Australian Journal of Basic and Applied Sciences, 6(4): 115-121, 2012
ISSN 1991-8178

Effect of Chitosan Doses and Nitrogen Sources on the Growth, Yield and Seed Quality of Cowpea

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Abstract: An experimental trial was carried out in the two successive seasons of 2010 and 2011 to investigate the effect of Chitosan, organic (cattle manure and compost) and inorganic fertilizers (NPK) on vegetative growth and productivity of cowpea plants. Chitosan solution was sprayed three times after 30, 45 and 60 days from seed sowing at concentrations of 1, 3 and 5 % until runoff. Data showed that the best effect on plant vegetative growth (plant height, number, fresh and dry weights of leaves and shoots), yield and its component (pod length, weight and diameter and number. of seeds and seed yield) and seeds quality (total protein, total carbohydrates N, P and K) was obtained by using the highest concentration of Chitosan (5%) with the application of the inorganic fertilizer, While the lowest value was recorded by using the lowest concentration of Chitosan (1%) with the application of the organic fertilizer of the cattle manure. There is a positive relationship between increasing the applied concentration of Chitosan and the response of all plant growth and yield parameters.

Key words: Cowpea, *Vigna unguiculata*, Chitosan, growth, yield, inorganic fertilization, cattle manure, compost.

INTRODUCTION

Cowpea (*Vigna unguiculata)* is a member of the *Fabaceae* family. There is about 170 species in the genus vigna. *Cowpea* is the most important grain legume in the world **(**Onwueme and Sinha, 1991).It is considered as one of the major summer vegetable crops grown in Egypt for local consumption and exportation. It represents a very interesting class of food crops due to its high protein content, heat tolerant, low fertilizer requirements and it can grow easily in the new reclaimed and different texture soils (Knany *et al.*, 2002). The protein of cowpea contains relatively high amount of the essential amino acids, lysine and tryptophan, and thus usefully compliments the protein supply by cereals, in which the contents of lysine and tryptophan are relatively low (Singh and Singh, 1992).

Chitosan is a natural polymer derived from deactylation of chitin. Chitin is readily available from shellfish waste from food processing. A positive effect of Chitosan was observed on the growth of roots, shoots and leaves of various plants including gerbera (Wanichpongpan *et al.*, 2001) and several crop plants (Chibu and Shibayama, 2001). However, some trials on Chitosan were conducted in organic and conventional crops with variable results (Walker *et al.*, 2004). While Chitosan application resulted in yield increases of nearly 20% in two out of three tomato trials, no significant difference in yield of treatments in the organic carrot trial (Walker *et al.*, 2004) or in average weight of individual carrots. They found also no significant differences among cucumber, capsicum, beet-root or pea plants from any treatment, however the Chitosan foliar treatment had a tendency for greater yield than the yield from other treatments.

Up till now the nitrogen fertilization of cowpea depends on biological nitrogen fixation (Bhupinder and Kalidindi, 2003; Chimphango *et al.*, 2004; Ngwn, 2005; Vesterager *et al.*, 2008).Nitrogen application to cowpea plants increased plant growth, dry matter content, yield and its quality as well as the nutritional value of seeds (Ismail and Badawi, 1998; Okpara, 2000; Suresh and Rao, 2000; Baboo and Mishra, 2001; Amujoyegbe and Alofe, 2003; Singh *et al.*, 2007, Solaiappan *et al.*, 2008 ; Nascimento *et al*,. 2008).

Organic fertilization is very important method of providing the plants with their nutritional requirements without having an undesirable impact on the environment (Saleh *et al.*, 2003; Dhull *et al.*, 2005; Ravindran and Rajan, 2005; Amanullah *et al.*, 2007; Menon *et al.*, 2010 ; Adeoye *et al.*, 2011) Also, it is necessary to apply significant amounts of organic matter to improve physical and chemical conditions of the soil particularly the newly reclaimed one. Therefore, organic fertilization can be used for this purpose (Bilalis *et al.*, 2005 ; Mohmoud and Salem, 2005).

In spite of slow release forms of nitrogen included in natural organic materials such as compost but nitrogen in compost is in a more stable form than N in other inorganic sources (Hue, 1995 ; Hue and Silva, 2000).

Organic manures could be used as safe, cheep and environmentally-friendly substitutes to mineral fertilizers (Ahmed and Elzaawely, 2010).

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No reports were found concerning the growth and production of cowpea in response to Chitosan application. Therefore, this study was intended to investigate the response of growth and yield of cowpea plants to the application of different doses of Chitosan in the field with the applications of either organic or inorganic fertilizers

MATERIAL AND METHODS

The present work was carried out during the two successive seasons of 2010 and 2011 at the experimental station of the National Research Center in Nubaria region (Behira Governorate), Egypt. The experiment aimed to investigate the effect organic (Chitosan) as foliar sprays with the application of inorganic fertilizer or two sources of organic fertilizers (cattle manure and compost) on the growth, yield and quality of cowpea (*Vigna unguiculata)* cv. Carem 7. Seeds were sown on 20 and 25 th of April in the first and the second seasons, respectively.

Chitosan solution was sprayed at the rates of 1.0, 3.0, 5.0 cm^3 /l .Chitosan was obtained by using the local commercial product of ChitoCare then dissolved in tap water to obtain the targeted concentrations. Foliar spraying took place three times after 30, 45 and 60 days from seed sowing.

Inorganic fertilizer was used according to the recommendation of the Ministry of Agriculture in Egypt (NPK at 40: 30: 40 unit/fed.). P was added during soil preparation before seed sowing, while N and K applications were added at 15N:10K during the first month, 15N:15K during the second month and 10N:15K during the third month from seed sowing.

Organic fertilizers were added as follows:

a- Cattle manure was applied to soil during preparation before sowing the seeds at 11.111 and 9.756 ton/fed. In the first and second seasons, respectively.

b- Nile compost was applied during soil preparation at 2 ton/fed.

The chemical analysis of the used Nile compost is shown in Table (1). Also, the chemical analysis of the used cattle manure is shown in Table (2). The normal agriculture practices took place whenever it was necessary according to the Ministry of Agriculture recommendations.

Table 1: The chemical analysis of the used Nile compost

Character	Nile compost
Weight of qubic meter (kg)	400
Moisture %	30
pH	7
EC (mmhos)	5
Organic carbon %	41
Organic matter %	70
Total nitrogen %	2
C/N ratio	1:17
Total phosphorous %	0.6
Total potassium %	0.6
Iron mg/kg	7900
Manganese mg/kg	190
Copper mg/kg	20
Zinc mg/kg	4.75

Table 2: The chemical analysis of the used cattle manure.

Weight of $1m^3$	Moisture %	pH	E.C (m.mohs/cm)	Organic carbon%	C/N ratio	Total N %	Total P %	Total K %
2010								
755	73	7.4	14.0	7.7	1:21	0.36	0.42	0.81
2011								
750	72	7.5	14.1	7.9	1:19	0.41	0.40	0.83

Experimental Design and Statistical Analysis:

The treatments were arranged in a split plot design with three replicates. Whereas, the three different concentrations of Chitosan were sprayed on the main plots and the inorganic fertilizer, compost and the cattle manure were distributed randomly in the sud-plot areas. Each sub-plot area was 12.6 m^2 consisted of three ridges each was 0.7 m in width and 6.0 m in length. Three or four cowpea seeds were sown on both sides of each ridge at 25 cm a part, 5 cm deep and thinning was done after complete germination to two plants/hill. The Physical properties and chemical analysis of the experimental soil are presented in Table (3).

Sampling and Data Recording:

Three plants from each treatment were chosen randomly at flowering stage and plant height, number of leaves/plant, number of shoots/plant, fresh and dry weights of leaves and shoots/ plant were recorded.

At harvesting marketable stage (120 days after seed sowing) a sample of 12 dry pods from each sub-plot was taken at random. The pod length, diameter and weight, as well as number of seeds/pod and average seed weight of plot were recorded.

Samples of seeds were fine grounded then the total nitrogen, phosphorus and potassium were determined according to the methods described by FAO, (1980), Troug and Mayer, (1939) and Brown and Lilleland, (1946), respectively. Also, total protein % in dry seeds were accounted by multiplying nitrogen content by 6.25 as explained by Doubetz and Wells(1968), and total carbohydrates were determined as glucose after acid hydrolysis and spectrophometrically determined using phenol, sulfuric acid reagent as described by Dubbois *et al.(* 1965).

The obtained data were statistically analyzed and means separation was carried out using Least Significant Difference (LSD) at $P < 0.05$ according to the method described by Gomez and Gomez (1984).

Table 3: Physical and chemical analysis of the experimental soil.

Physical properties	2010	2011
Soil texture	Sandy	Sandy
Clay (%)	0.65	0.61
Silt (%)	4.81	5.22
Fine sand (%)	21.15	22.10
Coarse sand (%)	73.40	72.10
Chemical analysis		
Available N (ppm)	25	30
Available P (ppm)	5.70	6.10
Available K (ppm)	49	50
$CO3^{--}$(meq/100g soil)		
$HCO3^{-}$(meq/100g soil)	6.59	7.21
CL^{-}(meq/100g soil)	2.83	2.90
$SO4^{--}$(meq/100g soil)	1.14	1.22
Ca^{++}(meq/100g soil)	4.56	5.25
Mg^{++}(meq/100g soil)	2.50	2.70
Na^{+}(meq/100g soil)	3.07	3.25
K^{+}(meq/100g soil)	0.36	0.40
EC (dS/m)	1.40	1.45
Ph	8.10	8.20

Results:

Vegetative Growth Characters:

Chitosan at 5% had the superior effect on all measured vegetative parameters (plant height, number of leaves and shoots, fresh and dry weights of leaves and shoots) followed in decreasing order by Chitosan at 3 then at 1% as shown in Tables(4 and 5). There were significant differences among the different concentrations for all vegetative growth parameters with few exceptions.

Concerning kind of fertilizers, the best results were obtained by using the inorganic fertilizer followed significantly in decreasing order by compost then cattle manure. Inorganic fertilizer had a superior effect on all measured vegetative parameters. These results were true in both seasons with the exception of number of leaves in second season.

Table 4: Effect of Chitosan doses and nitrogen sources on the vegetative growth of cowpea plants in 2010 season.

Chitosan% (A)		Nitrogen source (B)	Plant height (cm)	No. of leaves/ Plant	No. of shoots/ Plant	Leaf F.W (g /Plant)	Leaf D.W (g Plant)	Shoot F.W (g /Plant)	Shoot D.W (g/ Plant)
1%		Compost	46.30 ef	27.27 d	2.50 e	26.27 f	8.75 d	14.84 def	3.72 de
		Cattle manure	43.86 g	25.40 e	2.13 f	19.42 g	6.47 e	13.50 f	3.44 e
		NPK	49.18 d	28.15 d	2.93 bc	30.37 d	10.12 bcd	15.30 de	3.89 cde
	Mean		46.45 C	26.94 C	2.52 B	25.35 C	8.45 B	14.55 C	3.68 C
3%		Compost	53.10 c	29.82 c	2.82 cd	31.30 d	10.65 bc	16.20 cd	4.05 cd
		Cattle manure	45.53 fg	27.32 d	2.57 e	28.40 e	9.49 cd	14.33 ef	3.83de
		NPK	57.30b	30.21 c	3.13 ab	39.38 b	13.18 a	17.37 c	4.34 bc
	Mean		51.98 B	29.12 B	2.84 A	33.03 B	11.11 A	15.97 B	4.08 B
5%		Compost	56.37 b	31.33 b	2.95 bc	33.57 c	11.30 b	18.87 b	4.71 b
		Cattle manure	48.22 de	29.67 c	2.60 de	30.25 d	11.28 b	15.07 de	3.77 de
		NPK	60.43 a	32.50 a	3.33 a	41.23 a	13.04 a	21.77 a	5.45 a
	Mean		55.01 A	31.17 A	2.96 A	35.02 A	11.88 A	18.57 A	4.64 A
		Compost	51.92 B	29.47 B	2.76 B	30.38 B	10.23 B	16.63 B	4.16 B
		Cattle manure	45.87 C	27.46 C	2.43 C	26.02 C	9.08 C	14.30 C	3.68 C
		NPK	55.64 A	30.29 A	3.13 A	36.99 A	12.12 A	18.14 A	4.56 A

Table 5: Effect of Chitosan doses and nitrogen sources on the vegetative growth of cowpea plants in 2011 season.

Chitosan% (A)		Nitrogen source (B)	Plant height (cm)	No. of leaves/ Plant	No. of shoots/ Plant	Leaf F.W (g/ Plant)	Leaf D.W (g/ Plant)	Shoot F.W (g/ Plant)	Shoot D.W (g/ Plant)
1%		Compost	48.30 cd	23.30 cd	2.17 ef	23.58 cd	8.31 b	13.23 de	4.40 de
		Cattle manure	45.23 e	21.13 e	1.63 g	20.25 e	6.74 c	11.21 g	3.72 g
		NPK	51.10 abc	24.43 bc	2.50 cde	24.97 bc	8.32 b	13.67 cde	4.48 cde
	Mean		48.21 B	22.96 A	2.10 B	22.93 B	7.79 B	12.70 C	4.20 C
3%		Compost	50.40 bcd	25.72 ab	2.73 bcd	24.27 bc	8.09 b	14.07 cd	4.69 cd
		Cattle manure	47.97 de	22.53 de	1.90 fg	21.07 e	6.91 c	11.78 fg	3.90 fg
		NPK	53.65 a	25.97 ab	3.03 ab	26.40 b	8.79 b	16.07 b	5.35 b
	Mean		50.67 A	24.74 A	2.56 A	23.91 B	7.93 B	13.97 B	4.64 B
5%		Compost	51.53 ab	26.23 ab	2.83 abc	25.37 bc	8.47 b	14.47 c	4.82 c
		Cattle manure	48.43 cd	23.00 cde	2.27 def	21.70 de	7.23 c	12.63 ef	4.19 ef
		NPK	51.83 ab	27.07 a	3.27 a	31.63 a	10.53 a	17.23 a	5.74 a
	Mean		50.60 A	25.43 A	2.79 A	26.23 A	8.75 A	14.78 A	4.92 A
		Compost	50.08 B	25.08 A	2.58 B	24.41 B	8.29 B	13.92 B	4.64 B
		Cattle manure	47.21 C	22.22 B	1.93 C	21.01 C	6.96 C	11.87 C	3.94 C
		NPK	52.19 A	25.82 A	2.93 A	27.67 A	9.21 A	15.66 A	5.19 A

Respecting the interaction, the best results were obtained by using 5% Chitosan with the inorganic fertilizer. While, the lowest value was obtained by using 1% Chitosan with cattle manure. These results held significantly true in both seasons with the exception of leaf dry weight in the first season and plant height in the second season which gave the best values by using 3% Chitosan with inorganic fertilizer.

B-Seed Yield and Physical Quality:

The best results were obtained by using the highest level of Chitosan (5%) followed significantly in decreasing order by Chitosan at 3% then Chitosan at1% (Tables 6and7) This was true for all tested characters in both seasons, however no significant differences were detected between the effect of 5 and 3% Chitosan in some cases

As for the kind of fertilizers, the best results in both seasons were obtained by using the inorganic fertilizer (NPK) followed significantly in decreasing order by compost then cattle manure. Inorganic fertilizer had a superior effect on yield and all of its components.

Concerning the interaction, the best results were obtained by using 5% Chitosan with the inorganic fertilizer (NPK). While, the lowest value was obtained by using 1% Chitosan with cattle manure. These results held true in both seasons.

C-Nutritional Values:

In both seasons, the best results of N, P, K, total carbohydrate and total protein values were obtained by using the highest level of Chitosan (5%) followed significantly in decreasing order by Chitosan at 3% then at 1% as shown in Table (8).This was true with few exceptions the differences between either Chitosan at 5% and 3% or Chitosan at 3% and at 1% were not significant in few cases.

Concerning the kind of fertilizers, the highest values of N, P, K, total carbohydrate and total protein in both seasons were recorded by using inorganic fertilizer followed significantly in decreasing order by compost then cattle manure.

Table 6: Effect of Chitosan doses and nitrogen sources on the yield and its components of cowpea plants in 2010 season.

Chitosan % (A)		Nitrogen sources (B)	Pod length (cm)	Pod weight (g Plant)	Pod diameter (cm)	No. of seeds/pod	Seed yield (g/plot)
1%		Compost	12.80 de	0.98 d	0.90 de	9.67 b	1117.67 d
		Cattle manure	12.17 f	0.79 e	0.83 e	8.00 d	941.67 f
		NPK	13.20 bcd	1.05 cd	1.07 bc	11.00 a	1210.00 c
	Mean		12.72 C	0.94 C	0.93 C	9.56 B	1089.78 B
3%		Compost	13.16 cd	1.15 bc	1.00 cd	10.67 a	1251.67 bc
		Cattle manure	12.57 ef	0.85 e	0.87 e	8.67 cd	966.00 ef
		NPK	13.70 bc	1.23 b	1.17 b	11.33 a	1312.67 ab
	Mean		13.14 B	1.08 B	1.01 B	10.22 A	1176.78 A
5%		Compost	13.73 b	1.22 b	1.00 cd	10.67 a	1296.33 ab
		Cattle manure	12.77 de	1.03 cd	0.90 de	9.33 bc	1012.00 e
		NPK	15.10 a	1.43 a	1.37 a	11.33 a	1333.33 a
	Mean		13.87 A	1.23 A	1.09 A	10.44 A	1213.89 A
		Compost	13.23 B	1.12 B	0.97 B	10.33 B	1221.89 B
		Cattle manure	12.50 C	0.89 C	0.87 C	8.67 C	973.22 C
		NPK	14.00 A	1.24 A	1.20 A	11.22 A	1285.33 A

Table 7: Effect of Chitosan doses and nitrogen sources on the yield and its components of cowpea plants in 2011season.

Chitosan % (A)		Nitrogen sources (B)	Pod length (cm)	Pod weight (g/ Plant)	Pod diameter (cm)	No. of seeds/pod	Seed yield/plot (g/ Plant)
1%		Compost	11.83 d	0.91 d	0.87 de	9.67 c	996.67 bc
		Cattle manure	11.07 e	0.74 e	0.73 e	8.67 d	863.33 d
		NPK	12.87 ab	1.03 cd	1.10 bc	10.67 b	1146.67 a
	Mean		11.92 B	0.89 C	0.90 B	9.67 B	1002.22 C
3%		Compost	12.70 bc	1.10 bc	1.13 abc	10.67 b	1148.33 a
		Cattle manure	11.67 de	0.90 d	0.97 cd	9.33 cd	933.33 cd
		NPK	13.23 ab	1.23 ab	1.27 ab	11.33 ab	1166.67 a
	Mean		12.53 A	1.08 B	1.12 A	10.44 A	1082.78 B
5%		Compost	13.37 ab	1.23 ab	1.20 ab	11.00 ab	1180.00 a
		Cattle manure	12.03 cd	1.03 cd	1.07 bcd	9.67 c	1016.67 b
		NPK	13.47 a	1.34 a	1.33 a	11.67 a	1196.67 a
	Mean		12.96 A	1.20 A	1.20 A	10.78 A	1131.11 A
		Compost	12.63 B	1.08 B	1.07 B	10.44 B	1108.33 B
		Cattle manure	11.59 C	0.89 C	0.92 C	9.22 C	937.78 C
		NPK	13.19 A	1.20 A	1.23 A	11.22 A	1170.00 A

Table 8: Effect of Chitosan doses and nitrogen sources on the seed percentage of N, P, K, total carbohydrates and total protein of cowpea plants.

Treatments			Season 2010					Season 2011				
Chitosan% (A)		Nitrogen sources (B)	N	P	K	Total carbohydrates	Total protein	N	P	K	Total carbohydrates	Total protein
1%		Compost	2.23 d	0.491 e	2.26 c	2.23 d	13.94 d	2.18 de	0.442 e	2.26 e	16.83 e	13.65 cd
		Cattle manure	1.86 e	0.455 f	1.91 d	1.86 e	11.60 e	1.72 f	0.370 f	1.80 g	15.57 f	10.77 e
		NPK	2.61 bc	0.511 d	2.64 b	2.61 bc	16.31 bc	2.59 abc	0.488 d	2.54 bc	19.83 b	16.21 ab
	Mean		2.23 C	0.486 C	2.271 C	18.74 B	13.95 C	2.17 B	0.433 C	2.20 C	17.41 C	13.54 B
3%		Compost	2.46 c	0.515 d	2.37 c	2.46 c	15.40 c	2.35 cd	0.521 c	2.42 d	17.73 d	14.67 bc
		Cattle manure	2.07 d	0.473 ef	2.05 d	2.07 d	12.96 d	1.93 ef	0.410 e	2.05 f	16.20 ef	12.08 de
		NPK	2.69 b	0.583 b	2.71 ab	2.69 b	16.83 b	2.75 ab	0.586 b	2.62 ab	21.95 a	17.17 a
	Mean		2.41 B	0.524 B	2.377 B	19.53 AB	15.06 B	2.34 A	0.506 B	2.36 B	18.63 B	14.64 A
5%		Compost	2.58 bc	0.553 c	2.63 b	2.58 bc	16.15 bc	2.53 bc	0.558 b	2.50 cd	18.76 c	16.50 ab
		Cattle manure	2.18 d	0.485 e	2.30 c	2.18 d	13.65 d	2.04 e	0.425 e	2.17 e	16.65 e	12.73 d
		NPK	2.88 a	0.610 a	2.88 a	2.88 a	18.02 a	2.83 a	0.630 a	2.73 a	22.70 a	17.69 a
	Mean		2.55 A	0.549 A	2.602 A	19.99 A	15.94 A	2.47 A	0.539 A	2.47 A	19.37 A	15.64 A
		Compost	2.43 B	0.520 B	2.420 B	18.93 B	15.16 B	2.35 B	0.508 B	2.39 B	17.77 B	14.94 B
		Cattle manure	2.04 C	0.471 C	2.088 C	17.66 C	12.74 C	1.90 C	0.402 C	2.01 C	16.14 C	11.86 C
		NPK	2.73 A	0.568 A	2.742 A	21.67 A	17.05 A	2.72 A	0.568 A	2.63 A	21.49 A	17.02 A

Regarding the interaction, the highest values of N, P , K, total carbohydrate and total protein in both seasons were recorded by using Chitosan 5% with inorganic fertilizer. While, the lowest values were obtained by using Chitosan 5% with cattle manure.

Discussion:

No doubts that any given additional fertilization supplements has significant impact on plant growth in new reclaimed lands which is characterized with infertility. In this work, all foliar applied Chitosan and the soil applications of inorganic and organic (compost and cattle manure) fertilizers showed positive effects on promoting cowpea plant growth and production.

The superiority in plant growth, yield and its parameters of cowpea which treated by inorganic fertilizer might due to that the N source in this case gives plants available source which can be absorbed directly while in the case of organic fertilizers it take some weeks after application to give plant available N to absorb (Hue and Silva, 2000). In addition, only 10-50% of the N from an organic source would be converted to NH_4 in a six month period (Hue, 1995). On the other hand, Saleh *et al*. (2003) and Amanullah *et al*.(2007) revealed that all the organic manure treatments recorded better growth and yield compared to the control treatment. The obtained results are in good accordance with those recorded by other investigators (Abebe *et al.*, 2005; Oliveira *et al.*, 2000, Oliveira *et al.*, 2001).

Meanwhile the positive effects of Chitosan may come from providing some amino compounds required for plant growth. The latter authors reported that Chitosan application proved to stimulate early growth stages of lettuce, soybean and upland rice. More recently, Abdel-Mawgoud *et al.* (2010) found an improvement effects on strawberry growth and production as a result of Chitosan application. Nevertheless, the exact mechanism(s) of Chitosan effects on plant growth and production is not yet determined. Similar effects of Chitosan were recorded by Ghoname *et al.* (2010) on sweet pepper plant behavior. Chibu and Shiayama (2001) reported positive effects of Chitosan incorporated into the soil on early growth stages of soybean, mini-tomato, upland rice and lettuce. The degree of responses differed according to the applied concentration of Chitosan. This was also reported to differ by the crop and concentration (Chibu and Shiayama, 2001; Walker et al., 2004). The increment in total N content in the leaves maybe brought about by the amino components in chitosan and or

higher ability of the plant to absorb N from the soil when Chitosan was degraded. Also the higher content of K explains the higher quality of the fruits due to the presence of K which acts on photosynthate translocation from the leaves to the storage organs.

Generally, all applied materials improved plant vegetative growth such as number of leaves and shoots which must have been reflected on total plant leaf area. This means higher light interception and more assimilate production which appeared in the form of high fresh and dry weights of the plants. Since pod yield is a fraction of total plant biomass, yield was also improved by the applied treatments. As each treatment differed regarding its contents and concentration, the degree of response differed according to the type of contents and was also positively related to the concentration of the applied substances.

Conclusion:

It could be concluded that all applied materials have positive and growth promoting effects on cowpea plants by providing supplemental doses of nutrients to the plants which increased its growth and yield. However, the highest results which gave the best values of plants growth parameters, total yields of dry seeds and nutritional values of dry seeds were obtained by using the interaction of Chitosan at 5% with the inorganic NPK fertilizer.

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