Scientific Journal of Agricultural Sciences 2 (2): 90-103, 2020
Print (ISSN 2535-1796) / Online (ISSN 2535-180X) DOI: 10.21608/sjas.2020.42913.1038

Effect of Intercropping of Some Oil Summer Crops with Maize under Levels of Mineral N and Nano N Fertilizers

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Received on: 14/9/2020 **Accepted on: 31/10/2020**

ABSTRACT

In Egypt, we have a big gap between our production and consumption of edible oil accounted by more than 95%. In recent few years many attempts and efforts were pushed to increase our production, one of these attempts is intercropping of oil summer crops with maize to increase the production in addition to provide the soil with natural nitrogen. Therefore, two field experiments were carried out at Mallawi Agricultural Research Station, Minia, ARC, during 2018 and 2019 seasons, to study the effect of intercropping three oil crops on productivity, quality and profitability of maize and using different rates of N nano + mineral fertilizer A complete Randomized Block Design in a split plot arrangement. Main plots were devoted for the following soybean, groundnut and sesame 50% of the recommended. The following rates of fertilizer, 100 % N mineral fertilizer, 100% N nano fertilizer,75%nano+25% mineral fertilizer, 50% nano + 50% mineral fertilizer and 25 % nano+ 75% mineral fertilizer added for maize and three oil crops from recommended does were allocated in the sub- plots. The intercropping groundnut with maize gave the highest values of grain yield (23.25 & 21.61) ardab/fad in the both seasons respectively. The intercropping groundnut with maize and using 75% N nano fertilizer +25% N mineral fertilizers recorded the highest values for land Equivalent Ratio (LER). The pattern of maize- 50% groundnut intercrop fertilized with 75% nano fertilizer N +25% mineral fertilizer N of the recommended for maize were more profitable for farmer.

KEYWORDS: Nano fertilizer, intercropping, sesame, groundnut**,** LER, oil crops.

1. INTRODUCTION

Oilseed crops are not only oil producing crops but also income generation crops. Groundnut (*Arachis hypogeae L.*) ranks with each of soybean, rapeseed and sunflower as four of the most important annual crops in the world grown for edible oil. They are the promising oil seed crops which can play an important role in increasing edible oil production in Egypt. The use of corn oil is also gaining momentum where large volumes of maize are used in ethanol production. Companies are developing and improvements of crude corn oil to facilitate conversion into biodiesel (FAO, 2016). Sesame oil is of good quality, and according to, the oil is used for cooking, baking, candy making, soaps and alternative medicine (in the control of blood pressure, stress and tension). (Kafiriti and Deckers 2001; Alam *et al.*, 2007).

Maize (*Zea mays L.*) is the third largest cereal crop in the country. Maize is used primarily for food for humans and feed for livestock. It is important in the development of starch, oil and alcohol in the industry (Kling and Edmeades, 1997).

Intercropping decreased the number of pods and component groundnut grain yields. With increased planting density, the number of pods and grain yields grew. Productivity indices indicated that intercropping of groundnut / maize was efficient; Intercropping reduced the number of pods and grain yields of the groundnut portion. The number of pods and grain yields increased with an increased density of planting. Productivity indices indicated that groundnut / maize intercropping was productive and that maize was the dominant portion. The marginal rate of return for the best combinations was 116.13 per cent, indicating the viability of intercropping systems (Godwin and Egbe 2014; Metwally *et al.*, 2005 a,b and Sheriff *et al.*, 2005).

Maize-sesame intercropping is considered to be effective due to the risk of loss of sesame output associated with pure sesame development. Growing intercrop also places less pressure on labor and fertile land, both of which are restricted in supply. In addition, maize and sesame are considered healthy companion crops, which additionally contribute to the restoration of soil fertility and weed suppression (Mkamilo, 2004).

Systems that intercrop maize with legumes are capable of decreasing the amount of nutrients taken from the soil relative to maize monocrops. Once nitrogen fertilizer is applied to the field, intercropped legumes use inorganic nitrogen instead of nitrogen from the air and thus compete with maize for nitrogen. However, when nitrogen fertilizer is not used, intercropped legumes can release much of their nitrogen from the atmosphere and will not compete with maize for nitrogen supplies (Adu-Gyamfi *et al.*, 2007).

Nano fertilizers are valuable tools in agriculture to increase crop growth, yield and quality parameters by increasing the efficiency of nutrient usage, reducing fertilizer waste and the cost of cultivation. Nano-fertilizers increase crop growth before optimum concentrations increase more concentration can inhibit crop growth due to the toxicity of the nutrient. Nano-fertilizers provide more surface area for different metabolic reactions in the plant, which increase the photosynthesis and prophylaxis process (Rameshaiah *et al.*, 2015 and Meena *et al.*, 2017). Nitrogen (N) has been better used in nano-fertilizer treatments than in traditional fertilizer treatments, suggesting that there is a nano-fertilizer variety in crop agriculture. However, using this at the farmer's level would require a pilot scale fertilizer synthesis. Study showed a higher accumulation of N in plants grown with nano fertilizers. Post-effect Nano Fertilizer application in soil showed better pH, moisture, CEC and usable nitrogen under nano-fertilizer treatment than (Anjuman *et al.*,2016). Nano-fertilizers are known to release nutrients slowly and steadily for more than 30 days which may assist in improving the nutrient use efficiency without any associated ill-effects. Since the nano-fertilizers are designed to deliver slowly over a long period of time, the loss of nutrients is substantially reduced vis-a-vis environmental safety. The work done on nano-fertilizers is very limited across the globe, but the reported literature clearly demonstrated that these customized fertilizers have a potential role to play in sustaining farm productivity (Sekhon, 2014 and Siddiqui *et al.*, 2015). Development, yield, quality and nutrient uptake of maize were consistently higher for nanozeourea (nanozeolite-coated urea) treatment than traditional urea (Manikandan and Subramanian, 2016). Hasaneen *et al.*, (2016) demonstrated that nanomaterials are leading to significant improvement in plant through enhancing the growth and hence dry weight, leaf area and growth rate.Nano fertilizer has a positive significant effect on soil mineral nitrogen, due to available by plant. Post-effect nano-fertilizer application in soil showed better pH, moisture, EC and usable nitrogen under nano-fertilizer treatment than traditional fertilizers. Nano fertilizer, the most important field of agriculture, has attracted the attention of soil scientists as well as environmentalists due to its ability to increase yield, enhance soil fertility, minimise contamination and create a favorable environment for microorganisms (Ahmed *et al.*, 2012).

The highest values of these study characters were obtained with 75% nano fertilization NPK + 25% mineral fertilization NPK fed^{-1}. There was consistent and remarkable increase in ear characters by increasing nano fertilizer. Maize grain yield behaved in parallel trended as yield components (Nagwa *et al.*, 2019). Maize with soybean had significant advantage in yield, economy, land utilization ratio and reducing soil nitrate nitrogen(N) accumulation (Yitao *et al.*, 2015). Land equivalent ratio without significant reduction in maize yield /fad. LER ranged from 1.81 to 1.56(Sherif 2010)75% of recommended dose of mineral N along with 25% nano urea, increased productivity of maize by 17.03 and 14.11% compared with mineral fertilization (Ijoyah *et al.*, 2014; Yasser *et al.*, 2020). The productivity of maize-cropping systems can be improved by intercropping soybean between maize plants as confirmed by high LER. MAI was positive for all intercrops in both locations and years, which shows definite yield and economic advantages compared to the sole cropping systems tested. (Alpha *et al.*,2017).

The objective of this research was to study the response of summer oil crops i.e., soybean, groundnut and sesame to intercrop with maize and applied fertilizer N nano fertilizer particles does for achieving success under intercropping conditions on the yield and its components under Middle Egypt conditions.

2. MATEREALS AND METHODES

A field experiments were conducted at Mallawi Agricultural Research Station, Minia Governorate, ARC, during two summer seasons of 2018 and 2019. Maize cv. Giza 168 (yellow corn), soybean (Giza111), groundnut (Giza 6) and sesame (Shindauel 3) were used in this study. These experiments were laid out in split – plot arrangement using Randomized Complete Blocks Design with three replicates. The sub – plot area was 28m^2 consisting of 5 beds, each of bed was 140 cm in width and, 4m in length.

The main plots were devoted to the three intercropping oil summer crops, soybean, groundnut and sesame with maize.

A1- 100% maize +50% soybean from recommended.

A2- 100% maize +50% groundnut from recommended.

A3- 100% maize +50% sesame from recommended.

The sub-plots were occupied by the levels of mineral and nano particles of N fertilization.

F1- 100% mineral fertilizer N of maize from recommended.

F2- 100%Nano particles N fertilizer of maize from recommended.

F3- 75% Nano particles N + 25% mineral N fertilizer of maize from recommended.

F4-50% Nano particles N + 50% mineral N fertilizer of maize from recommended.

F5- 25%Nano particles N + 75% mineral N fertilizer of maize from recommended.

Amount of N nano fertilizer utilization equal 1/3 amount recommended dose nitrogen for maize and three oil crops.

Solid plots of maize and three oil summer crops, soybean, groundnut and sesame were also included in each replication for comparison and determination of the competitive relationships and to calculate the yield advantage of crops, total income and net return fad. Maize was planted on two sides of beds with one plant/ hill at 25cm apart in all intercropping patterns (24.000plant/fad). The three oil crops were planted in the center of the bed and were sown two rows for oil crops, two plant/hill at 20cm between hills (70.000 plant/fad) for soybean, one plant / hill at 20 cm between hills for sesame (35.000 plant/fad) and one plant /hill at 20 cm between hills (35.000 plant /fad) for groundnut. Oil crops were seeded before maize on May 15th and 18 th in 2018 and 2019seasones, respectively. Maize plants were planted one side of ridges as pure stand and oil crops pure were planted as recommended. Plants maize was seeded onJune6th and 9th in 2018 and 2019 seasons, respectively. The preceding crop was onion in both seasons. Normal cultural practices were applied for crops under study either in pure stand or in intercropping as recommend for the region. Nano fertilizers were prepared in laboratory by ball-milling (Photon Company, Egypt). The size and morphology of nano particles were studied using transmission electron microscope (JEM-1400 TEM, Japan). The average size 5.42 nm nano-particle with a range from 4.42 to 8.42 nm. The obtained investigated N fertilizes data showninFig.1.

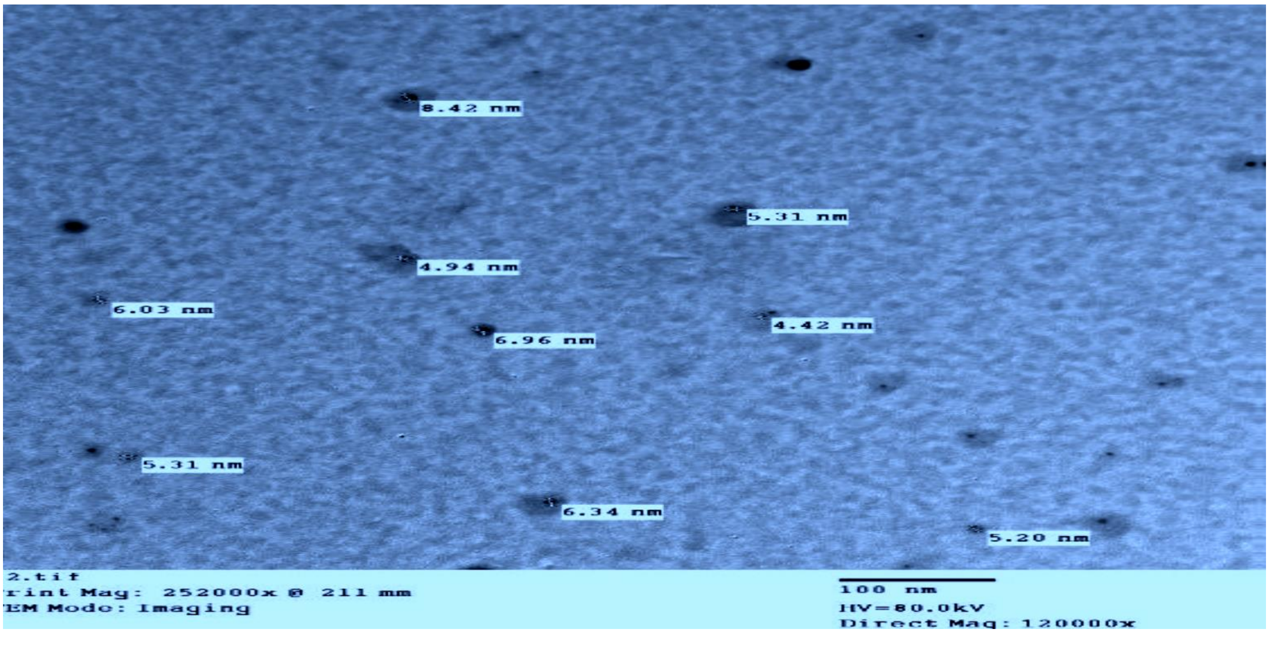

Fig. 1. Transmission electron microscopy (TEM) micrograph of synthesized N nano

Nano fertilizers as spraying on soil application at two times i.e., after 30 and 45 days from sowing. However, nitrogen fertilizer was applied as ammonium nitrate (33.5%N) at a rate 100 kg N fad in three equal doses jest before the first, second and irrigation of maize. Calcium super phosphate (15%P_2o_5) at a rate of 150 kg fed^{-1}.was added during preparation the land for sowing. Potassium fertilizer was applied before sowing (during seeded preparation) at rate of 50 kg/fed., in the form of potassium sulphate (48%K_2o). All other agricultural practices for maize and oil crops production was carried out as recommended by the Ministry of Agriculture.

2.2. The studied traits:

2.2.1. maize: At harvest time 110 days after sowing, the following traits were measured on ten guarded plants, plant height (cm), stem diameter (cm) ear height (cm), ear length and diameter (cm), number of grain and ear weight (g), grain yield / plant(g), 100 weight grain(g), number of ears / plant and grain yield ardab/fad (ardab=140kg).

2.2.2. Soybean: At harvest time 120 days after sowing, the following traits were measured on ten guarded plants i.e. plant height (cm) number of fruiting branches/plant number of pods, seed index, seed yield (kg/fad) and Straw yield (ton /fad).

2.2.3. Groundnut: At harvest time 140 days after sowing, the following traits were measured on ten guarded plants, plant height (cm) number of fruiting branches, number of pods, seed index, pods yield ardab/fad (ardab= 75 kg) and green yield ton /fad.

2.2.4. Sesame: At harvest time 100 days after sowing, the following traits were measured on ten guarded plants, plant height (cm) and length of fruiting zone (cm), no. of capsule/plant, seed index and seed yield ardab /fad (ardab=120 kg).

2.3. Competitive relationships and yield advantages:

2.3.1. Land Equivalent Ratio (LER) was calculated according to (Willey 1979*)* using the following formula: LER = yab/ yaa + yba / ybb

Where: Yaa = pure stand yield of species a (maize). Ybb= pure stand yield of species (b). Yab = mixture yield of a (when combined with b)

Yba = mixture yield of b (when combined with a).

2.3.2. Land Equivalent Coefficient (LEC) is a measure of interaction concerned with the strength of relationship **(Adetiloye *et al.*, 1983)**. It is calculated as follows: LEC = La x Lb

Where La = LER of crop a (maize), Lb = LER of crop b (intercropping crops).

2.3.3. Competitive ratio (CR) was calculated by the following formula as given by Willey and Rao (1980). CR = CRa + CRb

CRa = LERa / LERb X Zba/ Zab

Where: LERa and LERb represent relative yield of a, b intercrops respectively. Since the CR values of the two crops will in fact be reciprocals of each other. CRa, CRb are the competitive ratio for (a) and (b) intercropping.

2.3.4. Aggressivity (Agg): This was proposed by Mc-Gilichrist (1965) and was determined according to the following formula:

Aab = Yab / yaax zab - Yba/ ybb x zba. An aggressivity value of zero indicates that the component crops are equally competitive. For any other situations both crop will have the same numerical value but, the high of the dominant crop is positive and the dominated is negative. The greater numerical value of (Agg), gave greater difference in competitive abilities and hence the larger difference between actual and expected yield. Where Zab representing the sown proportion of intercrop a (soybean, groundnut and sesame) in combination with (maize) and zba the sown proportion of intercrop a (maize) in combination with b (soybean, groundnut and sesame).

2.3.5. Monetary advantage index (MAI): Suggests that the economic assessment should assess on the basis of the rentable value of this land. MAI was calculated according to the formula suggested by Willey (1979).

MAI= Value of combined intercrops x LER-1/LER

2.3.6. Farmer's benefit: It was calculated by determining the total costs and net return of intercropping culture as compared to recommended solid planting of maize as follows: Total return of intercropping cultures = Price of maize yield + price of intercropping pattern yield. To calculate the total return, the average of soybean, groundnut and sesame prices presented by Agriculture Statistics (2017 and 2018) seasons was used.

Net return per fed. = Total return – (fixed costs of maize + variable soybean, groundnut and sesame according to intercropping pattern). L.E 480 for ardab of maize; L.E 7000 for ton of soybean, L.E 1200 for ardab groundnut and L.E 3000 for ardab sesame.

2.4. Statistical analysis:

All data were statistically analyzed using analysis of variance (ANOVA) with the Statistical Analysis System MSTAT–C Statistical Packing (Freed 1991). Probabilities equal to or less than 0.05 were considered significant. If ANOVA indicated differences between treatment means LSD test was performed according to (Steel and Torrie 1980).

Table 1. Some physical and chemical properties of the soil of experiment site during 2018 and 2019 seasons.

Properties	Sand%	Silt%	Clay%	pH	EC	CaCo 3%	O. M %
1st season	9.81	38.83	51.36	8.01	1.73	1.80	1.60
2nd season	10.69	40.26	49.05	8.05	1.76	1.74	1.66
Soil texture	Salty clay loam						
Available nutrient							
	N %	P ppm	K mm				
1st season	0.19	20	350				
2nd season	0.20	22	370				

E.C = Electric conductivity (ds/m, 1:5 soil water extract). O.M= Organic matter.

RESULTS AND DISCUSSION

3.1. Maize:

3.1.1. Effect of intercropping oil crops on maize:

The tabulated results in Table (2) indicated that intercropping of soybean, groundnut and sesame with maize had a significant effect on plant height, grain weight /plant (g) and grain yield (ardab/fad) in the two summer seasons and ear height, ear length and ear diameter in the 2nd season. Intercropping groundnut with maize gave the highest values of all characters under study while intercropping sesame with maize gave the lowest values of all characters in the 1st and 2nd seasons. Intercropping groundnut with maize gave the highest values of grain yield (23.25&21.61 ardab/fad) in the 1st and 2nd seasons, respectively, which due to increase the yield components. Whereas sesame intercropping with maize gave the lowest values of grain yield (20.69 &17.40 ardab/fad) in the both seasons, respectively. Densities of groundnut had no effect, on yield of maize /fad as compared with sesame. maize-legume intercropping, the maize is more competitive than the legume under high soil N conditions (This is mostly due to the ability of legumes to fix N2 and the apparent reduced competition for radiation between the intercrop components in poorly fertile fields leading to reduced shading of the legume by the intercropped maize crop, to the benefit of corn as a quadruple carbon crop. In addition, peanuts have less competition with corn because of the smaller group of vegetative growth than soybean or sesame. These results are accordance with those obtained by (Mohamed 2007; Sherif 2010; yu *et al.*, 2016 and Michael *et al.*, 2017). Soybean has good effect on soil fertility and physiological properties, therefore significant amount of residual nitrogen for maize plants and encourage maize growth characteristics (Toaima, 2006).

Table 2. Yield traits of intercropped maize with soybean, groundnut, and sesame as affected by N mineral fertilization and N nano fertilizer rate of maize 2018 and 2019 cropping seasons.

Intercropping Pattern. (A)	Plant height (cm)	Stem Dime. (cm)	Ear Height (cm)	Ear		No of grain ear^{-1}	Weight ear (g)	Grain weight /plant (g)	100 weight Grain (g)	No of ears /plant	Grain yield ardab/ fad
				Length (cm)	Dimater (cm)						
2018 season											
M+50% soybean	255.24	1.93	150.13	26.37	4.39	662.74	268.87	234.33	32.00	1.12	21.85
M+50% groundnut	261.07	1.98	153.20	28.27	4.45	699.47	282.92	250.26	34.48	1.18	23.25
M+50% sesame	250.53	1.86	148.00	25.40	4.31	566.08	277.10	225.43	30.20	1.13	20.69
L.S.D 5%	5.70	N.s	N.s	N.s	N.s	N.s	N.s	44.62	N.s	N.s	1.21
Solid maize	24.48 ardab/fad										
2019 season											
M+50% soybean	210.27	1.88	127.89	20.82	4.60	612.42	220.13	185.74	30.87	1.00	19.76
M+50% groundnut	216.55	1.91	131.63	21.42	4.70	632.33	223.24	208.57	31.40	1.146	21.61
M+50% sesame	204.49	1.78	127.65	20.29	4.60	581.26	218.23	177.24	30.27	0.96	17.40
L.S.D 5%	6.39	N.s	5.36	1.81	0.19	N.s	N.s	30.56	N.s	N.s	1.87
Solid maize	22.14 ardab/fad										

3.1.2. Effect of N mineral and nano particles fertilizer rates on maize:

Data presented in Table 3 revealed the effect of spraying on soil application of nano and mineral fertilizer on maize and companion crops. Plant height, stem and ear diameter are an important vegetative growth parameter of maize plant that are directly influenced by nano fertilizer. The data over seasons (Table3) revealed number significant differences among the different applications of nano and mineral fertilizer for ear weight (g) and number of ears/plant in the 2 nd season. While, significant differences were found among the different applications for the all other characters. Plant height, stem diameter, ear length, ear diameter, ear weight yield, grain / plant and grain yield/fad recorded the highest values under the application of 75% nano fertilizer N+ 25% N mineral fertilization of maize. The lowest values for the studied characters were recorded when application of 100 % mineral fertilization N of maize. (Suppan 2017 and Meena *et al.*, 2017) reported that, nano fertilizer enhance the yield components such as plant height, stem diameter, ear diameter etc., though, increasing the meristematic activity and stimulation of cell elongation in plants.

Table 3. Yield traits of maize as affected by N mineral and N nano fertilization 2018 and 2019 cropping seasons.

Fertilzer. (B)		Plant height (cm)	Stem Dimet. (cm)	Ear Height (cm)	Ear Length (cm)	Ear Dimater (cm)	No of grain ear^{-1}	Weight Ear (g)	Grain weight /plant (g)	100 weight Grain (g)	No of ears /plant	Grain yield ardab/ fad
2018 season												
N nano +N mineral fertilizer	B1	253.0	1.82	144.89	23.94	4.32	520.80	263.0	187.65	29.00	1.16	16.19
	B2	255.18	1.87	146.33	25.17	4.37	583.28	273.50	233.56	31.00	1.13	21.34
	B3	263.89	2.06	157.44	29.33	4.49	818.08	305.97	267.5	36.06	1.15	26.33
	B4	254.56	1.93	152.89	28.00	4.37	663.04	289.56	253.33	33.30	1.12	24.17
	B5	251.44	1.90	150.67	26.94	4.35	628.61	281.61	241.33	32.11	1.15	21.63
L.S.D 5%		5.75	0.11	3.51	1.20	0.080	65.64	34.00	29.31	2.52	0.14	2.70
Solid maize		24.48 ardab/fad										
2019 season												
N nano +N mineral fertilizer	B1	204.44	1.54	124.10	19.18	4.36	526.70	188.48	157.67	27.78	0.89	13.73
	B2	210.92	1.82	125.89	20.44	4.53	572.75	204.79	171.14	29.56	0.90	19.59
	B3	215.56	2.03	134.78	22.72	4.88	678.33	256.31	228.72	34.11	1.40	25.24
	B4	212.33	1.97	131.48	21.47	4.82	647.04	235.16	206.14	32.00	1.00	20.62
	B5	208.92	1.94	129.05	20.40	4.60	618.53	217.94	188.89	30.78	0.90	18.77
L.S.D 5%		5.60	0.11	5.01	1.74	0.22	71.60	N.s	25.52	2.90	N.s	3.78
Solid maize		22.14 ardab/fad										

B1: 100% mineral fertilization N of maize
B2: 100% Nanotechnology fertilization N of maize
B3: 75% Nanotechnology fertilization N + 25% mineral fertilization N of maize
B4: 50% Nanotechnology fertilization N + 50% mineral fertilization N of maize
B5: 25% Nanotechnology fertilization N + 75% mineral fertilization N of maize

Maize grain yield behaved in parallel way with yield components in the two seasons (Table3). The application of 75% nano fertilizer N+ 25% N mineral fertilization of maize gave the highest values of grain yield (26.33 & 25.24 ardab/fad) in the 1 st and 2 nd seasons, respectively, via increasing yield component. Whereas the application of 100 % N mineral fertilization of maize gave the lowest values of grain yield (16.19 &13.73 ardab/fad) in the 1 st and 2 nd seasons, respectively. Nano-fertilizers provide more surface area for different metabolic reactions in the plant which increase rate of photosynthesis and produce more dry matter and yield of the crop. It is also preventing plant from different biotic and a biotic stress. Nitrogen (N) was better in nano fertilizer treatments than in the conventional fertilizer treatments indicating the fact that there is a scope of nano-fertilizer in crop agriculture. (Rameshaiah *et al.*, 2015; Meena *et al.,* 2017 and Yasser *et al.,* 2020).

3.1.3. Interaction effect:

All interactions between intercropping and N mineral and nano particles fertilizer did not show significant effect on all studied traits in the first and second seasons.

2.5. Soybean:

Result in (Table4) show that number of pods, seed index, seed yield kg/fad and straw yield ton/fad of soybean were significant, while plant height and number of fruiting branches/plant were not significantly affected by rate of N nano and mineral fertilizer in both seasons. The application of 50% nano fertilizer N+ 50% N mineral fertilization of soybean gave the highest values of seed yield (534.98 & 505.61 kg/fad) and straw yield (1.89 &1.59 ton/fad) in the two seasons, respectively, because increasing yield component. Whereas the application of 100 % N mineral fertilization of soybean gave the lowest values of seed yield (238.59&209.24kg/fad) and straw yield (1.37 &1.07 ton/fad) in the both seasons, respectively. The nano-fertilizers have higher surface and reactive area it is mainly due to very less or smallest size of particles which provide more sites to facilitate different metabolic process in the plant system result production of more photosynthesis and intern more growth and yield (Meena *et al.,* 2017 and Yasser *et al.,*2020).

Table 4. Yield traits of intercropped soybean with maize as affected by different rates of N mineral and N nano fertilizer in 2018 and 2019 cropping seasons.

Rate of fertilizer	Plant height (cm)		No of fruiting branches/plant		No .of pods/plant		Seed index (g)		Seed yield (kg/fad)		Straw yield (ton /fad)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
100% N mineral	97.68	97.22	3.133	2.52	67.46	64.67	17.00	16.06	238.59	209.24	1.37	1.07
100%N nano	98.57	110.67	3.20	3.00	73.33	65.07	17.67	16.93	324.85	295.48	1.47	1.17
75%Nnano+25% N mineral	105.17	112.67	3.21	3.53	73.60	66.92	18.00	17.30	435.83	406.46	1.57	1.20
50%% N nano+ 50%N mineral	115.53	125.54	3.40	3.97	92.60	94.27	19.33	18.63	534.98	505.61	1.89	1.59
25%Nnano+75% Nmineral	106.00	113.05	3.30	3.87	86.70	76.11	18.67	17.90	480.25	450.88	1.73	1.43
L.S.D 5 %	N.s	N.s	N.s	N,s	15.70	13.32	1.23	1.32	95.60	95.60	0.42	0.52
Solid soybean st season 1.282 ton/fad												
Solid soybean nd season 1.134 ton/fad												

2.6. Groundnut:

Data in Table (5) indicate that there was consistent and gradual increase in groundnut yield and its attributes with increasing the rate of nano nitrogen fertilization from 25% to 75%/fad. Differences were significant in both seasons for all traits in both seasons. Seed yield/fad behaved the same trend of yield components characters in both seasons, where application 50% N nano along with 50% mineral fertilization increased seed yield by 60.82, 60.70% in first and second seasons, respectively, compared to conventional fertilization. However, separately applied nano fertilization decreased seed yield/fad by 34.22, 34.15% in the 1 st and 2 nd seasons, respectively. The application of 50% nano fertilizer N+ 50% N mineral fertilization of groundnut gave the highest values of green yield (47.33&45.00 ton/fad) in the two seasons, respectively. Whereas the application of 100 % N mineral fertilization of groundnut gave the lowest values of green yield (32.67&32.00 ton/fad) in the both seasons, respectively. If fertilizers use as nano form, it increases the availability of elements, may prevent N fixation and increased absorption and uptake through different plant parts (Hussein *et al.*, 2015; Yessar *et al.*, 2020). Results are in according to those obtained by (Manikandan & Subramanian 2016 and Nagwa *et al.*, 2019).

Table 5. Yield traits of intercropped groundnut with maize as affected by different rates of N mineral and N nano fertilizer in 2018 and 2019 cropping seasons.

Rate of fertilizer	Plant height (cm)		No of fruiting branches/ plant		No of pods/plant		Seed index (g)		pods yield (ardab /fad)		Green yield (ton /fad)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
100% N mineral	74.67	65.47	15.00	17.77	21.07	20.56	81.67	80.67	4.39	3.74	32.67	32.00
100%N nano	76.78	76.33	18.35	16.25	23.40	22.13	82.67	81.67	5.26	4.48	38.33	37.67
75%Nnano+25% N mineral	80.53	78.5	20.33	17.17	22.92	23.67	86.33	86.00	5.86	4.99	41.00	40.33
50%% N nano+ 50%N mineral	84.45	81.23	23.00	20.20	28.67	30.23	94.00	90.67	7.06	6.01	47.33	45.00
25%Nnano+ 75%Nmineral	82.2	78.67	20.42	19.70	25.00	25.67	89.67	88.33	6.21	5.28	44.00	42.00
L.S.D 5 %	5.95	5.63	3.34	2.06	4.65	5.08	8.77	8.94	1.95	1.52	6.02	5.59
Solid groundnut st season 11.75 ardab/fad												
Solid groundnut nd season 10.89 ardab/fad												

2.7. Sesame:

Mean of plant height, length of fruiting zone, number of capsule/plant, seed index and seed yield ardab/fad were significantly affected by different fertilization treatments in the both seasons (Table 6). The results obviously indicated that 50% N nano + 50% N mineral treatment recorded the highest values of these characters, while application of 100% mineral alone had the lowest values and not suitable for application. Seed yield ardab/fad recorded the highest values were added application 50% N nano+50% N mineralon sesame (2.70&3.39 ardab/fad), while application 100% mineral alone was lowest values (1.98&2.21 ardab/fad). These results may be attributed to nanomaterials are leading to significant improvement in plant through enhancing the growth and hence dry weight, leaf area and growth rate (Hasaneen *et al.*, 2016).

Table 6. Yield traits of intercropped sesame with maize as affected by different rates of N mineral and N nano fertilizer in 2018 and 2019 cropping seasons.

Rate of fertilizer	Plant height (cm)		Length of fruiting zone (cm)		No .of capsule /plant		Seed index (g)		Seed yield (ardab /fad)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
B1	145.33	151.57	93.33	87.67	66.73	75.12	3.53	3.3	1.98	2.12
B2	153.803	156.64	107.33	92.00	70.87	78.22	3.7	3.39	2.29	2.28
B3	167.67	163.67	114.50	96.61	73.38	79.63	3.92	3.8	2.46	2.59
B4	172.35	171.33	114.87	104.07	88.93	99.87	4.17	3.93	2.7	3.39
B5	162.67	166.67	107.97	103.52	84.6	83.2	4.08	3.88	2.59	2.83
L.S.D 5 %	18.38	17.54	10.54	11.34	14.99	14.37	0.28	0.29	0.37	0.36
Solid sesame st season 5.40 ardab/fad										
Solid sesame nd season 5.23 ardab/fad										

The increases in these characters due to the combination between nano and mineral fertilization at different percent of its recommended could be attributed to nano fertilization increase availability of nutrient to the growing plant (Hediat & Salama, 2012) and reduced losses of conventional N (Wu & Liu, 2008). Consequently, meristematic activity, stimulation of cell elongation and increased production. Application of foliar fertilizer is an effective way of correcting soil nutrient deficiencies, when soil applied fertilizers are not readily available or when plants are unable to absorb them directly from the soil (Manikandan & Subramanian 2016).

Seed yield/fad of sesame gave the same trend of plant height, length of fruiting zone, no of capsules/plant. The increase in seed yield/fad due to applied 75% N nano of its recommended along with 25% mineral was 36.36 and 59.91% in first season and 17.90 and 48.68% in second season compared to conventional and nano only, respectively. These results may be attributed to nanomaterials are leading to significant improvement of plant through enhancing the growth and hence dry weight, leaf area and growth rate (Hasaneen *et al.,* 2016).

2.8. Competitive relationships:

3.5.1. Land equivalent ratio (LER): Data presented in Table (7&8) clearly indicated that land equivalent ratio in all treatments of the interaction between intercropped maize and N nano-mineral fertilization were greater than one in both seasons, which few exception indicating the advantageous to grow maize with each of soybean, groundnut and sesame in association than in solid culture. Intercropping groundnut with maize and using 75% nano fertilizer +25% mineral fertilizers recorded the highest values for (LER) which was 1.72 &1, 75 in 1 st and 2 nd seasons, respectively. Intercropping soybean with maize with using 100 % mineral fertilizer recorded the lowest values for (LER) which was 0.79&0.87 in the 1 st and 2 nd seasons, respectively. Similar results were obtained by Metwally *et al.,* 2005a, band Toaima 2006. Who found that LER values were greater with intercropping system than sole crop of them.

Land equivalent coefficient (LEC) is a measure of interaction concerned with the strength of relationship.LEC is used for two –crop mixture the minimum expected productivity coefficient (PC) 25% that is a yield advantage is obtained if LEC value exceeded 0.25. The effects of intercropping oil crops on maize and their interaction on the LEC of intercropping maize exceeded 0.25 in the intercrop combinations used intercropping 50% groundnut with maize and 75% nano fertilizer recorded the highest values for LEC of 0.67 and 0.59in the 1 st and 2 nd seasons, respectively (Table7&8). LEC values followed a trend similar to that of LER. This is consistent with findings of wafaa et al., 2013.

3.5.2. Effect of various cropping systems on competitive ratio (CR):

Data presented in Tables (7&8) revealed that the lowest values of CR were recorded for intercropping sesame with maize of 1.09 and 0.96 in the 1 st and 2 nd seasons, respectively. However, the highest values of CR were recorded for intercropping soybean with maize at 100 % Nano and 100% mineral N1.77, 1.90 in the 1 st and 2 nd seasons, respectively. Similar results were recorded by Wafaa *et al.,* 2013 and Nagwa *et al.,* 2019.

3.5.3. Effect of various cropping systems on Aggressivity(Agg)

Data in Tables (7&8) show that aggressivity values of maize were positive, whereas values of soybean and groundnut intercrop were negative, meaning that maize was dominant and the two intercrops were

Table 7. Competitive relationships and yield advantage for intercropping of soybean, groundnut and sesame with maize and fertilizer rates of maize on 2018 season.

intercropping pattern	rat fertilizer	maize ardeb/fad	Intercrop. pattern	LERM	LERB	LER	LEC	CR m	CR b	CR	Aggm	Aggb
M+50% Soybean	B1	14.833	239.59	0.61	0.19	0.79	0.11	1.59	0.09	1.68	+0.34	-0.34
	B2	21.36	324.85	0.87	0.25	1.13	0.22	1.69	0.09	1.77	+0.53	-0.53
	B3	27.07	534.98	1.11	0.42	1.52	0.46	1.30	0.11	1.41	+0.38	-0.38
	B4	25.22	435.83	1.03	0.34	1.37	0.35	1.48	0.10	1.58	+0.51	-0.51
	B5	20.767	480.25	0.85	0.37	1.22	0.32	1.11	0.13	1.24	+0.13	-0.13
Mean		21.85	403.1	0.89	0.31	1.21	0.28	1.39	0.11	1.50	+0.38	-0.38
M+ 50% Groundnut	B1	18.917	4.39	0.77	0.37	1.15	0.29	1.01	0.15	1.16	+0.02	-0.02
	B2	21.51	5.26	0.88	0.45	1.33	0.39	0.96	0.15	1.11	-0.05	+0.05
	B3	27.443	7.06	1.12	0.60	1.72	0.67	0.91	0.16	1.08	+0.016	-0.016
	B4	25.033	5.86	1.02	0.50	1.52	0.51	1.00	0.15	1.15	-0.15	+0.15
	B5	23.363	6.21	0.95	0.53	1.48	0.50	0.88	0.17	1.05	-0.18	+0.18
Mean		23.2532	5.756	0.95	0.49	1.44	0.47	0.95	0.15	1.10	-0.07	+0.07
M+ 50% Sesame	B1	14.833	2.00	0.61	0.37	0.98	0.22	0.80	0.18	0.99	-0.22	+0.22
	B2	21.137	2.29	0.86	0.42	1.29	0.37	1.00	0.15	1.15	-0.003	+0.003
	B3	24.477	2.7	1.00	0.50	1.50	0.50	0.98	0.15	1.13	-0.02	+0.02
	B4	22.25	2.46	0.91	0.46	1.36	0.41	0.98	0.15	1.13	-0.02	+0.02
	B5	20.767	2.59	0.85	0.48	1.33	0.41	0.87	0.17	1.04	-0.19	+0.19
Mean		20.693	2.408	0.85	0.45	1.29	0.38	0.93	0.16	1.09	-0.09	+0.09
Solid maize	24.48	ardab/fad										
Solid soybean	1.282	ton/fad										
Solid groundnut	11.75	ardab/fad										
Solid sesame	5.40	ardab/fad										

Table 8. Competitive relationships and yield advantage for intercropping of soybean, groundnut and sesame with maize and fertilizer rates of maize on 2019 season

intercropping pattern	rat fertilizer	maize ardeb/fad	intercropping pattern	LERM	LERB	LER	LEC	CR m	CR b	CR	Agg m	Agg b
M+50% *Soybean*	B1	15.163	209.24	0.68	0.18	0.87	0.13	1.82	0.08	1.90	+0.46	0.46
	B2	19.99	295.48	0.90	0.26	1.16	0.24	1.70	0.09	1.78	+0.56	-0.56
	B3	25.40	406.48	1.15	0.36	1.51	0.41	1.57	0.09	1.66	+0.63	-0.63
	B4	19.72	505.61	0.89	0.45	1.34	0.40	0.98	0.15	1.13	-0.02	+0.02
	B5	18.50	584.21	0.84	0.52	1.35	0.43	0.79	0.18	0.98	-0.31	+0.31
Mean		19.76	400.20	0.89	0.35	1.25	0.31	1.24	0.12	1.36	+0.26	-0.26
M+ 50% Groundnut	B1	14.24	3.74	0.64	0.34	0.99	0.22	0.92	0.16	1.08	-0.08	+0.08
	B2	19.13	4.48	0.86	0.41	1.28	0.36	1.03	0.14	1.17	+0.04	-0.04
	B3	28.55	4.99	1.29	0.46	1.75	0.59	1.38	0.11	1.49	+0.54	-0.54
	B4	23.17	6.01	1.05	0.55	1.60	0.58	0.93	0.16	1.09	-0.11	+0.11
	B5	22.98	5.28	1.04	0.48	1.52	0.50	1.05	0.14	1.19	-0.08	+0.08
Mean		21.61	4.90	0.98	0.45	1.43	0.44	1.06	0.14	1.20	+0.09	-0.09
M+ 50% Sesame	B1	11.79	2.12	0.53	0.41	0.94	0.22	0.64	0.23	0.87	-0.43	+0.43
	B2	19.65	2.28	0.89	0.44	1.32	0.39	1.00	0.15	1.14	+0.01	-0.01
	B3	21.76	2.58	0.98	0.49	1.48	0.48	0.98	0.15	1.13	-0.02	+0.02
	B4	18.98	3.39	0.86	0.65	1.51	0.56	0.65	0.23	0.87	-0.68	+0.68
	B5	14.83	2.83	0.67	0.54	1.21	0.36	0.61	0.24	0.85	-0.64	+0.64
Mean		17.40	2.64	0.79	0.50	1.29	0.40	0.76	0.19	0.96	-0.35	+0.35
Solid maize					22.14	ardab/fad						
Solid soybean					1.134	ton/fad						
Solid groundnut					10.89	ardab/fad						
Solid sesame					5.23	ardab/fad						

dominated. Those agrgressivity values of maize were negative when maize intercropping sesame in the two seasons. Similar results were recorded by Toaima 2006; Wafaa *et al.*, 2013 and Nagwa *et al.*,2019.

3.5.4. Total returns and monetary advantage index (MAI):

The data of economic analysis as influenced by intercropping pattern and rate fertilization compared with solid planting of both crops are presented in Table (9&10). It reveals that the net profit of using 75% Nano plus25 % mineral N fertilizer for maize and groundnut intercrop recorded 13.875 &11.922 L.E. fad. While The monetary advantage index (MAI) recorded 13.303&11.35 L.E. fad, meanwhile, the lowest net return was recorded for intercropping soybean with maize received rate of 100% mineral fertilizer 1.022&0.968 L.E. fad and monetary advantage index (MAI) of 0.128 &0.181 L.E. fad in the 1 st and 2 nd successive seasons respectively.

Table 9. Economic analysis of intercropping pattern and rates of N nano and mineral fertilize of maize on 2018 season.

intercropping pattern	Rat fertilizer	Crops yield		Total income (LE /fad)		Total income	Total expenditure (LE/fad)	Net profit (LE/fad)	MAI
		Maize ardab	intercropping p	maize	intercropping pattern	(LE/fad)			
M+50% soybean	B1	14.833	239.59	7.1198	1.677130	8.79693	7.775	1.0219	0.128
	B2	21.36	324.85	10.253	2.273950	12.52695	7.015	5.5120	4.650
	B3	27.07	534.98	12.994	3.744860	16.73886	7.385	9.3539	8.692
	B4	25.22	435.83	12.106	3.050810	15.15681	7.705	7.4518	6.706
	B5	20.767	480.25	9.9682	3.361750	13.32995	7.075	6.2550	5.514
Mean		21.85	403.1	10.488	2.821700	13.3097	7.391	5.9187	5.119
M+50% groundnut	B1	18.917	4.39	9.0802	5.268	14.3482	8.160	6.1882	5.178
	B2	21.51	5.26	10.325	6.312	16.637	7.400	9.2370	8.456
	B3	27.443	7.06	13.1726	8.472	21.6446	7.770	13.8746	13.303
	B4	25.033	5.86	12.0158	7.032	19.0478	8.090	10.9578	10.333
	B5	23.363	6.21	11.2142	7.452	18.6662	7.460	11.2062	10.548
Mean		23.2532	5.756	11.1615	6.907	18.0685	7.776	10.2925	9.593
M+50% Sesame	B1	14.833	2	7.1198	6.000	13.1198	7.635	5.4848	4.421
	B2	21.137	2.29	10,1458	6.870	101464.9	6.875	3.2720	2.514
	B3	24.477	2.7	11.7490	8.100	19.849	7.245	12.6040	11.928
	B4	22.25	2.46	10.680	7.380	18.06	7.565	10.4950	9.833
	B5	20.767	2.59	9.9682	7.770	17.7382	6.935	10.8032	9.977
Mean		20.693	2.408	9.9326	7.224	17.1566	7.251	9.9056	9.130
Solid Maize		24.48		11.750			7.535	4.215	4.215
Solid soybean		1282		8.974			5.798	3.176	3.176
Solid groundnut		11.75		14.100			7.266	6.834	6.834
Solid sesame		5.4		16.200			6.272	9.928	9.928

L.E 480 for ardab of maize L.E 7000 for ton of soybean L.E 1200 for ardab groundnut L.E 3000 for ardab sesame.

3. Conclusion

Intercropping of oil crops with maize showed money benefits and intercropping maize- legumes are produced greater seed yield than either crops grown alone. In addition, land use efficiency greater LER than sole crops. Intercropping oil crops with maize increases the cultivated area of them, which reduces the gap between production and consumption to obtain self-sufficiency and to using the residues of both soybeans and groundnut as animal feed., the legume crops enhance land fertility through the natural nitrogen fixed by legume crops. More than less, using Nano N fertilizer is a profitable component in agricultural practices as it has a rapid impact on plant. So, the pattern of maize-groundnut intercrop fertilized with 75% Nano N fertilizer plus 25% mineral N fertilizer of the recommended is very important to make maize more profitable for farmer.

Table 10. Economic analysis of intercropping pattern and rates of N nano and mineral fertilize of maize on 2019 season.

Intercropping Pattern	Rat fertilizer	Crops yield		Total income (LE /fad)		Total income	Total expenditure (LE/fad)	Net profit (LE/fad)	MAI
		maize	intercroppi patteren	Maize	intercropping patteren	(LE/fad)			
M+50% soybean	B1	15.163	209.24	7.278	1.465	8.743	7.775	0.968	0.181
	B2	19.99	295.48	9.595	2.068	11.663	7.015	4.648	3.786
	B3	25.40	406.48	12.192	2.845	15.037	7.385	7.652	6.990
	B4	19.72	505.61	9.465	3.539	13.004	7.705	5.299	4.553
	B5	18.50	584.21	8.880	4.089	12.969	7.075	5.894	5.153
Mean		19.76	400.20	9.485	2.801	12.286	7.391	4.895	4.095
M+50% groundnut	B1	14.24	3.74	6.835	4.488	11.323	8.160	3.163	2.153
	B2	19.13	4.48	9.182	5.376	14.558	7.400	7.158	6.377
	B3	28.55	4.99	13.704	5.988	19.692	7.770	11.922	11.351
	B4	23.17	6.01	11.122	7.212	18.334	8.090	10.244	9.619
	B5	22.98	5.28	11.030	6.336	17.366	7.460	9.906	9.248
Mean		21.61	4.90	10.373	5.880	16.253	7.776	8.477	7.778
M+50% Sesame	B1	11.79	2.12	5.659	6.360	12.019	7.635	4.384	3.320
	B2	19.65	2.28	9.432	6.840	16.272	6.875	9.397	8.639
	B3	21.76	2.58	10.445	7.740	18.185	7.245	10.94	10.264
	B4	18.98	3.39	9.110	10.170	19.28	7.565	11.715	11.053
	B5	14.83	2.83	7.118	8.490	15.608	6.935	8.673	7.847
Mean		17.40	2.64	8.352	7.920	16.272	7.251	9.021	8.246

22.14	ardab/fad	10.627	7.535	3.092	3.092
1.134	ton/fad	7.938	5.798	2.14	2.14
10.89	ardab/fad	13.068	7.266	5.802	5.802
5.23	ardab/fad	15.690	6.272	9.418	9.418

L.E 480 for ardab of maize L.E 7000 for ton of soybean L.E 1200 for ardab groundnut L.E 3000 for ardab sesame

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الملخص العربى

تحميل بعض محاصيل الزيت الصيفيه مع الذرة الشامية تحت مستويات من التسميد النيتروجينى النانو و المعدنى

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نظرا لاهميه المحاصيل الزيتيه وسد الفجوه الغذائيه منها، تم تحميل ثلاثة محاصيل زيتيه صيفيه (فول الصويا والفول السودانى والسمسم) مع الذرة الشامية لزيادة ألانتاج منهاعلاوة على ذلك فان أستبدال الاسمدة المعدنيه باسمدة جديدة مثل أسمدة النانو تؤدى للحد من تلوث التربة وزيادة كفاءة نمو النبات مما ينعكس على زيادة محصول الذرة الشامية . لذلك تم إجراء تجربتين حقليتين في محطة ملوي للبحوث الزراعية ، بمحافظة المنيا ، مركز البحوث الزراعية ، خلال موسمين صيفيين متعاقبين 2018 و 2019 لدراسة تأثير تحميل محاصيل الزيت الثلاثة (فول الصويا- الفول السودانى- السمسم) مع الذرة الشامية وتوليفة من السماد المعدني و أسمدة النانوالنيتروجينى على المحصول ومكوناته والعلاقات التنافسية لكل منهم.

أستخدم تصميم القطع المنشقة مرة واحدة فى ثلاث مكررات. تم تخصيص القطع الرئيسية للمحاصيل الزيتيه: فول الصويا والفول السودانى والسمسم بنسبة 50 ٪ من الموصى به. تم تخصيص المعدلات التالية من الأسمدة النانويه النيتروجينية وسماد النيتروجين المعدنى بنسبة (100 ٪ من السماد النيتروجينى النانو – 100% من السماد المعدني النيتروجينى – 75 % من السماد النانو النيتروجينى+ 25 % من السماد النيتروجينى المعدني– 50 % من كل من السماد النانو والمعدنى- 25 % من سماد النانو + 75% من السماد المعدنى النيتروجينى من الموصى بة للذرة الشامية والمحاصيل الزيتيه الثلاثه كلا على حدة وتم ذلك فى القطعة المنشقة من التصميم الاحصائى.

يمكن تلخيص النتائج التي تم الحصول عليها على النحو التالي :-

سجل تحميل الفول السوداني علي الذرة الشامية أعلى محصول للفدان 23.25 و 21.61 أردب للفدان بينما سجل السمسم مع الذرة الشاميهأقل محصول للذره 20.69 و 17.40أردب للفدان فى الموسمين.

أعلى محصول من الذرة الشامية عند تطبيق 75% نيتروجين نانو +25% نيتروجين معدنى حيث سجل 26.33و25.24 أردب للفدان بينما سجل تطبيق 100% معدنى أقل محصول من الذرة الشاميه 16.19 و 13.73 أردب للفدان فى الموسمين على التوالى.

- سجل تحميل الفول السودانى مع الذرة الشامية وأضافة 75% نيتروجين نانو+25% نيتروجين معدنى أعلى قيم لمعدل أستغلال الارض 1.72و 1.75 بينما سجل تحميل فول الصويا مع الذرة الشاميه وأضافة 100 % من التسميد المعدنى أقل قيم لمعدل أستغلال الارض 0.79و 0.87 فى الموسمين على التوالى.

سجل تحميل الفول السودانى مع الذرة الشاميه والتسميد بمعدل 75% نيتروجين نانو+25% نيتروجين معدنى أعلى عائد نقدى للفدان 13.875 و 11.922 الف جنيها بينما سجل تحميل فول الصويا مع الذرة الشاميه والتسميد 100% معدنى أقل عائد نقدى للفدان 1.022و0.968 الف جنيها فى الموسمين على التوالى.

لذلك يتم التوصيه بتحميل الفول السودانى بنسبة 50% مع الذرة الشاميه مع التسميد بمعدل 75% نيتروجين نانو+25% نيتروجين معدنى للحصول على أعلى ربحية للمزارع.