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Effect of Fertility Stress Mitigation on Cotton (*Gossypium barbadense* L.) Yield and Nutrient Status under Calcareous Soil Conditions

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Abstract: Calcareous soils are characterized with high pH and dominated $CaCO_3$ which lead the plants to suffer from low availability of macro and micro-nutrients and cause problems more serious than their deficiencies. Increasing availability of these nutrients is one of the important objectives in plant nutrition to mitigate nutrient stress in such problem soils. Therefore, two field trials were conducted in the summer seasons of 2017 and 2018 to study the interactions between composted sludge, N and P fertilizers in order mitigate the fertility stress on nutrients particularly phosphorus as the availability of this nutrient tends to be restricted on such calcareous soils. The experiment included 32 treatments which were the combinations of three compost rates i.e.; 0, 5, 10 and 15 $m^3 fd^{-1}$ as well as 4 additional phosphatic fertilizer rates 0, 15.5, 22.75 and 31 kg $P_2O_5 fd^{-1}$ as well as two N fertilizer levels 0 and 64 kg N fd^{-1}. The results showed that addition of compost resulted in highly significant effects ($P<0.001$) on all of the measured parameters. Seed cotton yields and biological yields were significantly increased by P fertilizer addition compared with the control treatment and the largest seed cotton yield was on the highest P fertilizer addition (31 kg P_2O_5 fd^{-1}), whereas the largest biological yield was at the lowest rate (15.5 kg P_2O_5 fd^{-1}). The application of nitrogen at 64 kg N fd^{-1} resulted in small non-significant increases in seed cotton yield and total biological yield. The interactions between compost and P fertilizer addition were statistically significant for each of the measured parameters (plant height and total crop yield at $P<0.01$ and seed cotton yield highly significant at $P<0.001$). The interaction between compost and N fertilizer was significant only for plant height, which was decreased by the addition of N with compost. Seed cotton yield and total crop yield were not affected by the addition of N fertilizer to the compost, although there was an indication that at the higher rates of compost addition, N fertilizer reduced seed cotton yield. The interactions between P and N fertilizers confirms the lack of sensitivity to N fertilizer to this crop and that the crop was much more responsive to the addition of P. Phosphate fertilizer on its own generally produced larger yields than when in combination with N fertilizer. The statistical analysis confirms that the optimum application rate for compost for maximum seed cotton yield is 10 m^3 fd^{-1} with 15.5 kg P_2O_5 fd^{-1} and no added nitrogen fertilizer. Higher rates of P fertilizer gave no additional yield benefit and the addition of nitrogen fertilizer depressed yields, since the N fertilizer generally increased total crop yield at the expenses of economic yield. Nutritional status of macro and micro-nutrients revealed that significant main effects were detected for Mn due to nitrogen fertilizer and for N, P, K and Fe from compost application. The interactions between nitrogen fertilizer and compost were only just significant for N, P and Zn, but inspection of the means revealed no consistent trends. Nitrogen and K concentrations are rather small in all treatments but P appears generally adequate. Manganese and Zn concentrations were borderline deficient and copper was below the recommended level for optimum crop production. Therefore improving P and other macro and micronutrients could effectively mitigate the circumstances of cotton growth under such severe conditions ($CaCo_3$>36%).

Key words: Calcareous soils · Composted sludge · Cotton · Nutrients

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INTRODUCTION

Cotton is one of the most important crops for both local industry and export. However, both area and production are decreasing from one year to another in Egypt [1]. The world area of cotton (*Gossypium barbadense* L.) harvested in 2014 was 34 747 265 ha with the world production of 79 069 252 tonnes of seed cotton. Egypt's harvested area of cotton in 2014 was 155.054 ha with the seedcotton production of 525 000 tonnes, [2].

Two major decisions should be taken to restore the situation of the Egyptian cotton. Through the improvement of the growing conditions of the crop or simply improving the crop management. Due to the difficulty of expansion of cotton cultivation in the old lands for competition with other strategic crops or irrigation system adopted in such soils (flood) which increase water consumption, it is necessary to find additional areas for horizontal expansion to grow cotton under rationalized use of water. One of the soil types candidated for this purpose is the calcareous soils. Calcareous soils are common in the arid areas of the earth [3] occupying >30% of the earth's surface and their $CaCO_3$ content varies from just detectable up to 95% [4]. The calcareous soils area in Egypt around 0.65 million feddans [5]. The North Western Coastal region of Egypt is considered as one of the important regions for its considerable potentialities and location. In calcareous soils where pH is high and $CaCO_3$ is dominated, plants sufferfrom low availability of P and K and would cause problems more serious than their deficiencies. Increasing availability of these nutrients is one of the important objectives in plant nutrition [6].

Soil fertility stress under calcareous soils was found to be an important factor for the lower cotton yield in Bangladesh. Supplying optimal quantities of mineral nutrients of macro and micronutrients to growing crops is one way to improve crop yields [7]. According to several authors the improvement of fertility and quality of soil requires the input of organic materials [8-10]. Singh and Ahlawat [11] reported that 25% substitution of recommended dose of nitrogen through farmyard manure played a significant role in increasing cotton growth parameters and seed cotton yields in a cotton/peanut intercropping. Furthermore, organic fertilizer inputs enhanced cotton productivity, NUE and soil N fertility, with the BF treatment presenting greater results than the CM treatment when applied at an equivalent rate [12]. In fact, organic nutrients not only provide plant with nutrients but also enhance and / or sustain the soil health. The micronutrients content in organic fertilizer may be sufficient enough to meet the plant requirement, but problem of soil low fertility is one of the obstacles to mention and sustain agricultural management and productivity [13, 14]. However, the use of appropriate and conjunctive use of application of suitable nutrients through organic and inorganic solely or in combination can provide the solution to the problems such as increase in the price of inorganic fertilizers and deterioration effect of soil fertility and productivity [15].

The reported data of [16] indicated that phosphorus application improves cotton yield by enhancing reproductive organ biomass and nutrient accumulation in two cotton cultivars with different phosphorus sensitivity. Reiter and Kreig [17] reported some positive and notable P effects on lint quality factors, although both lint yield and lint quality were driven more by moisture availability than by P. Echer, *et al.* [18] mentioned that phosphorus is a nutrient related to the energy supply used in the production of photoassimilates [19]. Brazilian soils are poor in P and the use of adequate levels of fertilization may improve the cultivar's yield [20]. In addition to the direct benefits that this nutrient on cotton, it can also be noted that P deficiency can reduce the absorption of N, K and zinc [21].

Cotton, like most crops, requires N for normal growth and development and farmers rely heavily on N fertilizers. Research involving N in cotton has been studied for many years [22-24]. Nitrogen is required through all phases of plant development because this essential element is a constituent of both structural (cell membranes) and nonstructural (amino acids, enzymes, protein, nucleic acids and chlorophyll) components of the plant. Without sufficient N, deficiency symptoms in cotton include stunting, chlorosis; and fewer and smaller bolls [25, 26].

Therefore, the experiments aimed to study the interactions between composted sludge and N and P fertilizers. This should provide more detailed information on the fertilizer value of compost, particularly phosphorus as the availability of this tends to be restricted on such calcareous soils. Cotton has been selected, not only because it is an industrial crop, but it also responds adversely to excessive nitrogen applications and so is a particularly sensitive crop to the interactions with other nutrients.

MATERIALS AND METHODS

Two field trials were conducted in the summer seasons of 2017and 2018 tostudy the interactions between composted sludge and K fertilizersin order to

Table 1: Physico chemical soil analysis

Clay (%)	Silt (%)	Sand (%)	Texture class
23.3	22.5	54.2	Sandy clay loam

				Total concentration ($mg\ kg^{-1}$)											
pH	EC ($dS\ m^{-1}$)	OM (%)	$CCaCO_3$ (%)	N	P	K	Fe	Mn	Zn	Cu	Cr	Co	Cd	Pb	Ni
8.14	0.39	1.45	33.0	2300	89	3393	11600	106.0	17.8	5.8	6.90	12.5	0.50	4.52	40.0

Table 2: Analysis and nutrient addition of composted sludge applied to cotton

					Total content (% ds)		Total content ($mg\ kg^{-1}$ ds)		Total concentration ($mg\ kg^{-1}$)							
ds (%)	VS (% ds)	OM (% ds)	pH	EC ($ds\ m^{-1}$)	N	P	K	Fe	Mn	Zn	Cu	Ni	Cd	Pb	Cr	Co
87.2	42.8	25.5	7.7	1.82	1.59	0.19	0.30	1.55	132	488	186	46	0.60	43	47	14
Nutrient application $-m^3$					Macronutrient kg- m^3				Micronutrient g- m^3							
					1.113	0.133	2.1	1.085	92.4	341.6	130.2	32.2	4. 20	30.1	32.9	9.8

provide more detailed information on the fertilizer value of compost, particularly phosphorus as the availability of this nutrient tends to be restricted on such calcareous soils. The experiments were conducted in on a private farm Bagdad village Nubaria, Alexandria governorate (28 km Alex-Cairo desert road). The soil under the present investigation was characterized by high calcium carbonate and low fertility status that could influence crop growth. The physical and chemical analysis of the soils are presented in Table 1.

The experiment included 32 treatments which were the combinations of three compost rates i.e.; 0, 5, 10 and 15 $m^3 fd^{-1}$ as well as 4 additional phosphatic fertilizer rates 0, 15.5, 22.75 and 31 kg $P_2O_5\ fd^{-1}$as well as two N fertilizer levels 0 and 64 kg N fd^{-1}. The experimental design was Split-Split plot Design with 4 replicates. The organic manure occupied the main plots phosphorus fertilizer levels in the sub plots and N fertilizer levels applied to the sub –sub plots. The composted sludge analyses used in the trial are presented in Table 2 (means of two seasons of study).

The experimental area was ploughed twice, ridged and divided to experimental unites each of $21m^2$. Organic manures rates were applied after manually calibration on a volumetric basis to the assigned plots. In order to secure homogenous incorporation with the soil surface layer, a rotary cultivator was used. Cotton variety was Giza 85 (Mubarak) seeds were sown in the experimental plots on 22 April 2017 and 27 April 2018, respectively Sowing was done by hand and Seed ratewas30 kg fd^{-1}, phosphatic fertilizer levels were applied assuperphosphate 15.5% P_2O_5 at 0, 15.5, 22.5 and 31.5 kg fd^{-1} during seed bed preparation whilenitrogen fertilizer levels were applied in two equal doses at 21 and 35 days from sowing as well as a common application of potassic fertilizer was applied at 24kg $K_2O\ fd^{-1}$. Before the second irrigation. Irrigation was carried out as followed in the district twice a week by drip irrigation. Weeds were controlled by manual cultivation after 20 and 34 days from sowing. Harvest date was29 and 27 October in 2017 and 2018, respectively.

Cotton leaf samples were taken on the 2nd week of August in both seasons seed-cotton yield and biological yield was determined from two central rows of each plot by quadrat.

The chemical analyses of soil, manure and leaves were carried out according to the methods described by [27] and [28]. The data were statistically processed using software package (MSTAT-C) [29]. LSD 5% test was adopted foe means comparison.

RESULTS

Nutrient Addition to Cotton: The chemical analysis of the composted sludge is given in Table 2. The data show that 1.113, 0.133 and 2.1 $kg^{-}\ m^3$ of N, P and K, respectively were applied to cotton. Micronutrient addition were 1.085 kg of Fe as well as 92.4, 341.6 and 130.2 g m^3 of Mn, Zn and Cu, respectively. Heavy metals addition were too small and could not pose any threat according to the alkaline nature of the soil and high pH values. These results are in accordance with the results of [30] who reported that sludge has improved the nutrient content of the crops, including that of the trace elements, which are often deficient in crops and the human diet in Egypt. Increases in the heavy metal content of plants were negligible due to the calcareous soil conditions of Egypt.

Tables 3 shows the main effects of fertilizer treatments on plant height, seed cotton yield and biological yield. The addition of compost resulted in highly significant effects ($P<0.001$) on all of the measured parameters. Compost applied at the lowest rate (5 $m^3\ fd^{-1}$)

Table 3: Main effects of compost and phosphate and nitrogen fertilizers on cotton yield characteristics

Treatment	Plant height (cm)	Seed cotton yield (kg fd^{-1})	Total crop yield (t fd^{-1})
Compost (m^3 fd^{-1})			
0	118.8	574.9	7.02
5	115.4	959.5	8.44
10	133.3	1180.0	10.22
15	121.8	995.3	9.13
cv %	6.6	14.4	16.3
Probability	<0.001***	<0.001***	<0.001***
$LSD_{0.05}$	5.44	96.3	1.02
Phosphate (kg fd^{-1})			
0	119.4	859.9	8.34
15.5	126.1	940.5	9.48
22.75	117.9	923.8	8.87
31.0	125.6	985.6	8.10
Probability	0.012*	0.030*	0.0451*
$LSD_{0.05}$	5.44	96.3	1.02
Nitrogen (kg fd^{-1})			
0	123.6	923.0	8.42
64	121.0	931.0	8.97
Probability	0.215	>0.05	0.131
$LSD_{0.05}$	ns	ns	ns

Note: Numbers in each column followed by different letters are significantly different at P<0.05

significantly increased yields over the untreated control, although plant height was not affected by this treatment. The largest values for all parameters were reported with 10 m^3 fd^{-1} application rate and this were significantly different to all other rates. In fact, organic nutrients not only provide plant with nutrients but also enhance and / or sustain the soil health [30]. The micronutrients content in organic fertilizer may be sufficient enough to meet the plant requirement, but problem of soil low fertility is one of the obstacles to maintain and sustain agricultural management and productivity [13, 14]. Furthermore, organic fertilizer inputs enhanced cotton productivity.

The main effects of phosphate fertilizer showed significant differences among rates of application, although at a lower level of significance compared with the compost (P<0.05). Overall, the effect of P on the yield parameters was proportionately much less than sludge compost. Seed cotton yields and biological yields were significantly increased by P fertilizer addition compared with the control treatment, but there were no differences between the rates of application. The largest seed cotton yield was on the highest P fertilizer addition (31 kg P_2O_5 fd^{-1}), whereas the largest biological yield was at the lowest rate (15.5 kg P_2O_5 fd^{-1}) and plant height was increased at the lowest and highest rate of P. P application should be related to soil P status because phosphorous is often lacking in calcareous soils. Amounts to apply depend on how deficient the soil is and the crop requirements. Excess applied phosphorus may lead to deficiency of zinc or iron. To be effective on calcareous soils, applied phosphorus fertilizer should be in water soluble form. Band application of phosphate is more effective as compared to broadcast application. Application at the time of seeding has been found to be most appropriate since phosphorus is required mostly during the younger stages of plant growth [3].

Iqbal, *et al.* [16] showed that the control treatment gave the lowest seed cotton yield compared with the other P application rates. Comparison of treatments showed that low and moderate rates increased the seed cotton yield.

The application of nitrogen at 64 kg N fd^{-1} resulted in small non-significant increases in seed cotton yield and total yield, but not plant height. This indicates that nitrogen on its own is not a growth limiting factor in this trial. Macronutrients N application increases cotton yield by increasing the number and length of branches and, therefore, the number of flowers, seed cotton yield and seed index. Excess N should be avoided as it may reduce yield and quality by over stimulating vegetative growth and delaying maturity. Emara, *et al.* [31] concluded that the early planting in combination with the high N fertilizer level (60kg N/fad) and foliar application with potassium silicate three times at squaring, floret initiation and two weeks after flowering obtaining the high productivity of Egyptian cotton (Giza 86) under this study clay loam soil.

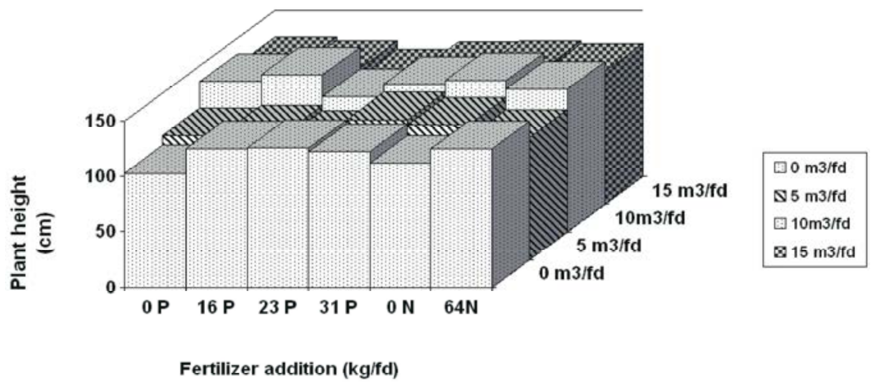

Fig. 1: Interactive effects between compost and P and N fertilizers on plant height

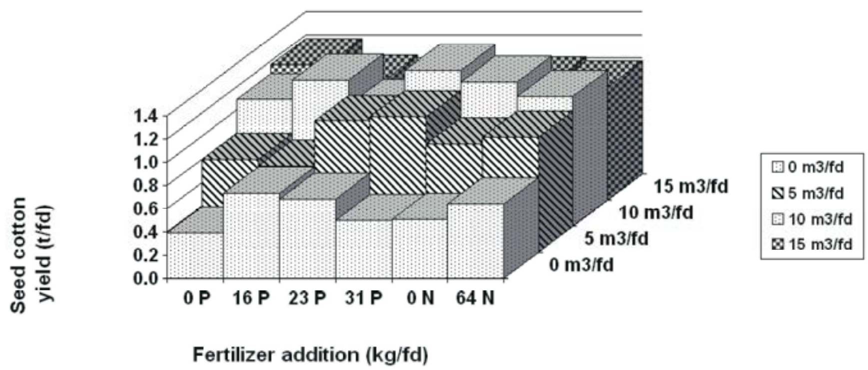

Fig. 2: Interactive effects between compost and P and N fertilizers on seed cotton yield

The interactions between the treatments are shown in Table 4 and illustrated in Figs. 1 and 2 for plant height and seed cotton yield, respectively. The interactions between compost and P fertilizer addition were statistically significant for each of the measured parameters (plant height and biological yield at P<0.01 and seed cotton yield highly significant at P<0.001). Compost applied at 10 m^3 fd^{-1} with 15.5 kg P_2O_5 fd^{-1} produced the tallest plants but the greatest seed cotton yield was found with the highest rate of Pfertilizer at the same rate of compost. Combinations of compost and/or P fertilizer at higher rates did not increase crop height or yields further. All parameters were reduced at the highest rate of compost application compared with 10 m^3 fd^{-1} at all rates of P fertilizer addition. Also compost applied at 5 m^3 fd^{-1} at the higher rates of P addition had seed cotton yields similar to those at 10 m^3 fd^{-1}.

The interaction between compost and N fertilizer was significant only for plant height, which was decreased by the addition of N with compost, although for N fertilizer on its own, this increased plant height over the untreated control. Seed cotton yield and biological yield were not affected by the addition of N fertilizer to the compost, although there was an indication that at the higher rates of compost addition, N fertilizer reduced seed cotton yield. This suggests that the lowest rate of compost can satisfy much of the N requirement of the crop and at the higher rates of total N addition, overgrowth of the crop was beginningto be evident, reducing the economic yield. Tao, *et al.* [12] indicated that the fertilization scenario with 20 to 40% MF substituted with 3.0 or 6.0 Mg ha^{-1} yr^{-1} of either CM or BF significantly increased cotton productivity and NUE. Furthermore, organic fertilizer inputs enhanced cotton productivity.

The interactions between P and N fertilizers confirms the lack of sensitivity to N fertilizer to this crop and that the crop was much more responsive to the addition of P. The combination of P and N did not affect plant height, but there were significant effects (P<0.05) on seed cotton yield and total yield. Phosphate fertilizer on its own generally produced larger yields than when in combination with N fertilizer and seed cotton yields were increased with increasing rate of P addition. Nitrogen fertilizer did not produce any significant effects on the yield parameters with increasing P addition. Iqbal, *et al.* [16] reported that P application had a drastic effect on the accumulation of N content arrangement in the RO of cotton throughout the growing period after transplanting.

Table 4: Interactive effects between compost and P and N fertilizers on cotton yield characteristics

Compost rate (m^3 fd^{-1})	Phosphate rate (kg P_2O_5 fd^{-1}) 0	15.5	22.75	31	Nitrogen rate (kg N fd^{-1}) 0	64	P rate (kg P_2O_5 fd^{-1})	Nitrogen rate (kg N fd^{-1}) 0	64
					Plant height				
0	102.8	125.0	125.5	121.8	112.5	125.0	0	118.5	120.4
5	112.5	114.5	109.0	125.5	121.3	109.5	15.5	131.0	121.3
10	136.0	142.0	122.0	133.0	137.3	129.3	22.75	117.8	118.1
15	126.5	123.0	115.3	122.3 cde	123.3	120.3	31	127	124.3
Probability	0.0024**				0.0011**			0.204	
$LSD_{0.05}$	11.7				8.26			ns	
					Seed cotton yield (kg fd^{-1})				
0	391.0	731.5	675.0	502.3	513.6	636.3	0	757.8	962.1
5	795.5	744.3	1129.3	1169.0	932.6	986.4	15.5	965.1	915.9
10	1086.3	1256.3	1040.0	1337.5	1241.8	1118.1	22.75	978.5	869.0
15	1167.0	1030	850.0	933.0	1006.3	984.4	31	993.0	978.1
Probability	<0.001***				0.077			0.0133*	
$LSD_{0.05}$	192.7				ns			136.2	
					Biological yield (t fd^{-1})				
0	7.07	9.29	5.49	6.21	6.75	7.46	0	7.66	9.01
5	8.95	7.45	9.47	7.88	8.85	8.03	15.5	9.04	9.93
10	9.62	10.05	10.99	10.20	9.67	10.77	22.75	9.64	8.10
15	7.71	11.11	9.54	8.11	8.61	8.61	31	7.35	8.85
Probability	0.0076**				0.193			0.0162*	
$LSD_{0.05}$	2.04				ns			1.45	

Note: Numbers in each column followed by different letters are significantly different at P<0.05

The triple interactions between the treatments are shown in Table 5 on the yield parameters. Many complex significant interactions were found for plant height (P<0.01) and seed cotton yield (P<0.05), but there were no statistically significant effects on total crop yield. This statistical analysis confirms that the optimum application rate for compost for maximum seed cotton yield is 10 m^3 fd^{-1} with 15.5 kg P_2O_5 fd^{-1} and no added nitrogen fertilizer. Higher rates of P fertilizer gave no additional yield benefit and the addition of nitrogen fertilizer depressed yields, since the N fertilizer generally increased total crop yield at the expenses of economic yield.

The lower rate of compost (5 m^3 fd^{-1}) could also achieve similar yields as compost at 10 m^3 fd^{-1} but only at the higher rates of P fertilizer addition. Under this regime, N fertilizer had no significant effects on yields (positive or negative). Cotton response to fertilizer is more critical than other crops. However the haphazard fertilization results in increasing the amount of nutrients not needed by the plant and increases the fertilizer costs of the farmer unnecessarily. Furthermore, incorrect fertilization leads to economic losses due to productivity falls besides environmental hazard [32]. For instance, excessive usage of nitrogenous fertilizer leads to yield's remaining behind [33].

Interactive effects have been observed when organic and inorganic fertilizers are combined. Singh and Ahlawat [11] reported that 25% substitution of recommended dose of nitrogen (RDN) through farmyard manure (FYM) played a significant role in increasing cotton growth parameters and seed cotton yields in a cotton/peanut (*Arachis hypogaea* L. Tao, *et al.* Integrated nutrient management provides a mechanism for recycling organic waste material and off sets mineral fertilizer use; therefore, it has the potential to reduce the deleterious effects associated with the off -farm movement of soluble nutrients into natural ecosystems.

Samples of cotton leaf were analysed for nutrients and trace elements, the data were statistically analysed by three-way ANOVA. The statistical probabilities and levels of significance are summarised in Table 6 and Table 7 presents the main effects means. Significant main effects were detected for Mn due to nitrogen fertilizer and for N, P, K and Fe from compost application. Second order interactions between nitrogen fertilizer and compost were only just significant for N, P and Zn, but inspection of the means revealed no consistent trends. Nitrogen and K concentrations are rather small in all treatments but P appears generally adequate. Manganese and Zn concentrations were borderline deficient and copper was below the recommended level for optimum crop production.

Table 5: Interactive effects of compost and phosphate and nitrogen fertilizers on cotton yield characteristics

Compost (m^3 fd^{-1})	Phosphate (kg P_2O_5 fd^{-1})	Nitrogen (kg N fd^{-1})	Plant height (cm)	Seed cotton yield (kg fd^{-1})	Biological yield (t fd^{-1})
0	0	0	83	152	6.48
		64	122	630	7.66
	15.5	0	124	709	8.22
		64	126	754	10.35
	22.75	0	128	658	5.80
		64	123	692	5.18
	31.0	0	115	536	5.78
		64	128	469	6.65
5	0	0	119	826	7.19
		64	106	766	9.98
	15.5	0	117	752	8.26
		64	112	736	6.65
	22.75	0	115	1104	10.92
		64	103	1154	8.02
	31.0	0	134	1048	8.30
		64	117	1290	7.46
10	0	0	147	864	9.28
		64	125	1308	9.98
	15.5	0	146	1431	9.10
		64	138	1082	11.00
	22.75	0	123	1214	12.35
		64	121	866	9.64
	31.0	0	133	1458	7.94
		64	133	1216	12.46
15	0	0	125	1189	7.00
		64	128	1145	8.42
	15.5	0	137	968	10.57
		64	109	1092	11.71
	22.75	0	105	938	9.50
		64	125	764	9.58
	31.0	0	126	930	7.38
		64	118	938	8.85
		Probability	0.0015**	0.0103*	0.3399
		$LSD_{0.05}$	16.5	272	ns

Note: Numbers in each column followed by different letters are significantly different

Table 6: Statistical probabilities and significance of treatment effects and interactions for chemical composition of cotton leaf

Source of variation	N	P	K	Fe	Mn	Zn	Cu
Nitrogen	0.4180ns	0.5195ns	0.3418ns	0.1543ns	0.0421*	0.8977ns	0.3256ns
Phosphorus	0.9824ns	0.0707ns	0.7562ns	0.5177ns	0.1568ns	0.6700ns	0.6937ns
Compost	0.0087**	0.0025**	0.0060**	0.0097**	0.2518ns	0.4103ns	0.1025ns
N x P	0.6514ns	0.2550ns	0.9982ns	0.3442ns	0.8726ns	0.4954ns	0.4023ns
N x Compost	0.0183*	0.0297*	0.6189ns	0.2518ns	0.3596ns	0.0419*	0.5027ns
P x Compost	0.9648ns	0.0922ns	0.9700ns	0.7429ns	0.5409ns	0.5281ns	0.6267ns
N x P x Compost	0.8398ns	0.7899ns	0.9907ns	0.0580ns	0.8749ns	0.9175ns	0.8117ns

Probability values in bold have attained statistical significance

Table 7: Chemical composition of cotton leaf (main effect means), Trial 2.4.1, Baghdad (Units: nutrients as %; other elements as mg kg^{-1})

Treatment	N	P	K	Fe	Mn	Zn	Cu
Nitrogen (kg N fd^{-1})							
0	2.67a	0.31a	1.64a	168.6a	22.8a	19.3a	4.69a
64	2.58a	0.33a	1.51a	183.0a	19.2b	18.9a	4.95a
Phosphorus (kg P_2O_5 fd^{-1})							
0	2.62a	0.33ab	1.70a	180.8a	20.3a	17.5a	4.94a
15.5	2.58a	0.31ab	1.53a	181.7a	20.3a	18.9a	4.55a
22.75	2.65a	0.26b	1.56a	163.0a	24.3a	18.0a	4.85a
31	2.64a	0.37a	1.51a	177.6a	19.0a	22.0a	4.94a
Compost (m^3 fd^{-1})							
0	2.52b	0.38a	1.57ab	200.0a	23.0a	20.2a	4.01a
5	3.04a	0.22b	1.98a	185.8ab	21.7a	15.6a	5.36a
10	2.50b	0.36a	1.53ab	163.4ab	18.3a	18.4a	4.72a
15	2.45b	0.32ab	1.22b	153.9b	20.9a	22.1a	4.79a

Values for each mean category within a column, followed by the same letter, are not significantly different at P = 0.05

CONCLUSION

Overall, the effect of P on the yield parameters was proportionately much less than sludge compost. This indicates that nitrogen on its own is not a growth limiting factor in this trial. Compost applied at 10 m^3 fd^{-1} with 15.5 kg P_2O_5 fd^{-1} produced the tallest plants but the greatest seed cotton yield was found with the highest rate of P fertilizer at the same rate of compost. Combinations of compost and/or P fertilizer at higher rates did not increase crop height or yields further. The results suggest that the lowest rate of compost can satisfy much of the N requirement of the crop and at the higher rates of total N addition, overgrowth of the crop was beginning to be evident, reducing the economic yield. The interactions between P and N fertilizers confirms the lack of sensitivity to N fertilizer to this crop and that the crop was much more responsive to the addition of P. Phosphate fertilizer on its own generally produced larger yields than when in combination with N fertilizer, Also, the results confirm that the optimum application rate for compost for maximum seed cotton yield is 10 m^3 fd^{-1} with 15.5 kg P_2O_5 fd^{-1} and no added nitrogen fertilizer.

REFERENCES

1. Abou-Zaid, M.K., 1999. Optimum technology for Egyptian cotton production in the newly reclaimed desert land of Egypt. Cotton Bull. Jan., 1999: 27-43, International Commerce Co., Ministry of Commerce, Egypt.
2. FAO., 2017. Production/yield quantities of cotton in world. http://www.fao.org/faostat.
3. FAO, 2016. FAO Soils Portal: Management of Calcareous Soils (accessed 01.04.16).
4. Marschner, H. and V. Romheld, 1995. Strategies of plants for acquisition of iron. Plant and Soil, 165: 261-274.
5. Rasha, E.A., 2005. The relation between active calcium carbonate and some properties of calcareous soils in North Africa. M. Sc. Thesis Cairo, Univ. of Ins. of African Res. and studies Dep. of Natural Resources.
6. Khalefa, A.M., 2007. Response of maize to application of microbial activator, sulphur and phosphotus to maize grown on a calcareous soil. J. Biol Chem. Sci., 2(2): 165-188.
7. Zubillaga, M.M., J.P. Aristi and R.S. Lavado, 2002. Effect of phosphorus and nitrogen fertilization on sunflower (*Helianthus annus* L) nitrogen uptake and yield. J. Agron. Crop Sci., 188: 267-74.
8. Stamatiadis, S., J.W. Doran and T. Kettler, 1999. Field and laboratory evaluation of soil quality changes resulting from injection of liquid sewage sludge. App. Soil Ecol., 12: 263-272.
9. Soumare, M., F.M.G. Tack and M.G. Verloo, 2003. Effects of a municipal solid waste compost and mineral fertilization on plant growth in two tropical agricultural soils of Mali. Bioresour. Tech., 86: 15-20.
10. Palm, A.C., C.N. Gachengo, R.J. Delve, G. Cadisch and K.E. Giller, 2001. Organic inputs for soil fertility management in tropical agroecosystems: application of an organic resource database. Agric. Ecosys. Environ., 83: 27-42.
11. Singh, R.J. and I.P.S. Ahlawat, 2014. Growth behaviour of transgenic cotton with peanut intercropping system using modified fertilization technique. Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci., 84: 19-30. doi:10.1007/s40011-013-0200-z.
12. Tao, R., S.A. Wakelin, Y. Liang and G. Chu, 2017 Organic Fertilization Enhances Cotton Productivity, Nitrogen Use Efficiency and Soil Nitrogen Fertility under Drip Irrigated Field. Agron. J., 109: 2889-2897 doi:10.2134/agronj2017.01.0054.
13. Ahmad, A.H., A. Wahid, F. Khalid, N. Fiaz and M.S.I. Zamir, 2011. Impact of organic and inorganic sources of nitrogen and phosphorous fertilizers on growth, yield and quality of forage oat (*Avena sativa* L.). Cercetari Agronomice in Moldova, pp: 39-49.
14. Kannan, R.L., M. Dhivya, D. Abinaya, R.L. Kreshna and S.K. Kumar, 2013. Effect of integrated nutrient management on soil fertility and productivity in maize. Bulletin of Environment, Pharmacology and Life Sciences, pp: 61-67.
15. Wailare, A.T. and A. Kesarwani, 2017. Effect of integrated nutrient management on growth and yield parameters of maize (*Zea mays* L.) as well as soil physicochemical properties. DOI Ó 10.26717 / Bjstr. 01. 000178.
16. Iqbal, B., F. Kong, I. Ullah, S. Ali, H. Li, J. Wang, W.A. Khattak and Z. Zhou, 2020. Phosphorus Application Improves the Cotton Yield by Enhancing Reproductive Organ Biomass and Nutrient Accumulation in Two Cotton Cultivars with Different Phosphorus Sensitivity. Agronomy 2020, 10, 153; doi:10.3390/agronomy10020153.
17. Reiter, J.S. and D.R. Kreig, 2000. Texas research shows fertigation is a viable option to save cotton growers both time and money on fertilizer inputs. Fluid J., 8(2): 20-22.

18. Echera, F.R., C.F.S.C., E.J. Ro T., 2019. The effects of nitrogen, phosphorus and potassium levels on the yield and fiber quality of cotton cultivars. Journal of Plant Nutrition https://doi.org/10.1080/01904167.2019.1702204.
19. Fahad, S., S. Hussain, S. Saud, S. Hassan, M. Tanveer, M.Z. Ihsan, A.N. Shah, A. Ullah, F. Nasrullah, F. Khan, 2016. A combined application of biochar and phosphorus alleviates heat-induced adversities on physiological, agronomical and quality attributes of rice. Plant Physiology and Biochemistry 103(2): 191-8. doi: 10. 1016/j.plaphy.2016.03.001.
20. Withers, P.J.A., M. Rodrigues, A. Soltangheisi, T.S. De Carvalho, L.R.G. Guilherme, V.D.M. Benites, L.C. Gatiboni, D.M.G. De Sousa, R.D.S. Nunes, C.A. Rosolem, 2018. Transitions to sustainable management of phosphorus in Brazilian agriculture. Scientific Reports, 8(1): 2537. doi: 10.1038/s41598-018-20887-z.
21. Duggan, B.L., S.J. Yeates, N. Gaff and G.A. Constable, 2009. Phosphorus fertilizer requirements and nutrient uptake of irrigated dry-season cotton grown on virgin soil in tropical Australia. Communications in Soil Science and Plant Analysis, 40(15-16): 2616-37. doi: 10.1080/00103620701759327.
22. Rochester, I.J., 2011. Assessing internal crop nitrogen use efficiency in high-yielding irrigated cotton. Nutrient Cycling in Agroecosystems, 90(1): 147-156.
23. Devkota, M., C. Martius, J.P.A. Lamers, K.D. Sayre, K.P. Devkota and P.L.G. Vlek, 2013. Tillage and nitrogen fertilization effects on yield and nitrogen use efficiency of irrigated cotton. Soil and Tillage Research, 134: 72-82.
24. Wanjuraa, J.D., E.M. B arnesb, M.S. Kelley, G.A. Holta and M.G. Pelletier, 2014.Quantification and characterization of cotton crop biomass residue, Industrial Crops and Products, 56: 94-104.
25. Tisdale, S.L., W.L. Nelson, J.D. Beaton and J.L. Havlin. 1993. Elements required in plant nutrition. In Soil fertility and fertilizers. McMillan Publishing Co., NY., pp: 48-49.
26. Radin, J.W. and J.R. Mauney. 1986. The nitrogen stress syndrome, pp: 91-105. In: J.R. Mauney and J.M Stewart (ed.). Cotton Physiology. Cotton Foundation. Memphis, TN.
27. Jackson, M.L., 1967. Soil ChemicaI Analysis. Prentic Hall of India, New Delhi, pp: 251-280.
28. Chapman, H.D. and P.F. Pratt, 1978. Methods of Analysis for Soils, Plants and Water. Univ. California, Div. Agric. Sci. Prical Publication, 4030: 12-19.
29. MSTAT-C, 1988. MSTAT-C, a microcomputer program for the design, arrangement and analysis of agronomic research. Michigan State University, East Lansing.
30. Abd El Lateef E.M., J.E. Hall, A.A. Farrag, M.S. Abd El-Salam and A.A. Yassin, 2019. The Egyptian Experience in Sewage Sludge Recycling in Agriculture. American-Eurasian Journal of Agronomy, 12(2): 12-18.
31. Emara, M.A.A., S.A.F. Hamoda, M.M.A. Hamada, 2018. Effect of Potassium Silicate and NPK Fertilization Levels on Cotton Growth and Productivity under Different Sowing Dates. Egypt. J. Agron. The 15th Int. Conf. Crop Science, pp: 115-123.
32. Bisson, P., M. Cretenot and E. Jallas, 1994. Nitrogen, phosphorus and potassium availability in the soil: physiology of the assimilation and use of these nutrients by the plant. In : Challenging the future : Proceedings of the World Cotton Research Conference, Brisbane, Australia, February 14-17, 1994. G.A. Constable, N.W. Forrester (eds.) - Brisbane : CSIRO, 1995. s.l. :s.n., pp: 115-124. ISBN 0-643-05811-7 World Cotton Research Conference. 1, Brisbane, Australie, 14 February 1994/17 February 1994.
33. Steenkamp, C.J. and A. Jansen, 1998. Nitrogen fertilization of cotton based on inorganic nitrogen analysis of the soil. Proceedings of the World Cotton Research Conference 2. Athens, Greece, September 6-12, pp: 420-423.