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Influence of Intercropping Cowpea with some Maize Hybrids and N Nano-Mineral Fertilization on Productivity in Salinity Soil

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A TWO-year field experiment was carried out at El-Serw Agricultural Research Station, during the 2018 and 2019 seasons to study the effect of intercropping cowpea (*Vigna unguiculata* L.) with three maize (*Zea mays* L) hybrids (SC 168, SC176 and TWC 321) and four N fertilization treatments (120kg N/fed as urea (100% N mineral), 50% N mineral + 50% N nano, 75% N mineral + 25% N nano and 3.0cm^3 N nano/ L (100% N nano) on maize and cowpea productivity, land use efficiency and economic return. A split-plot design with three replicates was used. Results showed that maize hybrids had significant effect on yield and yield attributes of maize and cowpea in both seasons, with some exception. The S.C.168 hybrid gave the highest grain yield and its components, while intercropping cowpea with S.C.176 hybrid significantly increased yield and its attributes of cowpea in comparison with other hybrids. Applying 75% N mineral along with 25% N nano significantly increased growth, yield and yield components of maize and cowpea in both seasons. Significantly increase in yield and its attributes of maize and cowpea was realized by interaction between maize SC168 and 75% N mineral +25% N nano fertilization. Intercropping cowpea with maize SC168 that received 75% of the N mineral + 25% nano fertilizer recorded the highest LER 1.67 and 1.66, ATER 1.59 and 1.58, Aggressivity 0.28 and 0.23, gross return15865 and 15854 L.E./fed and net return 7983 and 7972L.E./fed in first and second seasons, respectively, as well as rationalizing the use of N mineral fertilizers.

Keywords: Area time equivalent ratio (ATER), Conventional urea (N mineral), Land equivalent ratio (LER), Nano urea (N nano), Total income.

Introduction

Maize (*Zea mays* L.) is a major cereal crop in Egypt covering 28% of the total area under cereal cultivation (Bulletin of Statistical Cost Production and Net Return, 2016). However, total production is still not sufficient for local consumption. The productivity of small-holder cropping systems is typically in decline as a result of continuous maize monocropping and low soil fertility. Therefore, it is advisable to increase the yield of maize per unit area using new hybrids of maize which are characterized by high productivity along with suitable N fertilizer.

Introducing cowpea into the cropping systems not only addresses the problem of low soil fertility, but also increased protein in diets and green fodder utilization during summer. Legumes fix atmospheric nitrogen, which may be utilized by the legume and also excreted from the nodules into the soil and be used by other plants nearby (Shen & Chu, 2004; Sheahan, 2012) or compliment/supplement inorganic fertilizers (El-Shamy et al., 2015). Intercropped maize plants with cowpea, exhibited greater yield potential and resulted in higher growth, yield and yield components (Abdel-Wahab et al., 2016; Idoko et al., 2018; Toungos et al., 2018). However, fresh and dry forage yields of cowpea were lower in

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intercropping with maize than when cultivated without maize (Abdel-Wahab et al., 2016; Toungos et al., 2018). Land equivalent ratio, Aggressivity and economic benefit were higher, in maize/cowpea intercropping systems (Takim, 2012; Saudy, 2015; Abdel-Wahab et al., 2016; Olowolaju & Okunlola, 2017).

There are multitudes of available maize hybrids. Differences in leaf inclination and height of maize hybrids can result in differences in transmission of radiation to the other crop-plant in intercropping systems (Abdel-Galil et al., 2014; Lamlom et al., 2015). The S.C. hybrid 168 gave the highest values of plant height, grain yield and its components in comparison with other (Gomaa et al., 2017). Maize hybrids may have an important role to reduce inter-specific competition among the two species for basic growth resources, especially the superiority of maize grain yield of maize hybrids, particularly, single crosses over the three way crosses hybrids as reported by El-Ghobashy et al. (2018). All growth and yield characters of cowpea were significantly affected by maize hybrids (Idoko et al., 2018; Toungos et al., 2018). Maize hybrid SC 30K08 had the highest grain yield and its attributes when compared with TWC 310 or TWC 352 however, it is not suitable for intercropping culture (El-Ghobashy et al., 2018). Consequently, maize hybrids that interact positively with an intercropping system could play vital role to optimize intercropping maize-cowpea.

Several studies showed that 40–70% of the nitrogen applied in conventional fertilizers is lost to the environment and cannot be absorbed by plants, which causes not only large economic and resource losses, but also responsible for serious environmental pollution (Wu & Liu, 2008; Iqbal et al., 2013). Therefore, applying the optimum N level and suitable N carrier, loading of conventional fertilizers in polymeric nanoparticles (Corradini et al., 2010), are important means for raising the yield of maize and improving profitability.

Various studies have shown the importance of nano nutrient sources in improving crop yields and land productivity, Liu et al. (2009) found that increases in grain yields of rice (10.29%), spring maize (10.93%), soybean (16.74%), winter wheat (28.81%) and vegetables (12.34-19.76%) after applying fertilizer loading with nano-materials. Growth, yield, quality and nutrient uptake of maize were consistently higher for nanozeourea (urea coated by nano Zeolite) treatment than conventional urea (Manikandan & 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. Kandil & Marie (2017) showed that significant increase in yield and its components of wheat by using nano-fertilizer + amino acids during both growing seasons. Meanwhile, the applied mineral fertilizer, alone; gave the lowest mean values of the studied traits. Gomaa et al. (2017) found that application of mineral fertilizer in the soil + foliar application of nano- fertilizer recorded the highest value of plant height, ear length and number of rows/ear, number of grains/row, number of grains/ear, 100-grain weight, biological, straw and grain yield. Foliar application of NPK nano- fertilizers along with 75% soil application of NPK mineral fertilization increased yield and its components of wheat crop under the environmental conditions of Alexandria Governorate in Egypt (Gomaa et al., 2018). Emara et al. (2018) who found that Nano-fertilizer by Lithovit had significant effect on growth, seed cotton yield and it compounds.

The aim of this study was to reduce gap between production and consumption for green forage in summer season by intercropping cowpea with suitable maize hybrid and reduced environmental pollution by partial replacement of N mineral fertilizer with N nano fertilizer.

Materials and Methods

The present study was performed at El-Serw Agricultural Research Station, Domiate Governorate (Lat. 31˚24’59”N, Long. 31˚48’47”E, 16 m a.s.l.) Egypt, during the two growing seasons of 2018 and 2019 to assess intercropping cowpea with suitable maize hybrids with partial replacement of N mineral by N nano fertilization to increase productivity, maximizing land use efficiency and net return as well as reduced the green forage gap during summer season and reduced environmental pollution. Wheat was the preceding winter crop in both seasons. The soil of the experimental site was clayed. Mechanical and chemical analyses of the soil (0-30 cm) were determined using the methods described by Black (1965) as shown in Table 1.

TABLE 1. Physical and chemical soil characteristics at the experimental sites during the two seasons.

Growing season	Particle size distribution%				OM %	$CaCO_3$ %	CEC meq/ 100g soil	pH	EC dSm^{-1}	IWEC*
	Sand	Silt	Clay	Texture class						
1st	11.84	21.36	66.80	Clayey	0.77	1.40	43.8	8.1	5.92	1.60
2nd	11.79	22.26	65.95	Clayey	0.86	1.34	42.3	8.0	6.37	1.58

Growing season	Cations and anions in the soil water extract (1:5), meq/100 g soil								NPK available ppm		
	Cations				Anions				N	P	K
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}			
1st	3.05	2.76	11.25	0.26	---	1.45	12.12	3.75	32	8.06	485
2nd	3.11	2.69	11.40	0.28	---	1.60	12.20	3.68	33	7.94	479

IWEC, Irrigation water electrical conductivity, dSm^{-1}.

The three maize hybrids used for study were SC 168, SC 176 and TWC 321 and four treatments of N nano-mineral fertilization.

Treatments of N fertilization are as follows:

1- 120kg N/fed in form conventional urea (100% N mineral as recommended), control treatment.

2- 60kg N/fed (50% N mineral) + N nano at 1.50 cm^3/ L (50% N nano).

3- 90kg N/fed (75% N mineral) + N nano at 0.75 cm^3/ L (25% N nano).

4- 3.0cm^3 nano fertilizer/L in form nano urea (100% N nano). One litter of nano fertilizer contains 20% N in form urea coated by nano chitosan. Concentration of N nano was 600, 300 and 150 ppm, expressed as100, 50 and 25% N nano, respectively.

The size and morphology of nano particles were studied using transmission electron microscope (JEM-1400 TEM, Japan) as shown in Fig. 1. (The average size 42.57nm nano particle with a range from 23 to 80nm)

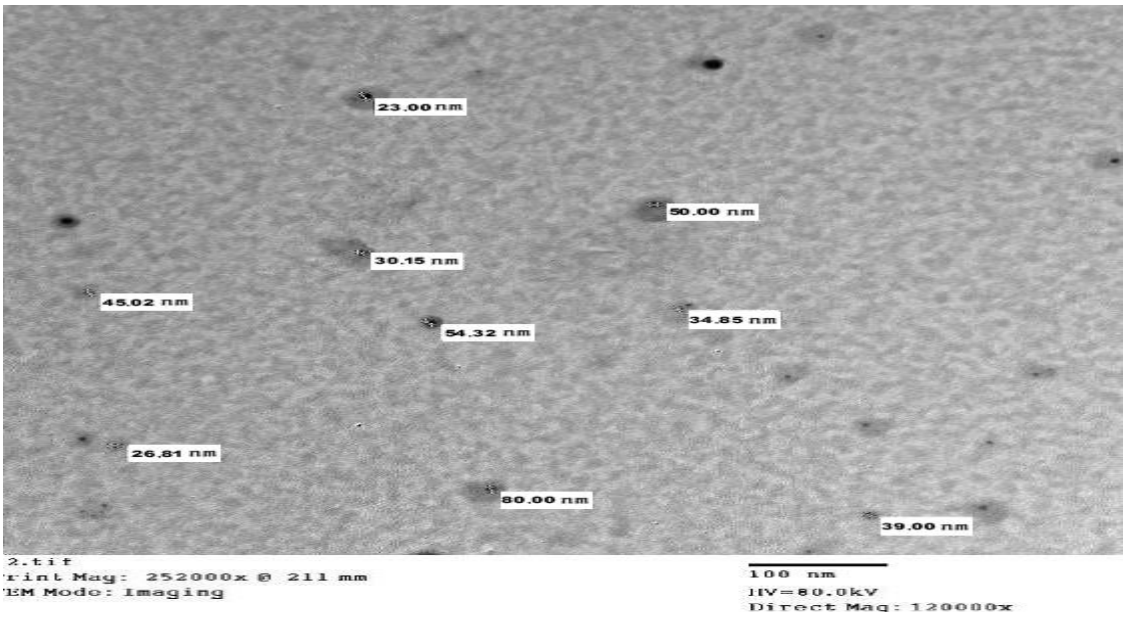

Fig. 1. Transmission electron microscopy (TEM) micrograph of synthesized N nano.

A split plot in randomized complete block design arrangement with three replications was used with maize hybrids as main plots and nitrogen fertilization treatments as sub-plots. Sub-plot area was 10.5m^2 (1/400 fed^{-1}) having 5 ridges of 3m in length and 3.5m in width.

Planting date of maize hybrids and cowpea (cv. Cream 7) were on June 15th and 10th in the 2018 and 2019 seasons, respectively. Harvesting date of maize was on October 9th and 4th in 2018 and 2019 seasons, respectively, whereas cowpea was harvested on August 4th and 9th for first cut and second cut was on December 18th and 23rd in 2018 and 2019 season, respectively. In intercropping culture, maize planted on one side of the ridge (70cm width) at 50cm apart and thinned to two plants per hill, while cowpea seeds were sowing on the other side of the ridge at 15cm apart and leaving two plants/hill (100% maize: 67% cowpea). In sole culture, maize was sown in one side of ridge (70cm width) with growing one plant/hill spaced at 25 cm, meanwhile, cowpea seeds were grown in both sides of the ridge (70cm width) two plant/hill spaced at 20cm. Cowpea seeds were inoculated by Rhizobium melitota before seeding and Arabic gum was used as a sticking agent in both culture systems. Beside of solid cultures of both crops were as recommended and using to determined competitive relationship and net return.

Soil application was used for conventional N in two equal doses, just before the 1st and 2nd irrigations. Foliar application of nano urea fertilizers was used twice, after 25 and 40 days of planting, carried out between 09:00 and 10:00AM. The foliar solutions volume was to 100L water/ fed using a knapsack sprayer. Product name of nano urea is nitrogen conjugated to chitosan nanoparticles. Trade name of nano urea is Nitrogen loaded on nano chitosan, Chemical formula $(C_6H_{11}NO_4)_n$. Chemical composition: Chitosan 80% and Nitrogen 20% (Source of Nitrogen is urea). Nano urea was produced by NanoFab Technology Company, Cairo, Egypt. It is synthesized by the Ionic gelation method. All agronomic practices were kept normal and uniform for all treatments.

Data collected

At harvest, 10 plants were taken at random from each sub-plot to estimate growth and yield attributes of maize and cowpea.

Maize traits: Plant height (cm), No. of green leaves/plant at 85 days of planting, stem diameter (mm), leaf area index (LAI), No. of rows/ear, Ear length (cm), Ear diameter (cm), Ear grain weight (g) and 100-grain weight (g). Grain yield kg/fed was recorded on whole sub-plot basis adjusted to 15.5% moisture content and then converted to ardab/fed (ardab= 140kg).

Cowpea traits: Plant height (cm), No. of branches/plant No. of leaves/plant and LAI were measured in first cut. Forage yield was estimated from the whole sub-plot area in kg/plot, then it was converted to forage yield ton/fed for both cuts. The 1st cut of cowpea was after 60 days from planting, while the 2nd cut was 45 days later of the 1st cut in solid and intercropping culture.

Land equivalent ratio (LER)

LER defines as the ratio of area needed under sole cropping to one of intercropping at the same management level to produce an equivalent yield (Willey 1979). It is calculated as follows: LER= (Yab/Yaa) + (Yba/Ybb), where Yaa= Pure stand yield of crop a (maize), Ybb= Pure stand yield of crop b (cowpea), Yab= Intercrop yield of crop a (maize) and Yba= Intercrop yield of crop b (cowpea).

Area time equivalent ratio (ATER)

Area time equivalent ratio provides more realistic comparison of the yield of intercropping over monocropping in terms of time taken by component crops in the intercrop according to Hiebsch (1980).

ATER= (LERa x DCa + LERb x DCb)/ Dt where LER is land equivalent ratio of crop, DC is duration (days) taken by crop, Dt is days to intercropping system from planting to harvest.

Aggressivity (Agg)

Is another index that represents a simple measure of how much the relative yield increase in crop a is greater than that of crop b in an intercropping system. It was calculated as:

Aab= (Yab/Yaa x Zab) – (Yba/Ybb × Zba).

where, Yaa and Ybb are yields as sole crops of a and b and Yab and Yba are yields as intercrops of a and b. Zab and Zba are the sown proportions of a and b, respectively. If Aab= 0, both crops are equally competitive, if Aab is positive, a is dominant, if Aab is negative a is dominated crop (Mc-Gilchrist, 1965).

Economic evaluation

Gross return of intercropping cultures= Price of maize yield + price of cowpea yield (L.E.).

Net return/fed= Total return – (fixed costs of maize + variable costs of cowpea according to grain maize prices presented by Bulletin of Statistical Cost Production and Net Return (2018), while forage yield of cowpea prices presented by market price (2018). One ardab of maize grains was L.E. 480 and L.E. 300 for one ton of cowpea.

Statistical analysis

Data were statistically analyzed using the MSTAT-C Statistical Software Package (Freed, 1991). The treatment means were compared using the Least Significant Differences (LSD) test with a significance level of 5% according to Gomez & Gomez (1984).

Results and Discussions

Maize characters

Growth characters

Varietal differences: Data illustrated in Table 2 showed that the differences between maize hybrids under study were significant for plant height, number of green leaves/plant, stem diameter and leaf area index (LAI) in both seasons except stem diameter was not significant in the second season. Maize TWC 321 gave the higher plant height compared to SC176 and SC 168 in both seasons. The differences in plant height among maize hybrids might be attributed to the differences in number and/or length of the internodes reflecting the genetical makeup. However, The results obviously indicated that maize SC168 gave the highest values of number of green leaves/plant and stem diameter followed by SC176, while TWC 321 was the lowest once, while leaf area index behaved the opposite trend in both seasons. This finding might be attributed to the differences in their genetic constitution. These results are in agreement with those obtained by Abdel-Galil et al. (2014), Lamlom et al. (2015) and Gomaa et al. (2017).

Effect of N nano- mineral fertilization: Data in Table 3 show that application of N nano-mineral fertilization significantly affected plant height, number of green leaves/plant, stem diameter and leaf area index (LAI) compared with control treatment (260kg/ fed conventional urea without nano) in both seasons. The highest values of plant height, number of green leaves/plant, stem diameter and leaf area index were (310.28cm, 13.93, 25.35mm and 6.08) respectively, in the first season and (316.30cm, 13.78, 25.41mm and 6.04) respectively, in the second season. Which recorded with adding 75% N mineral + 25% N nano treatment followed by 50% N mineral + 50% N nano treatment then control. Whereas, the lowest once (261.39cm, 12.43, 15.54mm and 3.62) in first season and (270.92 cm, 12.56, 16.43 mm and 3.94) in the second season, respectively, were recorded with 100% nano fertilizer alone. The NPs efficiency is determined by their chemical composition, surface covering, size, reactivity, and the most importantly is the dose which they are effective (Khodakovskaya et al., 2012). The increases in these characters because of partial replace of conventional urea with nano urea could be attributed to nano fertilization increases availability of nutrient to the growing plant (Hediat & Salama, 2012) and reduced losses of conventional N (Wu & Liu, 2008; Iqbal et al., 2013). 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 (Qureshi et al., 2018). These results are in accordance with those obtained by Manikandan & Subramanian (2016) they found that growth, yield, quality and nutrient uptake of maize were consistently higher for nanozeourea (urea coated by nano Zeolite) treatment than conventional urea. Gomaa et al. (2017) found that application of mineral fertilizer in the soil + foliar application of nano- fertilizer recorded the highest value of maize plant height.

Interaction effects: The interaction between N nano-mineral fertilizers and maize hybrids significantly influenced plant height, number of green leaves, stem diameter and leaf area index (LAI) for both seasons, except plant height in first season and stem diameter in second season (Table 4). Fertilized SC 168 hybrid with 75% mineral along with 25% nano fertilizer recorded the highest value of number of green leaves (14.87 and 14.78) and stem diameter (25.57 and 25.70) in the first and second seasons, respectively. On the other hand, the lowest of these values were recorded by 100% nano-urea with TWC 321 hybrid. With respect to plant height and leaf area index, the highest values were recorded with hybrids TWC321 when fertilized with 75% N mineral + 25% N nano fertilization that is true for both seasons. Under this study, the high concentration was not suitable for application. Nanoparticles causing many morphological and physiological changes, depending on the properties of NPs. The NPs efficiency is determined by their chemical composition, surface covering, size, reactivity, and the most importantly is the dose which they are effective (Khodakovskaya et al., 2012). Auffan et al. (2009) stated that unlike macronutrients nanomaterials have particular properties, such as surface effect, volume effect and quantum size effect and so on. The magnitude of increased growth variables was most pronounced with low concentration 10% nano-NPK (Abdel-Aziz et al., 2016). Adding K_2SO_4 nanoparticles at the low level led to the highest shoot dry weight, relative yield, root length and dry weight of roots in used genotypes (El-Sharkawy et al., 2017).

Yield and yield components characters

Varietal differences: Results shown in Table 5 clearly indicate that SC168 maize hybrid gave the highest values of studied characters followed by SC 176, then TWC 321 maize hybrid. This is completely true for each of number of rows/ear, ear length, ear diameter, ear grain weight, 100-grain weight and grain yield/fed in both seasons. These differences among hybrids are mainly due to genetic differences among the three hybrids. Difference in the genetical constituent of different maize hybrids might account much to difference in length and size of ears, especially there was a positive and highly correlated relationship among ear fill, ear length and ear circumference with grain weight/ear (Paudel, 2009). The hybrid SC 168 recorded the highest value for grain yield/ fed 22.20 and 22.85 ardab/fed (ardab= 140kg) followed by SC 178 (21.39 and 21.82ardab/ fed) and the lowest value (18.54 and 18.91ardab/ fed) was produced by maize TWC 321 hybrid in first and second seasons, respectively. Grain yield/fed showed the same trend for the yield components of maize, i.e. ear length, ear diameter, ear grain wt. and 100-grain weight. These variations in growth, grain yield and its components among maize under this study might be due to differences in their genetic makeup. These results were harmony with those obtained by Lamlom et al. (2015), Gomaa et al. (2017) and El-Ghobashy et al. (2018).

TABLE 2. Effect of intercropping cowpea with some maize hybrids on some growth characters of maize in 2018 and 2019 seasons.

Character / Maize hybrid	Plant height (cm)		No.of green leaves/ plant at 85 days		Stem diameter (mm)		LAI	
	2018	2019	2018	2019	2018	2019	2018	2019
SC 168	282.59	290.83	13.64	13.79	22.31	22.55	5.29	5.43
SC 176	272.44	279.72	12.93	13.08	21.32	22.09	4.43	4.62
TWC 321	294.57	306.39	12.90	12.61	20.65	20.53	5.84	5.75
LSD 0.05	**8.22**	**9.07**	**0.17**	**0.47**	**0.41**	**N.S**	**0.60**	**0.96**

SC= Single cross hybrid, TWC= Three way cross hybrid.

LSD = Least significant differences

TABLE 3. Effect of N nano-mineral fertilization on some growth characters of maize in 2018 and 2019 seasons.

Character / N Treatment	Plant height (cm)		No.of green leaves/ plant at 85 days		Stem diameter (mm)		LAI	
	2018	2019	2018	2019	2018	2019	2018	2019
100% mineral (control)	270.65	288.33	12.94	12.98	21.76	22.14	5.37	5.36
50% mineral + 50% nano	290.48	293.70	13.33	13.33	23.05	22.92	5.68	5.72
75% mineral + +25% nano	310.28	316.30	13.93	13.78	25.35	25.41	6.08	6.04
100% N-urea	261.39	270.92	12.43	12.56	15.54	16.43	3.62	3.94
LSD 0.05	**2.45**	**4.14**	**0.24**	**0.36**	**0.42**	**0.18**	**0.20**	**0.33**

TABLE 4. Interaction effect between intercropping cowpea with some maize hybrids and N nano-mineral fertilization on some growth characters of maize in 2018 and 2019 seasons.

Hybrid x N \ Character		Plant height (cm)		No.of green leaves/ plant		Stem diameter (mm)		LAI	
	Mineral Nano	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
SC 168	100% Miner.	270.28	285.55	13.31	13.60	22.84	23.81	5.53	5.66
	50:50	289.39	291.67	13.87	13.67	24.00	24.25	5.83	6.01
	75:25	308.61	312.78	14.87	14.78	25.57	25.70	6.04	6.16
	100% Nano	262.09	273.33	12.50	13.11	16.82	16.45	3.74	3.88
SC 176	100% Miner.	258.89	270.00	12.83	13.00	21.87	22.11	4.75	4.77
	50:50	279.00	276.11	13.00	13.44	22.70	22.52	4.63	4.78
	75:25	299.17	307.78	13.80	13.89	25.22	25.20	5.29	5.50
	100% Nano	252.71	265.00	12.07	12.00	15.49	18.53	3.06	3.42
TWC 321	100% Miner.	282.78	309.44	12.67	12.33	20.57	20.50	5.82	5.64
	50:50	303.05	313.33	13.12	12.89	22.46	22.00	6.59	6.37
	75:25	323.06	328.33	13.11	12.67	25.26	25.33	6.90	6.45
	100% Nano	269.38	274.44	12.71	12.56	14.31	14.30	4.06	4.52
LSD 0.05		**N.S**	**7.18**	**0.42**	**0.63**	**0.72**	**N.S**	**0.34**	**0.29**

TABLE 5. Effect of intercropping cowpea with some maize hybrids on yield and yield components of maize in 2018 and 2019 seasons.

Maize hybrid \ Character	No of rows/ear		Ear length (cm)		Ear diameter (cm)		Ear grain weight (g)		100-grain weight (g)		Grain yield (ardab/fed)	
	2018	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
SC 168	16.08	15.50	23.67	22.47	4.11	4.04	143.10	148.39	29.04	31.33	22.20	22.85
SC 176	15.15	15.00	21.96	19.64	4.15	4.00	126.22	137.89	28.38	30.25	21.39	21.82
TWC 321	13.13	13.50	17.41	17.39	4.00	3.97	115.87	130.00	23.48	27.00	18.54	18.91
LSD 0.05	**0.35**	**N.S**	**0.14**	**0.51**	**0.06**	**0.17**	**9.25**	**3.26**	**0.41**	**1.62**	**0.50**	**0.83**
Solid grain yield of	**SC 168**	24.70		24.81	**SC 176**	23.60	24.03		**TWC 321**	21.14	21.22	

One ardab of grain maize= 140kg

Effect of N nano- mineral fertilization: Data presented in Table 6 indicated the effect of N nano-mineral fertilization on number of rows/ear, ear length, ear diameter, ear grain wt., 100-grain wt. and grain yield/fed of maize were significant in both seasons, except number of rows/ear was significantly influenced in season one. The highest values of number of rows/ear, ear length, ear grain wt., 100-grain wt. (14.97, 23.31, 4.48, 148.93 and 28.66) in the first seasons, respectively, and (15.33, 21.66, 4.35, 156.96 and 32.89) in the second season. Which were recorded with 75% mineral + 25% nano fertilization, followed by 50% mineral +50% nano and then 100% mineral (control). Meanwhile the lowest values for these characters (14.57, 18.43, 3.70, 111.24 and 24.99) in the first season and (13.56, 18.04, 3.68, 126.78 and 26.89) in the second season were achieved by 100% nano urea. Mahmoodzadeh et al. (2013) reported that direct exposure of wheat plants to specific types of nanoparticles cause significant increase in all growth variables determined at optimum concentrations of nanosolution. The contributory effect of foliar applied fertilizer in this work may be attributed to the fact that the foliar applied fertilizer provides a quicker response and release of some nutrients than soil applied fertilizers but cannot completely replace soil fertilization in maize (Liang & Silberbush, 2002).

Grain yield/fed behaved the same trend of yield components characters in both seasons, where application 75% N mineral along with 25% nano fertilization increased grain yield by 14.54 and

12.36% in first and second seasons, respectively, compared to conventional fertilization. However, separately applied nano fertilization decreased grain yield/fed by 26.62 and 21.17% in the first and second seasons, respectively. At nano scale physical and chemical properties are differing than bulk material (Nel et al., 2006). If fertilizers use as nano form, it increase the availability of elements, may prevent fixation and increased absorption and uptake through different plant parts (Hussein et al., 2015; Hussein & Abu Bakr, 2018). Folia applied fertilizers provide a quicker response and are more effective for some nutrients than soil applied fertilizers (Oluwafemi & Funsho, 2015). Results herein accordance with those obtained by Manikandan & Subramanian (2016), Kandil & Marie (2017), Gomaa et al. (2017, 2018). However, nano fertilizer efficiency depended on size and rate of nanoparticles. Similar results were reported by Mahmoodzadeh et al. (2013) and El-Sharkawy et al. (2017).

Interaction effects: Data presented in Table 7 revealed that ear length, ear diameter, ear grain wt., 100-grain wt., and grain yield/fed were significantly affected by the interaction between maize hybrids and N nano-mineral fertilization in both seasons. Data revealed that SC 168 when fertilized by 75% N mineral of its recommended + 25% N nano achieved the highest values for ear length (25.00 and 24.44), ear diameter (4.55 and 4.46), ear grain wt. (158.80 and 170.78), 100-grain wt., (30.67and 36.00) and grain yield yield/fed (26.52 and 25.96) in the first and second seasons, respectively. Opposite trend of these characters were obtained when maize hybrid TWC321 were fertilized by nano fertilization only, that is true in both seasons. This reduction under 100 % nano fertilizer may be attributed increased toxicity due to high concentration of N nano. This results accordance with those obtained by Khodakovskaya et al., (2012) and Mahmoodzadeh et al. (2013) reported that direct exposure of wheat plants to specific types of nanoparticles cause significant increase in all growth variables determined at optimum concentrations of nano solution.

Cowpea characters

Effect of maize hybrids

Data presented in Table 8 display that all agronomic characters of cowpea i.e., plant height, number of branches/plant, number of leaves/plant, LAI, fresh forage yield of 1st and 2nd cuts as well as total fresh forage yield. The tallest cowpea plants (47.07 and 48.00) were recorded by maize hybrid TWC 321. Meanwhile, the maximum value of number of branches/plant (5.42 and 5.83), number of leaves/plant (46.97 and 47.04), LAI (5.46 and 5.76) and total fresh forage yield/fed (8.90 and 9.67) were obtained under SC 176 maize hybrid in first and second seasons, respectively, followed by intercropping cowpea with SC168 and the lowest values of these characters were showed with intercropped cowpea with maize TWC 321. Maize hybrid SC 176 that had the lowest leaf area index could be allowed more solar radiation penetration to adjacent cowpea plants which reflected positively on No.of branches, leaves number/plant and LAI during cowpea growth and development compared to the other treatments.

TABLE 6. Effect of N nano-mineral fertilization on yield and yield components of maize in 2018 and 2019 seasons.

Character / N Treatment	No of row/ear		Ear length (cm)		Ear diameter (cm)		Ear grain weight (g)		100- grain weight (g)		Grain yield (ardab/fed)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
100% mineral	14.80	14.67	20.08	19.48	3.99	3.94	126.47	133.52	26.65	27.89	21.18	21.35
50% mineral + 50% nano	14.81	15.11	22.22	20.15	4.17	4.04	126.93	137.78	27.56	30.44	21.87	22.60
75% mineral +25% nano	14.97	15.33	23.31	21.66	4.48	4.35	148.93	156.96	28.66	32.89	24.26	23.99
100% nano	14.57	13.56	18.43	18.04	3.70	3.68	111.24	126.78	24.99	26.89	15.54	16.83
LSD 0.05	**N.S**	**0.74**	**0.32**	**0.44**	**0.04**	**0.11**	**8.43**	**4.68**	**0.32**	**0.67**	**0.52**	**0.42**

One ardab of grain maize= 140kg

TABLE 7. Interaction effects between intercropping cowpea with some maize hybrids and N nano-mineral fertilization on yield and yield components of maize in 2018 and 2019seasons.

Hybrid x N treatment		Ear length (cm)		Ear diameter (cm)		Ear grain weight (g)		100- grain weight (g)		Grain yield (ardab/fed)	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
SC 168	100% Mineral	22.58	22.00	4.00	3.92	142.93	146.22	28.63	29.67	22.66	22.75
	50% Min. :50% Nano	24.67	22.33	4.24	4.02	143.27	145.56	30.11	32.00	23.44	25.13
	75% Min. :25% Nano	25.00	24.44	4.55	4.46	158.80	170.78	30.67	36.00	26.52	25.96
	100% nano	22.42	21.11	3.65	3.74	127.40	131.00	26.75	27.67	16.19	17.55
SC 176	100% Mineral	20.83	19.77	4.05	3.99	123.87	134.33	28.75	28.33	22.23	22.40
	50% Min. :50% Nano	24.08	20.34	4.27	4.20	121.80	136.11	29.28	32.33	22.74	23.15
	75% Min. :25% Nano	25.17	20.55	4.54	4.28	146.00	153.45	30.20	33.67	24.88	24.75
	100% nano	17.75	17.89	3.73	3.54	113.20	127.67	25.28	26.67	15.71	16.98
TWC 321	100% Mineral	16.83	16.67	3.92	3.91	112.60	120.00	22.56	25.67	18.64	18.89
	50% Min. :50% Nano	17.92	17.78	3.99	3.91	115.73	131.67	23.30	27.00	19.43	19.52
	75% Min. :25% Nano	19.75	20.00	4.34	4.31	142.00	146.67	25.11	29.00	21.37	21.26
	100% nano	15.13	15.11	3.73	3.74	93.13	121.67	22.94	26.33	14.73	15.97
LSD 0.05		**0.55**	**0.77**	**0.06**	**0.19**	**12.22**	**8.11**	**0.56**	**1.16**	**0.89**	**0.73**

One ardab of grain maize = 140 kg

TABLE 8. Effect of intercropping cowpea with some maize hybrids on some characters of cowpea in 2018 and 2019 seasons.

Hybrid	Plant height (cm)		No.of branches/ plant		LAI		No.of leaves/ plant		Fresh yield of 1st cut (Ton/fed) at 60 days		Fresh yield of 2nd cut (Ton/fed) at 45 days		Total forage yield (Ton/fed) at 105 days	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
SC 168	43.40	46.25	5.28	5.47	4.79	5.33	45.96	46.75	6.16	6.57	2.32	2.29	8.49	8.89
SC 176	42.83	44.11	5.42	5.83	5.46	5.76	46.97	47.04	6.48	7.25	2.42	2.46	8.90	9.67
TWC 321	47.07	48.00	4.30	4.99	4.58	4.93	43.66	44.59	5.73	6.01	2.01	2.05	7.73	8.06
LSD 0.05	**1.56**	**2.21**	**0.28**	**0.82**	**0.54**	**0.38**	**1.03**	**0.72**	**0.31**	**0.54**	**0.20**	**0.22**	**0.41**	**0.36**
Fresh forage yield of cowpea in solid culture									11.57	11.20	5.75	7.20	17.32	18.40

Intercropping cowpea with maize hybrid SC 176 increased total fresh forage yield/fed by 4.83and 15.14% in the first season and by 8.77 and 19.98% in the second one, than those intercropped with maize hybrid SC 168 and TWC 321, respectively. These results may be attributed to the TWC321hybrid which the tallest plant height and highest LAI compared to single cross hybrids. Increased shading effect on cowpea plants may be due to differences among leaf inclination and height of the maize hybrids can result in differences in transmission of radiation to the other component in the intercropping system. Similar results were obtained by Abdel-Galil et al. (2014), Lamlom et al. (2015) and El-Ghobashy et al. (2018).

Effect of N nano-mineral fertilization

Plant height, number of branches/plant, number of leaves/plant, LAI, fresh forage yields of 1st cut and total forage yield were significantly affected by different fertilization treatments Table 9. However 2nd cut of cowpea insignificantly affected by N fertilization treatment in both seasons that result may be due to N fertilizers applied up to 45 days from planting. The results obviously indicated that 75% N mineral + 25% N nano treatment recorded the highest values of these characters, while application of 100% nano urea alone was the lowest once and not suitable for application. 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; Iqbal et al., 2013). Consequently, meristematic activity, stimulation of cell elongation and production of cowpea increased. 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 (Oluwafemi & Funsho, 2015).

Total fresh yield/fed of cowpea gave the same trend of plant height, number of branches/plant, number of leaves/plant and LAI. The increase in forage yield due to applied 75% N mineral of its recommended along with 25% nano was 34.07 and 55.41% in first season and 31.19 and 52.04% in second season compared to conventional urea and nano urea only, respectively. These results may be attributed to foliar fertilization with N nano, which could be used as supplementation with soil applied fertilizers but cannot replace soil fertilization in the case of maize (Liang & Silberbush, 2002). Also, 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). While, high concentration of nano urea adversely affected on growth, yield and its attributes of cowpea plants. Nanoparticles causing many morphological and physiological changes, depending on the properties of NPs. These results are accordance with those obtained by El-Sharkawy et al. (2017) who found that nanoparticles at the low level led to the highest shoot dry weight, relative yield, root length and dry weight of roots in used genotypes.

Interaction effects

Data in Table 10 showed that plant height, number of leaves/plant, LAI, fresh forage yield of 1st cut and total fresh forage yield were significantly affected by the interaction between maize hybrids and N nano-mineral fertilization treatments in both seasons, while number of branches/plant and fresh forage yield of 2nd cut were insignificantly affected in the second season and both seasons, respectively. Data revealed that the highest values were recorded by application 75% mineral + 25% nano and intercropping cowpea with single hybrids compared to three way cross. On the other hand, intercropping cowpea with TWC321 that received 100% nano only recorded the lowest values for these characters, except plant height in both seasons. These results could be attributed to intercropping cowpea with single hybrids positively interacted with 75% mineral + 25% nano to furnished better basic growth recourses and reduced inter specific competition among maize and cowpea plants for cowpea growth and development compared with the other treatments. While, high concentration of nano urea adversely affected on growth, yield and its attributes of cowpea plants. Nanoparticles causing many morphological and physiological changes, depending on the properties of NPs. The NPs efficiency is determined by their chemical composition, surface covering, size, reactivity, and the most importantly is the dose which they are effective (Khodakovskaya et al., 2012). Adding K2SO4 nanoparticles at the low level led to the highest shoot dry weight, relative yield, root length and dry weight of roots in used genotypes (El-Sharkawy et al., 2017). On the other hand, Emara et al. (2018) found that foliar application with Nano fertilizer Lithovit at (5g/L water) gave the high productivity of Egyptian cotton variety Giza 86 compared to control and Lithovit at (2.5g/L water).

TABLE 9. Effect of N nano-mineral fertilization on some characters of cowpea in 2018 and 2019 seasons.

Character / N Treat.	Plant height (cm)		No.of branches/ plant		No.of leaves/ plant		LAI		Fresh yield of 1st cut (Ton/fed) at 60 days		Fresh yield of 2nd cut (Ton/fed) at 45 days		Total forage yield (Ton/fed) at 105 days	
	2018	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
100% mineral	40.42	40.56	4.81	4.84	40.32	41.13	4.72	5.30	5.52	5.91	2.21	2.33	7.72	8.24
50% Min.+50% Nano	48.02	51.52	5.16	5.66	52.01	52.76	5.07	5.50	6.39	6.97	2.36	2.36	8.77	9.34
75% Min. +25% Nano	56.31	58.00	5.98	7.41	56.31	56.72	6.00	6.16	7.99	8.48	2.36	2.33	10.35	10.81
100% Nano	32.98	34.40	4.04	3.81	33.47	33.87	3.99	4.40	4.59	5.07	2.07	2.04	6.66	7.10
LSD 0.05	**3.18**	**2.03**	**0.40**	**0.35**	**1.27**	**1.24**	**0.22**	**0.31**	**0.22**	**0.19**	**N.S**	**N.S**	**0.35**	**0.38**

TABLE 10. Interaction effect between intercropping cowpea with some maize hybrids and N nano-mineral fertilization on cowpea characters in 2018 and 2019 seasons.

Hybrid x N	Character	Plant height (cm)		No.of branches/ plant		No.of leaves/ plant		LAI		Fresh forage yield of 1st cut (Ton/fed)		Total fresh forage yield (Ton/fed)	
	Min. :Nano	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
SC 168	100% mineral	43.33	44.22	5.17	5.00	40.42	40.83	4.74	5.32	5.57	5.88	7.91	8.14
	50:50	46.4	48.22	5.40	5.44	52.40	53.25	4.85	5.35	6.62	6.71	8.92	9.08
	75:25	50.73	57.67	6.20	7.45	56.29	57.69	5.59	6.32	8.05	8.72	10.45	11.18
	100% Nano	33.13	34.89	4.33	4.00	34.71	35.21	3.98	4.34	4.40	4.98	6.69	7.04
SC 176	100% mineral	37.27	37.67	5.07	5.22	41.33	42.36	4.94	5.42	5.98	6.63	8.23	9.23
	50:50	45.60	52.44	5.40	6.11	53.38	52.7	5.59	6.01	6.65	7.86	9.33	10.35
	75:25	56.40	53.33	6.87	7.55	57.67	56.88	6.93	6.62	8.15	8.79	10.65	11.21
	100% Nano	32.07	33.00	4.33	4.44	35.51	36.22	4.37	4.96	5.14	5.70	7.40	8.02
TWC 321	100% mineral	40.67	39.78	4.20	4.31	39.20	40.21	4.46	5.17	5.00	5.21	7.03	7.35
	50:50	52.07	53.89	4.67	5.44	50.27	52.34	4.75	5.12	5.91	6.35	8.06	8.58
	75:25	61.80	63.00	4.87	7.22	54.98	55.6	5.49	5.53	7.78	7.93	9.96	10.03
	100% Nano	33.73	35.33	3.47	3.00	30.20	30.19	3.61	3.89	4.22	4.54	5.88	6.28
LSD 0.05		**5.51**	**3.51**	**0.69**	**N.S**	**2.20**	**2.66**	**0.39**	**0.53**	**0.37**	**0.33**	**0.46**	**0.55**

Competitive relationships:

Land equivalent ratio (LER): Data presented in Table 11 clearly indicated that land equivalent ratio in all treatments of the interaction between maize hybrids and N nano-mineral fertilization were greater than one in both seasons, indicating that it is advantageous to grow maize and cowpea in association than in solid culture. The increases were arranged between 4% and 67% in first season and 9 to 66% in the second season. Data showed that Lm was more contributed for LERs compared with Lc in both seasons. This result may be due to maize components usually tended to have greater competitive ability over cowpea. Also, data illustrated that the highest value for LER as recorded when maize SC 168 hybrid fertilized by 75% mineral + 25% nano in both seasons, whilst the lowest values obtained by TWC 321 that received 600ppm N nano (100% nano) only in both seasons, since high concentration unsuitable for application. Intercropping cowpea with hybrid SC168 that received 75% mineral + 25% nano enhance growth and development of the intercrops as a result of decreasing inter specific competition between maize and cowpea plants for basic growth resources and in turn more efficient utilization of the basic resources. Maize hybrid SC 168 had lower leaf area index than TWC 321 (Table 2) could be passed more solar radiation to the intercropped cowpea plants and consequently more dry matter accumulation of cowpea plants by enhancing the photosynthetic process. These results are in parallel with those obtained by Saudy (2015), Abdel-Wahab et al. (2016) and Olowolaju & Okunlola (2017).

Area time equivalent ratio (ATER): ATER provides more realistic comparison of the yield advantage of intercropping over sole cropping in terms of variation in time taken by the component crops of intercropping culture. Total ATER values were more than one in all treatments (Table 11). In all the treatments, the ATER values were lesser than LER values indicating the over estimation of resource utilization. the highest ATER (1.59 and 1.58) were obtained when intercropped cowpea with maize SC 168 hybrid and fertilized by 75% of recommended dose of mineral N along with foliar application by 150ppm N nano (25% nano) in both seasons, respectively. These values indicated that intercropping system was highly efficient in utilizing the growth resources than solid culture of both crops at the optimum nano fertilizer rate. This result was accordance with those obtained by Takim (2012), Olowolaju & Okunlola (2017) and El-Ghobashy et al. (2018).

Aggressivity (A): Aggressivity determines the difference in competitive ability of the component crops in intercropping association. The positive sign indicates the dominant component and the negative sign indicates the dominated component. Higher numerical values of aggressiveness denote greater difference in competitive ability, as well as, bigger difference between actual and expected yield in both crops. The results indicate that the value of aggressivity of maize was positive for all treatments, whereas, the value of aggressivity was negative for all intercropped cowpea in both seasons as shown in Table 11. Maize plants were dominant, whereas cowpea plants were dominated component. In general, the highest negative values were obtained by intercropping cowpea with TWC 321 hybrid that received 100% mineral fertilization, meanwhile, intercropping cowpea with SC176 hybrid and fertilized by 100% nano urea only had the lowest negative values. Similar results are accordance with Takim (2012) and Saudy (2015) they found that maize was the dominant crop, while cowpea was the dominated one.

TABLE 11. Effect of intercropping cowpea with some maize hybrids and N nano-mineral fertilization on LER, ATER and aggressivity in 2018 and 2019 seasons.

Hybrid x N	Character	L maize		L cowpea		LER		ATER		Aggressivity			
										2018		2019	
	Min.: Nano	2018	2019	2018	2019	2018	2019	2018	2019	Ag m	Ag c	Ag m	Ag c
SC 168	100% Min.	0.92	0.92	0.46	0.44	1.38	1.36	1.32	1.31	+0.39	-0.39	+0.43	-0.43
	50:50	0.95	1.01	0.52	0.49	1.47	1.50	1.40	1.45	+0.30	-0.30	+0.46	-0.46
	75:25	1.07	1.05	0.60	0.61	1.67	1.66	1.59	1.58	+0.28	-0.28	+0.23	-0.23
	100% Nano	0.66	0.71	0.39	0.38	1.05	1.09	1.00	1.05	+0.13	-0.13	+0.23	-0.23
SC 176	100% Min.	0.94	0.93	0.48	0.50	1.42	1.43	1.36	1.37	+0.38	-0.38	+0.31	-0.31
	50:50	0.96	0.96	0.54	0.56	1.50	1.52	1.44	1.46	+0.26	-0.26	+0.21	-0.21
	75:25	1.05	1.03	0.61	0.61	1.66	1.64	1.58	1.56	+0.22	-0.22	+0.20	-0.20
	100% Nano	0.67	0.71	0.43	0.44	1.10	1.15	1.04	1.09	+0.04	-0.04	+0.09	-0.09
TWC 321	100% Min.	0.88	0.89	0.41	0.40	1.29	1.29	1.24	1.24	+0.48	-0.48	+0.49	-0.49
	50:50	0.92	0.92	0.47	0.47	1.39	1.39	1.32	1.33	+0.37	-0.37	+0.37	-0.37
	75:25	1.01	1.00	0.58	0.55	1.59	1.55	1.50	1.48	+0.25	-0.25	+0.31	-0.31
	100% Nano	0.70	0.75	0.34	0.34	1.04	1.09	0.99	1.05	+0.32	-0.32	+0.41	-0.41

LER: Land equivalent ratio.

ATER: Area time equivalent ratio.

Economic evaluation

Data presented in Table 12 indicated that all the combination between maize hybrids and N nano-mineral fertilization recorded higher values for gross return and net return as compared with solid culture of maize hybrids in both seasons, except three treatments. The combination between treatments which included 120 kg N/fed as100% N mineral, 50% mineral +50% nano and 75% mineral + 25% nano with three maize hybrids (9 treatments out of 12) recorded higher values for gross return and net return compared with solid culture of maize hybrids in both seasons, However, any maize hybrids under study which fertilized by nano urea only achieved the lowest values of gross return and net return compared with solid culture (3 treatments out of 12) in both seasons. This results it is expected since applying foliar nano urea only not suitable for application and decreased yield of maize and cowpea comparison with mineral soil application. Nanoparticles causing many morphological and physiological changes, depending on the properties of NPs. The NPs efficiency is determined by their chemical composition, surface covering, size, reactivity, and the most importantly is the dose which they are effective (Khodakovskaya et al., 2012). Similar results obtained by (Liang & Silberbush, 2002).

Intercropping cowpea with SC 168 maize hybrid gave the highest gross return (15865 and 15854LE/fed) and net return (7983 and 7972 L.E./fed) when fertilized by 75% mineral + 25% nano in first season and second season, respectively. On the other hand, the intercropping with TWC maize hybrid produced the lowest gross return (8834 and 9550 LE/fed) and net return (1264 and 1980 LE/fed) when fertilized by nano urea only in first and second seasons, respectively. Economic benefit was higher in maize/cowpea intercropping systems (Takim, 2012; Saudy, 2015; Abdel-Wahab et al., 2016; Olowolaju & Okunlola, 2017).

TABLE 12. Effect of maize hybrids and N nano-mineral fertilization on total and net return in 2018 and 2019 seasons.

Hybrid X N (Character)		Gross return (LE/fed)						Average cost of both seasons (LE/fed)	Net return (LE/fed)	
		Maize		Cowpea		Total				
	Mineral: Nano	2018	2019	2018	2019	2018	2019		2018	2019
SC168	100% Min.	10877	10920	2373	2442	13250	13362	7985	5265	5377
	50%:50%	11251	12062	2676	2724	13927	14786	7778	6149	7008
	75%:25%	12730	12461	3135	3393	15865	15854	7882	7983	7972
	100% Nano	7771	8424	2007	2112	9778	10536	7570	2208	2966
SC 176	100% Min.	10670	10752	2469	2769	13139	13521	7985	5154	5536
	50%:50%	10915	11112	2799	3105	13714	14217	7778	5936	6439
	75%:25%	11942	11880	3195	3324	15137	15204	7882	7255	7322
	100% Nano	7541	8150	2220	2406	9761	10556	7570	2191	2986
TWC 321	100% Min.	8947	9067	2109	2205	11056	11272	7985	3071	3287
	50%:50%	9326	9370	2418	2574	11744	11944	7778	3966	4166
	75%:25%	10258	10205	2988	3009	13246	13214	7882	5364	5332
	100% Nano	7070	7666	1764	1884	8834	9550	7570	1264	1980
Pure SC168		11856	11909	-	-			7535	4321	4374
Pure SC 176		11328	11534	-	-			7535	3793	3999
Pure TWC 321		10147	10186	-	-			7535	2612	2651

Prices of main products are that of 2018: L.E. 480 for one ardab of maize grains and L.E. 300 for one ton of cowpea.

Conclusion

It could be concluded that intercropping cowpea with maize hybrid SC 168 and 75% of recommended dose of mineral N along with 25% nano urea, increased productivity of maize by 17.03 and 14.11% and total fresh forage of cowpea by 32.11and 38.94% compared with mineral fertilization in first and second seasons, respectively. Maximizing LER (1.67 and 1.66), ATER (1.59 and 1.58), gross return 15865 and 15854LE/fed and net return 7983 and 7972LE/fed in first and second seasons, respectively, as well as rationalize the use of N mineral fertilizers and gaining added value that is reflected in the forage yield of cowpea. Under this study, results indicated that the high concentration of N nano (600ppm) was not suitable for application.

References

Abdel-Aziz, H.M.M., Hasaneen, M.N.A., Omer, A.M. (2016) Nano chitosan-NPK fertilizer enhances the growth and productivity of wheat plants grown in sandy soil. *Spanish Journal of Agricultural Research,* **14**(1), 1-9.

Abdel-Galil, A.M., Abdel-Wahab, Sh.I., Abdel-Wahab, T.I. (2014) Compatibility of some maize and soybean hybrids for intercropping under sandy soil conditions. *Proc. 1st Conf. of Inter. Soybean Res., Indore,* 22–24 February, India.

Abdel-Wahab, Sh.I., El Sayed, W.M., El-Manzlawy, Amal M. (2016) Influences of some preceding winter crops and nitrogen fertilizer rates on yield and quality of intercropped maize with cowpea. *American J. Exper. Agric.* **11**(6), 1-19.

Auffan, M., Bottero, J.Y., Wiesner, M.R. (2009) Chemical stability of metallic nanoparticles: A parameter controlling their potential cellular toxicity *in vitro*. *Environ. Poll.* **157,** 1127-1133.

Black, C.A. (1965) "*Methods of Soil Analysis*". Am. Soc. Agron. Madison, Wisc. USA.

Bulletin of Statistical Cost Production and Net Return (2016 and 2018) Summer and Nili Field Crops and Vegetables and Fruit. Agriculture Statistics and Economic Sector, Ministry of Egyptian Agriculture and Land Reclamation", Part (2), August 2018, Egypt.

Corradini, E., de Moura, M.R., Mattoso, L.H.C. (2010) A preliminary study of the incorporation of NPK fertilizer into chitosan nanoparticles. *Express Polymer Letters,* **4,** 509-515.

El-Ghobashy, Y.E., Shams, A.S., Lamlom, M.M. (2018) Maximizing land use efficiency by intercropping cowpea with some maize hybrids under different maize planting geometries. *Agric. Sci.* **9**, 1601-1620.

El-Shamy, M.A., Abdel-Wahab, T.I., Abdel-Wahab, Sh.I., Ragheb, S.B. (2015) Advantages of intercropping soybean with maize under two maize plant distributions and three mineral nitrogen fertilizer rates. *Advances in Bioscience and Bioengineering*. **3**(4), 30-48.

El-Sharkawy, M.S., El-Beshsbeshy, T.R., Mahmoud, E.K., Abdelkader, N.I., Al-Shal, R.M., Missaoui, A.M. (2017) Response of alfalfa under salt stress to the application of potassium sulfate nanoparticles. *American J. Plant Sci.* **8,** 1751-1773.

Emara, M.A.A., Hamoda, S.A.F., Hamada, M.M.A. (2018) Effect of Nano-fertilizer and n-fertilization levels on productivity of Egyptian cotton under different sowing dates. Egypt. J. Agron. *The 15th Int. Conf. Crop Science*, pp. 125–137.

Freed, R.D. (1991) MSTATC Microcomputer Statistical Program. Michigan State University, East Lansing, Michigan, USA.

Gomaa, M.A., Radwan, F.I., Kandil, E.E., Al- Challabi, D.H.H. (2017) Comparison of some new maize hybrids response to mineral fertilization and some nanofertilizers. *Alex. Sci. Exch. J.* **38**(3), 506-514.

Gomaa, M.A., Radwan, F.I., Kandil, E.E., Al-Msari, M.A.F. (2018) Response of some Egyptian and Iraqi Wheat hybrids to mineral and nanFertilization. *Egy. Acad. J. Biolog. Sci.* **9**(1), 19-26.

Gomez, K.A., Gomez, A.A. (1984) "*Statistical Procedures for Agricultural Research*". 2nd ed. Toronto, ON, Canada: John Willey and Sons.

Hasaneen, M.N.A., Abdel-Aziz, H.M.M., Omer, A.M. (2016) Effect of foliar application of engineered nanomaterials: carbo nanotubes NPK and chitosan nanoparticles NPK fertilizer on the growth of French bean plant. *Biochemistry and Biotechnology Research*, **4**(4), 68-76.

Hediat, M.H., Salama, A. (2012) Effects of nanoparticles in some crop plants, Common bean (*Phaseolus vulgaris* L.) and corn (*Zea mays* L.). *Inter. Res. J. Biote.* **3**(10), 190-197.

Hiebsch, C.K. (1980) Principles of intercropping. Effect of N fertilization and crop duration on equivalence, ratios in intercrops versus monoculture comparisons. *PhD Thesis*. North Carolina State Univ., Raleigh, N. C.Y., USA.

Hussein, M.M., Abu-Baker, N.H. (2018) The contribution of nano-zinc to alleviate salinity stress on cotton plants. *R. Soc. Opensci.* **5,** 1-11.

Hussein, M.M., El-Ashry, S.M., Haggag, W.M., Mobark, D. (2015) Response to moisture stress and nano fertilizer during different growth stages of cotton plants. *Intr. J. Chem. Tech. Res.* **8**(12), 643-650.

Idoko, J.A., Kalu, B.A., Osang, P.O. (2018) Influence of maize hybrids and date of planting cowpea into maize/cowpea intercropping system in Makurdi, Southern Guinea Savannah, Nigeria. *Inter. J. of Sci.: Basic and Appl. Res.* **38**(1), 98-113.

Iqbal, S., Khan, H.Z., Akbar, Ehsanullah N., Zamir, M.S.I., Javeed, H.M.R. (2013) Nitrogen management studies in maize hybrids. *Cercetări Agron. in Moldova,* **3**, 39-48.

Kandil, E.E., Marie, E.A.O. (2017) Response of some wheat hybrids to nano-, mineral fertilizers and amino acids foliar application. *Alex. Sci. Exch. J.* **38**(1), 53-68.

Khodakovskaya, M.V., Biris, K.de Silva A.S., Dervishi, E., Villagarcia, H. (2012) Carbon nanotubes induce growth enhancement of tobacco cells. *ACS Nano,* **6**(3), 2128-2135.

Lamlom, M.M., Abdel-Wahab, Sh.I., Abdel-Wahab, T.I., Gendy, E.K. (2015) Chemical and biological influences of some preceded winter field crops on productivity of intercropped three maize hybrids with soybean. *Donnish J. Agric. Res.* **2**, 55-65.

Liang, F., Silberbush, M. (2002). Response of maize to foliar vs. soil application of nitrogen–phosphorus–potassium fertilizers. *J. Plant Nutrition,* **25**, 2333-2342.

Liu, J., Zhang, Y.D., Zhang, Z.M. (2009) The application research of nano-biotechnology to promote increasing of crop production. *Hubei. Agric. Sci.* **48**, 123-127.

Mahmoodzadeh, H., Aghili, R., Nabavi, M. (2013) Physiological effects of TiO_2 nanoparticles on wheat (*Triticum aestivum*). *Technical J. Engin. and Appl. Scie. Science Explorer Publications,* **3**(14), 1365-1370.

Manikandan, A., Subramanian, K.S. (2016) Evaluation of zeolite based nitrogen nano-fertilizers on maize growth, yield and quality on inceptisols and alfisols. *Inter. J. Plant Soil Sci.* **9**(4), 1-9.

Mc-Gilchrist, C.A. (1965) Analysis of competition on experiments. *Biometrics*, 21975-985.

Nel, A., Xia, T., Madler, L., Li, N. (2006) Toxic potential of materials at the nano level. *Science,* **311**, 622-627.

Olowolaju, E.D., Okunlola, G.O. (2017) Comparative advantage of intercropping maize, cowpea and tomato to sole and mixed culture. *Annals of West University of Timişoara, ser. Biology,* **20**(1), 31-38.

Oluwafemi, A.B., Funsho, F.E. (2015) Response of Hybrid Maize, (*Zea mays* L.) to organic and inorganic fertilizers in soils of South-West and North-Central Nigeria. *IJPSS,* **7**(2), 121-127.

Paudel, M.M. (2009) Evaluation of hybrid and OPV maize hybrids for grain yield and agronomic attributes under farmers field conditions at Dukuchhap. *Nepal Agric. Res. J.* **9**, 17-20.

Qureshi, A., Singh, D.K., Dwivedi, S. (2018) Nanofertilizers: A novel way for enhancing nutrient use efficiency and crop productivity. *Int. J. Curr. Microbiol. App. Sci.* **7**(2), 3325-3335.

Saudy, H.S. (2015) Maize–cowpea intercropping as an ecological approach for nitrogen-use rationalization and weed suppression. *J. Archives Agron. Soil Sci.* **61**(1), 1-14.

Sheahan, C.M. (2012) Plant guide for cowpea (*Vigna unguiculata*). USDA-Natural Resources conservation service, Cape May Plants Materials Center, Cape May, NJ.

Shen, Q.R., Chu, G.X. (2004) Bi-directional nitrogen transfer in an intercropping system of peanut with rice cultivated in aerobic soil. *Biol. Fertil. Soils*. **40**(2), 81-87.

Takim, F.O. (2012) Advantages of maize-cowpea intercropping over sole cropping through competition indices. *J. Agric. Biodiversity Res.* **1**(4), 53-59.

Toungos, M.D., Zambua, B.W., Babayola, M. (2018) The performance of maize-cowpea intercropping as affected by hybrid and cropping patterns in Mubi, Northern Guinea Savanna of Nigeria. *Int. J. Innovativa Food, Nut. & Sust. Agric.* **6**(3), 54-60.

Willey, R.W. (1979) Intercropping its importance and research needs. Part I: Competition and yield advantages. *Field Crops Abst.* **32**, 1-10.

Wu, L., Liu, M.Z. (2008) Preparation and properties of chitosan-coated NPK compound fertilizer with controlled-release and water-retention. *Carbohydr. Polym.* **72**(2), 240-247.

تأثير تحميل لوبيا العلف مع بعض هجن الذرة الشامية والتسميد النيتروجيني النانو والمعدني على الإنتاجية بالأراضى الملحية.

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أجريت هذه الدراسة في محطة بحوث السرو - مركز البحوث الزراعية، خلال الموسمين 2018 و2019 بمحافظة دمياط، بهدف دراسة تاثير تحميل لوبيا العلف مع بعض هجن الذرة الشامية (هـ.ف 168، هـ.ف 176 و هـ.ث 321) وأربع معاملات من التسميد النتروجينى المعدنى والنانو هى 1-120 كجم ن/ف فى صورة يوريا (100% معدنى). 2- 50% ن معدنى + 50% نانو يوريا. 3- 75% ن معدنى + 25% نانو يوريا. 4- 100% نانو يوريا (بمعدل 3 سم^3 سماد نانو/ لتر) على إنتاجية الذرة ولوبيا العلف وكفاءة استخدام الأرض والعائد الأقتصادى. تم استخدام تصميم القطع المنشقة فى ثلاث مكررات. يمكن تلخيص أهم النتائج على النحو التالي: -

أثرت هجن الذرة الشامية المحمله مع لوبيا العلف معنوياً على معظم صفات الذرة ولوبيا العلف تحت الدراسة فى كلا الموسمين. تفوق الهجين الفردى 168 فى محصول الحبوب/فدان ومكوناتة، بينما تحميل لوبيا العلف مع الهجين الفردى 176 حقق اعلى محصول من لوبيا العلف بالمقارنة مع الهجن الأخرى. أدى التسميد ب 75% ن معدنى + 25% يوريا نانو إلى زيادة معنوية فى المحصول ومكوناتة لكلا من الذرة الشامية و لوبيا العلف المحملين، فى كلا الموسمين. التفاعل بين هجين الذرة 168 والتسميد بمعدل 75% ن معدنى + 25% يوريا نانو حقق زيادة معنوية فى محصول الذرة ولوبيا للفدان. تحميل لوبيا العلف مع هجين الذرة الفردى 168 والتسميد بمعدل 75% ن معدنى +25% نانو حقق أعلى قيمة للمكافئ الأرضى 1.67 و1.66، والمكافئ الزمنى 1.59 و1.58 وأقل عدوانية 0.28 و0.23 وإجمالي عائد 15865 و15854 جنية/ فدان وصافي الدخل 7983 و7972 جنيه/ فدان في الموسم الأول والثانى، على التوالي، كما ساهمت فى ترشيد استخدام السماد النتروجينى.