respectively. The significant decrease in aforementioned traits under intercropping patterns than pure stand of maize is mainly due to the increase in inter specific competition between maize and soybean plants for light and nutrient resources. Similar results were reported by El-Douby and Allam (2001).

Yield attributes characteristics of maize, i.e. ear length and diameter, No. of rows ear^{-1}, No. of kernels/row and 100-kernel weight were significantly affected by intercropping patterns in both seasons (Tables 1 and 2). It is clear from results that intercropping 50% soybean of its pure stand with 100% maize in ridges or beds decreased these traits compared maize pure stand. These results in yield attributes are expected as a result of trend some growth characters, i.e. ear height, No. of leaves plant^{-1} and leaf area index (LAI). Similar results were obtained by El-Douby (1992) and Sahar Sherif *et al*. (2006).

Maize grain yield fad^{-1} behaved the same trend of yield attributes in both seasons as shown in Table 2. Maize grain yield fad^{-1} of pure stand was superior to other intercropping patterns either in ridges or in beds. The decrease in maize grain yield were 32.80%, 21.22% for intercropping patterns 100% maize + 50% soybean in ridges (P1) and 100%+50%in bed (P2) in the first season, respectively; and 16.76% and 11.62% in the second season compared with maize grain yield in pure stand. Similar results were obtained with El-Douby *et al*. (1996) and Fathy *et al*. (2008).

C- Interaction effect:

Results presented in Table 3 revealed that plant height in the second season, No. of kernels, ear weight $^{-1}$, 100-kernel weight in the first season and maize grain yield fad^{-1} in both seasons were significantly affected by interaction between plowing depth and intercropping patterns.

Plant height recorded the highest value was maize soil tillage depth at 15 cm and planting 100% maize+50% soybean in ridges (D1X P1). On the other hand, the lowest value was showed with tillage at 25 cm depth and maize planting alone (D3X P3). With respect to No. of kernels/row, ear weight $^{-1}$, 100-kernel weight and maize grain yield fad^{-1} the highest values of aforementioned traits were recorded where soil tillage depth at 20 cm with maize alone (D2 X P3). Whereas, these characteristics indicated the lowest values when soil tillage at 25 cm depth with intercropping pattern (100% maize + 50% soybean) in ridges (D3X P1).

Second: Soybean

A- Soil tillage depth effect

Results in Table 4 show that soybean some growth, yield and yield components characteristics were significantly affected by ploughing depth in both seasons. Results indicated that ploughing at 20 cm (D2) depth gave the highest values followed by 25 cm (D3) and simultaneously ploughing 15 cm (D1) showed the lowest values. Their result is completely true for each of plant height, No. of

branches and pods plant^{-1}, 100-seed weight, seed and biological yield fad^{-1}. in both seasons. On the other hand, results indicated the soybean seed yield fad^{-1} decreased by 39.65, 32.65 and 38.01% when tillage depths at 15, 20 and 25 cm, respectively in the first season compared with soybean pure stand and were 45.49, 33.12 and 34.42 in the second seasons. It is evident that higher yield of soybean was obtained when soybean plants were grown under ploughing, depth at 20 cm (D2). Results revealed that biological yield fad^{-1} was related to seed yield and behaved the same trend of soybean seed yield in both seasons. These results are agreeing with those obtained by El-Sayed (1983), Sahar Sherif *et al*. (2006) and Hussein *et al*. (2007).

Table 3. Influence of the interaction between soil tillage depth and intercropping patterns of Maize in both seasons.

Soil depth Tillage	Plant height (cm) 2014			No. of kernels row^{-1} 2013			Intercropping patterns Kernel weight ear^{-1} (g) 2013			100 kernel weight (g) 2013			Maize grain ardab fad^{-1} 2013			2014		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
15 cm(D1)	259.3	247.0	234.7	38.2	37.2	40.7	215.7	219.0	226.5	33.3	34.7	35.4	14.1	17.5	22.2	17.3	17.9	18.4
20 cm(D2)	248.0	241.0	233.3	39.0	41.2	42.1	221.9	227.2	232.1	35.6	36.3	37.9	17.5	18.3	24.4	17.9	19.3	22.6
25 cm(D3)	228.0	224.7	220.0	35.4	36.4	40.1	198.1	211.2	213.1	29.2	30.4	32.8	14.1	17.4	21.3	14.8	15.9	19.2
LSD_{0-05}		8.60			1.80			5.59			1.25			1.73			0.73	

Whereas: Soil tillage depth 15, 20 and 25 cm (D1, D2 and D3)

Pattern (P1) refers to 100% maize + 50% soybean in ridges (0.70 m in width) and soybean were intercropped with maize at the other side of the ridge, Pattern (P2) refers to 100% maize +50 % soybean in beds (1.40 m in width) and maize was intercropped at the both sides of the bed, Pattern (P3) refers to pure stands of maize.

Table 4. Plant height, no. of branches and pods plant^{-1}, 100-grain weight, biological and seed yields fad^{-1} of soybean as affected by soil tillage depth and intercropping pattern in both seasons.

Main effects and interaction	Plant height (cm)		No. of branches plant^{-1}		No. of pods plant^{-1}		100-seed weight(g)		Seed yield (Kg fad^{-1})		Biological yield (Ton fad^{-1})	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Soil tillage depth(cm)												
15 cm(D1)	115.53	115.46	2.36	2.16	51.63	43.71	18.79	18.72	738.5	7751	4.74	5.42
20 cm(D2)	122.83	120.47	2.95	3.22	64.64	58.18	20.95	21.64	880.44	925.88	5.98	6.26
25 cm(D3)	119.24	118.30	2.68	2.90	61.01	45.94	19.86	20.25	810.00	907.89	5.57	5.80
F test	*	*	*	*	*	*	*	*	*	*	*	*
LSD_{0-05}	4.24	2.58	0.28	0.31	8.32	2.05	0.44	0.54	14.25	11.11	0.50	0.31
Intercropping pattern												
Pattern1	119.27	118.02	2.22	2.58	48.26	42.44	19.13	19.17	373.3	417.3	3.72	3.97
Pattern2	122.78	121.39	2.65	2.66	56.20	46.33	19.28	20.05	648.33	707.33	4.53	5.18
Pattern3	115.56	114.82	3.11	3.04	72.83	59.07	21.20	21.38	1306.78	1384.43	7.94	8.33
F test	*	*	*	*	*	*	*	*	*	*	*	*
LSD_{0-05}	2.58	1.70	0.21	0.37	6.07	2.50	0.44	0.43	22.85	15.10	0.34	0.31
Interaction (D×P)	N.S	*	N.S	N.S	N.S	N.S	*	*	*	*	N.S	N.S

Whereas: Soil tillage depth 15, 20 and 25 cm (D1, D2 and D3)

Pattern(P1)refers to 100% maize+50% soybean in ridges (0.70m in width)and soybean were intercropped with maize at the other side of the ridge, Pattern (P2) refers to 100% maize +50 % soybean in beds (1.40 m in width) and maize was intercropped at the both sides of the bed, Pattern (P3) refers to pure stands of soybean.

B- Intercropping patterns effect:

Results in Table 4 indicate significant effects on all aforementioned traits of soybean in both seasons. Results showed that growing soybean in beds with maize gave the highest values for plant height followed by intercropping patterns 100% maize + 50% soybean in ridges and the shortest plant height was showed with soybean pure stand. Soybean plants under intercropping patterns were higher than pure stands of soybean. These results may be due to sever inter specific competition between maize and soybean plants for light and nutrients. Similar results were obtained by El-Douby and Allam (2001), Fathy *et al*. (2008) and Lamloum and Ewis (2015).

Results present in Table 4 showed that pure stands of soybean recorded the highest values and intercropping soybean with maize as (100% maize+ 50 soybean %) on beds(P2) ranked the 2nd whereas on ridges gave the lowest value. These results were true in traits of No. of branches and pods plant^{-1}, 100-seed weight seed and biological yield fad^{-1} in both seasons. Results revealed that seed yield fad^{-1} where found achieved intercropping patterns 100% maize + 50% soybean in ridges (P1) and beds(P2) 40.09 and 49.61% of its pure stand, respectively in the first seasons; and 40.96 and 51.09% in the second seasons. Biological yield fad^{-1} behaved the same trend of seed yield in both seasons. Biological yield was 46.85 and 57.05% in the first seasons; and 47.65 and 62.18% in the second season. Similar results were obtained by Sahar Sherif *et al*. (2006), Fathy *et al*. (2008) and Lamloum and Ewis (2015).

C- Interaction effect:

Table 5 show that plant height in the first season, 100-seed weight and seed yield fad^{-1} in both seasons were significantly affected by the interaction between different tillage depth and intercropping patterns(D x P).

Plant height of soybean recorded the highest value under tillage depth at 20 cm with intercropping pattern (100% maize + 50% soybean) in beds (D2xp2) and opposite, the lowest value for this character was obtained under tillage depth at 15 cm with soybean solid.

Table 5. Influenced by the interaction between soil tillage depth and intercropping pattern of soybean in both seasons.

Soil tillage depth	Intercropping pattern: Plant height cm) 2014			100-seed weight (g) 2013			2014			Seed yield (kg fad^{-1}) 2013			2014		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
15 cm(D1)	116.0	120.6	109.8	18.8	18.6	19.1	18.2	18.3	19.6	343.2	618.3	1254.0	358.3	642.0	1325.0
20 cm(D2)	120.6	122.2	118.6	19.6	20.3	22.8	20.9	21.3	22.6	405.3	726.6	1359.6	433.0	766.6	1428.0
25 cm(D3)	117.5	121.4	116.0	19.2	18.9	21.5	18.40	20.4	21.9	373.3	600.0	1306.6	460.0	713.3	1400.3
LSD_{0-05}		3.50			0.77			0.93			39.57			26.16	

Whereas: Soil tillage depth 15, 20 and 25 cm (D1, D2 and D3)
Pattern (P1) refers to 100% maize + 50% soybean in ridges (0.70 m in width) and soybean were intercropped with maize at the other side of the ridge, Pattern (P2) refers to 100% maize +50 % soybean in beds (1.40 m in width) and maize was intercropped at the both sides of the bed, Pattern (P3) refers to pure stands of soybean.

Planting of soybean in pure stand under tillage at 20 cm (D2xP3) gave the highest value and opposite intercropping soybean by 50% + 100% maize in ridges under tillage 15 cm depth (D1xP1) gave the lowest value. This is completely true of both 100-seed wt. and seed yield fad^{-1}. in both seasons. This result may be due to growing soybean as a pure stand was planted by 100% while under intercropping patterns was planted by 50% of its pure stand, on the other hand, decreasing the percentage of less than 50% in seeding rates increased the main distance between adjacent plants in row for a given number of seeds per unit area and then the crop yield was increased, Similar results were obtained (Abo-Habaga, 1992).

Third: Competitive relationship:

Land equivalent ratio (LER):

Results presented in Table 6 show the effect of intercropping patterns on land equivalent ratio (LER). Land equivalent ratio is a measure of the efficiency of the intercrop. The advantage is measured by the decimal above the unit. In Table 6, however both intercrops showed yield advantages. The least one is that involved intercropping on ridges (1.05 in combined analysis). The best intercropping pattern which involved intercropping on the beds (1.35 in combined analysis).

Table 6. Land equivalent ration (LER), land equivalent coefficient (LEC), relative crowding coefficient (RCC), as affected by between soil tillage depth and intercropping pattern in both seasons (2013 and 2014) and their combined.

Intercropping pattern	Mean effect intercropping patterns: Grain yield of maize (Kg fad^{-1})	Seed yield of soybean (Kg fad^{1})	Lm	Ls	LER	LEC	RCC Km	RCC Ks	RCC K
			Season 2013						
Pure stands of maize (P3)	3108	-----	1.0	-----	1.0	1.0	-----	-----	-----
Pure stands of soybean (P3)	-----	1206.73	-----	1.0	1.0	1.0	-----	-----	-----
(100%maize +50%soybean on ridges(P1)	2128	523.89	0.69	0.29	0.98	0.42	1.07	0.82	0.88
(100%maize +50%soybean on beds) (P2)	2494.8	373.93	0.80	0.50	1.30	0.40	2.00	2.00	4.00
			Season 2014						
Pure stands of maize (P3)	2805.6	-----	1.0	-----	1.0	1.0	-----	-----	-----
Pure stands of soybean (P3)	-----	1384.43	------	1.0	1.0	1.0	-----	-----	-----
(100%maize +50%soybean on ridges) (P1)	2335.2	417.1	0.83	0.30	1.13	0.36	2.45	0.88	2.16
(100%maize +50%soybean on beds) (P2)	2479.4	707.33	0.88	0.51	1.39	0.45	3.74	2.12	7.94
			Combined (mean seasons)						
Pure stands of maize (P3)	2956.80	-----	1.0	-----	1.0	1.0	-----	-----	-----
Pure stands of soybean (P3)	-----	1345.58	-----	1.0	1.0	1.0	-----	-----	-----
(100%maize +50%soybean on ridges) (P1)	2231.60	395.2	0.76	0.49	1.05	0.38	1.76	0.84	1.49
(100%maize +50%soybean on beds) (P2)	2487.10	677.83	0.84	0.51	1.35	0.43	2.87	2.06	5.97

Whereas: price ardab fad^{-1} of maize (L.E317) and yield ton fad^{-1} of soybean (L.E 4480)

Interaction effect

Results in Table (6-a) show that when both species were intercropped increased land usage in all combination intercropping patterns in both seasons combined analysis. Intercropping patterns on ridges and beds under tillage depth 15 cm recorded the highest values for land usage in the combined analysis and increased LER by 18 and 37%, respectively. While, intercropping pattern on ridges and beds under tillage depth 25 cm gave the lowest values in the pooled data and reached about 13 and 31 %, respectively. Similar results were obtained El-Douby *et al*. (1996), Sahar Sherif *et al*. (2006) and Fathy *et al*. (2008).

Land equivalent coefficient (LEC)

Results presented in Table 6 Show the effect of intercropping patterns on land equivalent coefficient (LEC). Land equivalent coefficient is a measure of the efficiency of the intercrop. The advantage is measured by the ratio above the 0.25. In Table 6, however both intercrops showed advantages except some intercropping in ridges and combined analysis. The least one is that involved intercropping on ridges (0.36 in combined analysis). The best intercropping pattern which involved intercropping on the beds (0.43 in combined analysis).

Interaction effect:

Results presented in Table (6-a) indicated that LEC some achieved yield advantage in combined analysis, where tillage depth at 20 cm when soybean was planted in ridges (0.31) or in beds (0.43) with maize in the combined which increase than 25%. The highest yield advantage was achieved from tillage at 15 or 20 cm depth when soybean was grown in beds (0.43) Whereas, the highest values were (0.31 and 0.43) in ridges or beds, respectively and the lowest values (0.22) was obtained with tillage at 15 in the combined analysis with intercropping pattern on ridges.

Relative crowding coefficient (RCC):

In all the treatments, soybean appeared to be highly dominant as it had higher values of K than the intercrops in different intercropping systems (Table 6). It can be inferred that the intercropped soybean utilized the resources more competitively than maize which appeared to be dominated. As products (K) of coefficients of the component crops were greater than one, there were yield advantage in both the intercropping systems. Results revealed that RCC or K values were more than one in all intercropping patterns in both seasons. Table 6 The least is that soybean and maize involved intercropping on ridges (1.49 in combined analysis). The best intercropping pattern which involved intercropping on the beds (5.97 in combined analysis).

Table 6-a. Land equivalent ration (LER), land equivalent coefficient (LEC), relative crowding coefficient (RCC), as affected by the interaction effect between soil tillage depth and intercropping patterns in both seasons.

soil tillage depth	Intercropping patterns																	
	LER						LEC						RCC					
	Pattern(P1)			Pattern(P2)			Pattern(P1)			Pattern(P2)			Pattern(P1)			Pattern(P2)		
	2013	2014	comb	2013	2014	Comb	2013	2014	comb	2013	2014	comb	2013	2014	comb	2013	2014	comb
15 cm(D1)	0.91	1.21	1.06	1.28	1.45	1.37	0.19	0.25	0.22	0.39	0.47	0.43	0.66	4.83	3.00	3.60	32.79	18.20
20 cm(D2)	1.02	1.10	1.06	1.29	1.39	1.34	0.39	0.24	0.31	0.40	0.46	0.43	1.08	1.72	1.33	4.40	6.74	5.57
25 cm(D3)	0.94	1.09	1.02	1.28	1.34	1.31	0.30	0.25	0.28	0.38	0.42	0.40	0.78	1.64	1.29	3.82	5.15	4.49

Whereas: Soil tillage depth 15, 20 and 25 cm (D1, D2 and D3)

Pattern (P1) refers to 100% maize + 50% soybean in ridges (0.70 m in width) and soybean were intercropped with maize at the other side of the ridge, Pattern (P2) refers to 100% maize +50 % soybean in beds (1.40 m in width) and maize was intercropped at the both sides of the bed, Pattern (P3) refers to pure stands of maize and soybean.

Interaction effect:

Results in Table (6-a) revealed that RCC or K values this mean that all intercropping patterns were positive in combined analysis. Intercropping soybean with maize in ridge or beds and procedure tillage system at 15 cm depth recorded the greatest values for RCC which 18.20 in combined analysis, respectively. Whereas, the lowest values were showed with intercropping pattern in ridge or beds and ploughing depth 25 cm which were 1.29 and 4.49 in combined analysis, respectively. As well as the clear superiority intercropping pattern in beds on intercropping pattern in ridge. Similar results were obtained by El-Douby *et al*. (1996), Sahar Sherif *et al*. (2006) and Lamloum and Ewis (2015).

Fourth: Total income:

Results in Table (7a and 7b) revealed that all intercropping patterns were grown in different depths were positive for total income comparative to maize pure stand in combined analysis of both seasons.

Table 7a. Total income and monetary advantage index (MAI) of maize and soybean as affected by soil tillage depth and intercropping patterns in combined analysis of both seasons.

Main effects	Total income L.E. fad^{-1}			MAI L.E. fad^{-1}
	Income for maize	Income for soybean	income Total	
Soil tillage depth				
15 cm (D1)	5690.97	3390.46	9081.43	1324.11
20 cm (D2)	6341.06	3672.11	10013.17	1335.77
25 cm (D3)	5421.23	3623.94	9045.17	1037.08
Intercropping patterns				
Pattern (P1)	5052.97	1771.49	6824.79	307.06
Pattern (P2)	5620.29	2886.54	8506.83	2157.51
Pattern (P3) maize	6779.86	-	6779.86	-
Pattern (P3) soybean	-	6028.15	6028.15	-

Table 7b. Total income and monetary advantage index (MAI) of maize and soybean as affected by interaction between soil tillage depth and intercropping patterns in combined analysis of both seasons.

Soil tillage depth x Intercropping patterns		Total income L.E. fad^{-1}			MAI L.E. fad^{-1}
		Income for maize	Income for soybean	Total income	
15cm (D1)	P1	4976.90	1571.35	6548.25	370.66
	P2	5609.32	2823.07	8432.39	2277.36
	Pattern(P3) maize	6486.68	-	6486.68	-
	Pattern(P3) soybean	-	5776.96	5776.96	-
20cm (D2)	P1	5621.99	1877.54	7499.53	424.50
	P2	5961.19	2894.77	8855.96	2247.03
	Pattern(P3) maize	7439.99	-	7439.99	-
	Pattern(P3) soybean	-	6244.03	6244.03	-
25cm (D3)	P1	4560.04	1866.59	6426.63	126.01
	P2	5290.73	2941.79	8232.52	1948.15
	Pattern(P3) maize	6412.91	-	6412.91	-
	Pattern(P3) soybean	-	6063.45	6063.45	-

Whereas: Soil tillage depth 15, 20 and 25 cm (D1, D2 and D3)

Pattern (P1) refers to 100% maize + 50% soybean in ridges (0.70 m in width) and soybean were intercropped with maize at the other side of the ridge, Pattern (P2) refers to 100% maize +50 % soybean in beds (1.40 m in width) and maize was intercropped at the both sides of the bed, Pattern (P3) refers to pure stands of maize and soybean.

The highest total income was achieved with plowing depth at 20 cm in beds (8855.96 L.E. fad^{-1}) and the lowest value was showed with plough at 25 cm in ridge (6426.63 L.E. fad^{-1}). The highest value of intercropping soybean with maize in beds for income and MAI were 8855.96 and 2247.3LE, respectively over than in ridges. Growing maize and soybean with plowing depth at 20 cm increased total income by 10.26 and 10.70%, while MAI increased by 0.88 and 28.80% compared with plowing depth 15 and 25 respectively. Similar results were obtained with Lamloum and Ewis (2015). It could be concluded that tillage at 20 cm depth and intercropping pattern (100% maize + 50% soybean) planted in beds to obtain the best land usage and total income.

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تأثير عمق الحرث وأنماط التحميل على الزراعة المنفردة والمحملة للذرة الشامية وفول الصويا

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالجميزة ، محافظة الغربية خلال عامي ٢٠١٣و٢٠١٤ وذلك لدراسة تأثير استخدام ثلاثة أعماق للحرث (١٥,٢٠,٢٥ سم) مع ثلاثة أنماط تحميل مختلفة لفول الصويا والذرة الشامية وهى نمط تحميل ١٠٠% ذرة شامية مع ٥٠ % فول صويا على خطوط ونمط تحميل ١٠٠% ذرة شامية مع ٥٠% فول صويا على مصاطب, الزراعة المنفردة لكل من الذرة الشامية وفول الصويا حسب الموصى به وتم استخدام تصميم الشرائح المنشقة مرة واحدة فى ثلاث مكررات حيث كانت أعماق الحرث فى الشرائح الرئيسية وأنماط التحميل في الشرائح الشقية. ويمكن تلخيص اهم النتائج على النحو التالي : أولا:- الذرة الشامية: تأثرت جميع صفات الذرة الشامية معنويا بأعماق الحرث (١٥,٢٠,٢٥ سم) فيما عدا صفة طول النبات في الموسم الأول وكانت اعلي القيم لمحصول الحبوب مع عمق الحرث ٢٠سم في كلا الموسمين.حققت الزراعة المنفردة لنباتات الذرة أعلى القيم ثم نمط تحميل ١٠٠% ذرة شامية مع ٥٠% فول صويا على مصاطب بينما أعطى نمط تحميل ١٠٠% ذرة شامية مع ٥٠% فول صويا على خطوط اقل القيم فى كلا الموسمين .وجد تفاعل معنوي بين أعماق الحرث وأنماط التحميل لمحصول الحبوب فدان$^{-1}$ لنباتات الذرة في كلا الموسمين، بينما صفة عدد حبوب سطر$^{-1}$ ، ووزن حبوب كوز$^{-1}$, ووزن١٠٠حبة كان معنويا في الموسم الأول وطول النبات في الموسم الثاني . ثانيا :- فول الصويا: تأثرت جميع صفات فول الصويا معنويا بعمق الحرث في كلا الموسمين , وقد سجل عمق الحرث ٢٠سم اعلى القيم يليه عمق الحرث ٢٥سم بينما أعطى عمق الحرث ١٥سم اقل القيم في كلا الموسمين .١- حققت الزراعة المنفردة في نباتات فول الصويا أعلى القيم للمحصول ومكوناته في كلا الموسمين يتبعها نمط تحميل ١٠٠% ذرة شامية مع ٥٠% فول صويا على مصاطب في كلا الموسمين.٣- وجد تفاعل معنوي بين أعماق الحرث وأنماط التحميل لوزن ١٠٠بذرة و محصول البذور/ فدان لنباتات فول الصويا في كلا الموسمين، وطول النبات في الموسم الثاني .ثالثا:- العلاقات التنافسية:وجد أن نمط تحميل ١٠٠% ذرة شامية مع ٥٠% فول صويا على مصاطب وبعمق الحرث للتربة ٢٠ سم قد سجل أعلى القيم بالتحليل المشترك في معدل المكافئ الارضى (LER)١.٣٤ ومعامل المكافئ الارضى (LEC)٠.٤٣ والإيرادات الإجمالية ٨٨٥٥.٩٦جنيها والعائد الاقتصادي (MAI)٢٢٤٧.٠٣ جنيها مقارنة مع أنماط التحميل الأخرى. التوصية : أن أفضل معدل استغلال للأرض والعائد الاقتصادي كان باستخدام نمط تحميل ١٠٠% ذرة شامية مع ٥٠% فول صويا على مصاطب وبعمق حرث للتربة ٢٠ سم وذلك تحت ظروف التجربة.