Effect of Nitrogen, Phosphorus and Potassium Fertilizers Sources and Levels on Growth, Productivity and Quality of Snap Bean Grown Under Greenhouses Conditions

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Abstract

Two field experiment were carried out during the two successive winter seasons of 2017-2018 and 2018-2019 in a private sector farm at Damalo Village, Qalubia Governorate, to investigate the effect of three mineral fertilizer levels (100,80 and 60% of recommended dose of NPK) as soil application and foliar spray with two different sources of NPK applications (NPK in 20:20:20 form, NPK in nano form and control) on vegetative growth, chemical composition and productivity as well as pod quality of snap bean (*Phaseolus vulgaris* L.*)* cv. moraleda. This experiment included 9 treatments resulted from the interaction between three NPK levels (100,80,60% of recommend dose) with three foliar applications (NPK in20:20:20 form, NPK in nano form and control). A split plot design with three replicates was adopted. Obtained results showed that, fertilizer snap bean plants with 100 and 80% of recommended dose of NPK as soil application with sprayed plants with nano NPK at 2ml/l for each element reflected the highest values in all studied vegetative growth characters, chemical constituents of plant foliage and pod yield and its components and chemical pod quality .

Key words: Snap bean- NPK20:20:20- nano NPK- Vegetative growth-Yield- Pod quality- Green house.

Introduction

Snap bean (*Phaseolus vulgaris* L.) is one of the most important cash leguminous vegetable crops grown in Egypt for local consumption and exportation. Snap bean characterized by its high content of protein, starch, and dietary fiber and considered as an excellent source of potassium, molybdenum, selenium, thiamine B1, niacin B6, and folic acid (Maiti and Singh., 2007). In Egypt, snap bean production area was42108 fed produced 175,898 tons with an average yield of about 4.2 tons /fed. Cultivated area under greenhouse are 1196370 m^2(2586 greenhouses) and total production of 7914 tons with an average productivity of 6.615 kg/ m2. (Bulletin of the Agric. Statistics.2017Ministry of Agric. and land Reclamation, Economic Affairs Sector).Moreover, the quantity of exported pods in 2018 reached 23,761 tons, mostly to England, Belgium, Germany, Italy and the Netherlands (Central Administration of Agricultural Quarantine - General Union of Producers and Exporters of Horticultural Crops).

Mineral fertilizers application is essential for plant growth, development and productivity of snap bean plants. With fertilizers, farmers can produce more food and cash crops of better quality, especially in the low soil fertility which has been over-exploited.

Nitrogen one of the 16 essential chemical elements which are of vital importance for plant growth due to being a part of amino acids, protein, enzymes and chlorophyll molecules **(Devlin and Witham., 1986).** Many investigators reported that increasing NPK levels improved the plant growth, yield and green pod quality of snap bean **(Souza *et al*., 2008 and El-Bassiony *et al*., 2010).** In addition, insufficient available N mostly leads to reduce growth, light interception, with limited yield and early crop senescence. On the other hand, frequent or excessive amounts of nitrogen fertilizers would led to unfavorable effect on the growth and yield of snap bean plants and will lead to the increase of the waist losses of nitrogen fertilizer. On this connection excessive available of N may be resulted in reducing and delaying yield with the lowest dry matter content (**Kleinkopf *et al.*, 1981).**

Finally, all vegetative growth parameters were gradually and significantly increased by increasing the level of nitrogen fertilizer application **(Asmaa *et al*., 2010).** So, the adequate amounts of nitrogen fertilization led to improve growth, yield and quality of pods

Phosphorus (P) is one of the major plant nutrients which constitutes about 0.2% of plant dry weight **(Schachtman *et al*., 1998)**. Phosphorus is considered as an integral part of the cellular activities of living organisms and contributes to several vital functions in the plant, such as early root and seedling growth, improving winter hardiness, promotion of early heading and uniform maturity, increasing seed formation and quality, and increasing water-use efficiency. Moreover, it is involved in several key plant functions including cell division, photosynthesis, storing and transfer of energy, regulation of some enzymes, transformation of sugars and nutrients within the plant, as well as, the transfer of genetic characteristics from one generation to another **(Taiz *et al.*, 2015).** Phosphorus deficiency affects not only plant growth and development and crop yield, but also the quality of the fruit and the formation of seeds **(Njira and Nabwami., 2015).** Availability, absorption and effectiveness of phosphorus to plants depends on many factors like pH, physicochemical properties of the soil, dominant climate and soil organic matter content and P fertilizer sources **(Gupta et al. 1985 and Ghoname *et al.* 2012).**

Foregoing searches shown that Potassium might play important roles in regulating the opening and closing of stomata and water retention (**Salisbury and Ross., 1992).** It promotes the growth of meristematic tissues, activates some enzymatic reactions, aids in nitrogen metabolism and the synthesis of proteins. It catalyzes activities of some mineral elements and aids in carbohydrate metabolism and translocation. **(Wilfret., 1980)** highlighted that Potassium deficiency resulted in reduced bud count, weak stalks and delaying flowering. He affirmed that with lack of potassium, roots become more easily infected with root-rotting. Potassium increases the resistance of plants to abiotic stress factors (frost, aridity, as well as salinity and sodicity, airless soil conditions) and the biotic factors such as disease infection **(Colpan et al., 2013)**. Plants with adequate potassium supply during growth can provide good yields even under stressed conditions **(Kemler and Krauss., 1987).** Owing to Potassium advantages, there is a need to assess its effectiveness in bean cultivation for production improvement.

A revolution emerged in industrial, agricultural and medical fields through utilizing of nano-technology sciences. This technology can offer a new approach and chance in agriculture to reduce the environmental pollution in several fields resulting from excessive usage of mineral fertilizers **(Chhipa., 2017).** The importance of nano-fertilizers was stated through several studies among them **(Bozorgi 2012).** Nanotechnology is the developing technology of this era and can be as a promising application in agriculture sector **(Chhipa and Joshi. 2016)**. Thus; nano-fertilizers can be of benefit effects in preventing nutrient losses to soil and thereby reducing soil pollution with excessive mineral fertilizers. Also, these nano-fertilizers can obviate the interaction between nutrients with air, waters, microorganisms and soil **(DeRosa *et al*., 2010).** In term of effect of nano-particles on pathogens (**Baker *et al*., 2005)** observed that, nanoparticles can exhibit antibacterial effectiveness when introduced into a media containing E.coli. Moreover, these nano-particles can play an important role in inhibition of fungi growth **(Ajirloo *et al*., 2015)**

Also, several studies paid attention to the positive role of nano-fertilizers in improving biomass, shoot length, root, chlorophyll and protein content in Vigna radiate, Cicerariatium, Cucumis sativas, Raphanus sativus, Brassica rapus and cluster bean (**Lin and Xing., 2007; Mahajan *et al*., 2011and Raliya and Tarafdar., 2013).**

Fertilizers are chemical compounds applied to promote plant and fruit growth. Artificial fertilizers are inorganic fertilizers formulated in appropriate concentrations and the combinations supply three main nutrients: nitrogen, phosphorus and potassium (N, P and K) for various crops and growing conditions. However, about 40–70% of nitrogen of the applied normal fertilizers is lost to the environment and cannot be absorbed by plants, causing not only substantial economic and resource losses but also very serious environmental pollution. Recently, the use of slow release fertilizers has become a new trend to save fertilizer consumption and to minimize environmental pollution. Therefore, developing encapsulated nitrogen fertilizers within nanoparticles providing protection for fertilizers by the nanoparticles for better survival in inoculated soils, allowing for their controlled release into the soil.

Chitosan nanoparticles are an interesting material for use in controlled release systems due to their polymeric cationic, biodegradable, bio absorbable, non-toxicity, ecofriendly and richness with chemical functional groups that can be easily modified, inducing bactericidal characteristics.

Current study aimed to determine the effect of spraying with 20:20:20 normal as mineral form and NPK in nano form also sources of phosphor on growth performance and nutrient uptake in snap bean plants.

Materials and Methods.

Two field experiments were carried out during the two winter successive seasons of 2017-2018 and 2018-2019 in private sector farm at Damallo Village, Benha, Qalubia Governorate to investigate the effect of nitrogen, phosphorus and potassium fertilizers sources as soil addition and level on vegetative growth, chemical composition ,pods yield and its components as well as quality of snap bean (Phaseolus vulgaris) cv. Moraleda grown under greenhouses conditions(18*18*3.5meter). Soil samples were taken at 30 cm from soil surface and soil physical and chemical properties were determined according to **Jackson (1973) and Black (1982)** and were illustrated at Table (1). Moreover, maximum and minimum air temperature (c^0) and relative humidity % under plastic house in the first and second season are shown in Table (2).

Table 1. Physical and chemical properties of the experimental soil during the two seasons of study.

Item	Unit	2017-2018 Season	2018-2019 Season
Coarse sand	%	5.66	4.98
Fine sand	%	16.75	15.50
Silt	%	22.87	26.02
Clay	%	54.72	53.5
Textural class		Clay	Clay
Bulk density	kg/m3	950	950
pH	(1:2.5)	7.02	7.18
E.C (1:2.5)	ds/m	6.52	6.63
Total nitrogen	ppm.	399	350
Total phosphate	ppm	9.9	9.5
Total potassium	ppm	506.68	505
Total Fe	ppm	5.10	5.25
Total Mn	ppm	1.33	1.76
Total Zn	ppm	3.09	2.88
Total Cu	ppm	4.78	4.01
Ca++	(meq/l)	60	60
Mg++	(meq/l)	23	22
Na+	(meq/l)	11	11.5
K+	(meq/l)	2.4	2.5
Cl-	(meq/l)	7.7	7.4
HCo^{3}-	(meq/l)	2.5	2.4

Table 2. Maximum and minimum air temperature (c^0) and relative humidity% under plastic house in the first and second season.

Months	First season (2017-2018)				Second season (2017-2018)			
	Temperature C^0		Relative humidity		Temperature C^0		Relative humidity	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
October	38	21	90	40.3	39	22.3	91	39.9
November	37	22.2	91	44.5	38.7	23	92	41
December	36.9	14.2	90	36.5	37.5	14.5	90	37
January	33.4	14.1	89	24.6	34.5	13.9	89	40.2
February	35.5	14.5	90	25.3	35.7	14.1	89.5	40.1
March	36.3	16.7	90.3	39.1	35.8	18	91.5	41.9

This experiment included nine treatments which resulted from using three levels of recommended mineral NPK fertilizers as soil addition interacted with three foliar sprays (NPK 20:20:20 in mineral form or in nano form and control). Each experimental plot included 1 bed with 3 meter in length and 150 cm in width with an area of 4.5 m^2. Seeds were sown on two sides of the ridge in hills 40 cm apart as one seed per hill in 6 th and 18^{th} of October during the first and second season, respectively

a-Soil addition of NPK :-

1- 100% of recommended dose
2- 80% of recommended dose
3- 60% of recommended dose

b- Foliar spray treatment: -

Foliar application of 2 g/l of different sources of NPK as form 20:20:20 and in nano form was sprayed onto the leaves of plants (25 cm tall) every14 days. Unfertilized plant were used as control

1-**NPK as 20:20:20** at 2g/l in mineral form starting after21days and every 14 days (from Monofia Co. for Development and Agric.). add in 8 times.

2. NPK as nano Form at 2 ml/l (from nano fab technology company):-

Nano nitrogen: - Nitrogen conjugated to Chitosan nanoparticles. The source of nitrogen is urea (10% nitrogen: 90% Chitosan)

a- **Nano phosphor:-** Hydroxyapatite Nanoparticles highly phosphorous percentage, Calcium hydroxyl phosphate, calcium phosphate. Average particle size: 20 X 80 nm

Table 3. Recommended dose from The Horticultural Export Improvement Association (HEIA) to snap beans plant under house green / (greenhouse 360 m^2).

Week	Ammonium nitrate(kg)	Phosphoric acid(l)	Potassium sulphate(kg)
3-4	3.5	0.4	0.8
5-6	4.0	0.5	1.2
7-8	5.0	0.5	1.4
9-10	5.0	0.7	1.6
11-12	5.0	0.8	1.6
13-14	5.0	0.7	1.8
15-16	5.0	0.6	1.8
17-18	4.0	0.5	1.5
19-20	2.5	0.4	1.1
Total	39.0	5.15	12.6

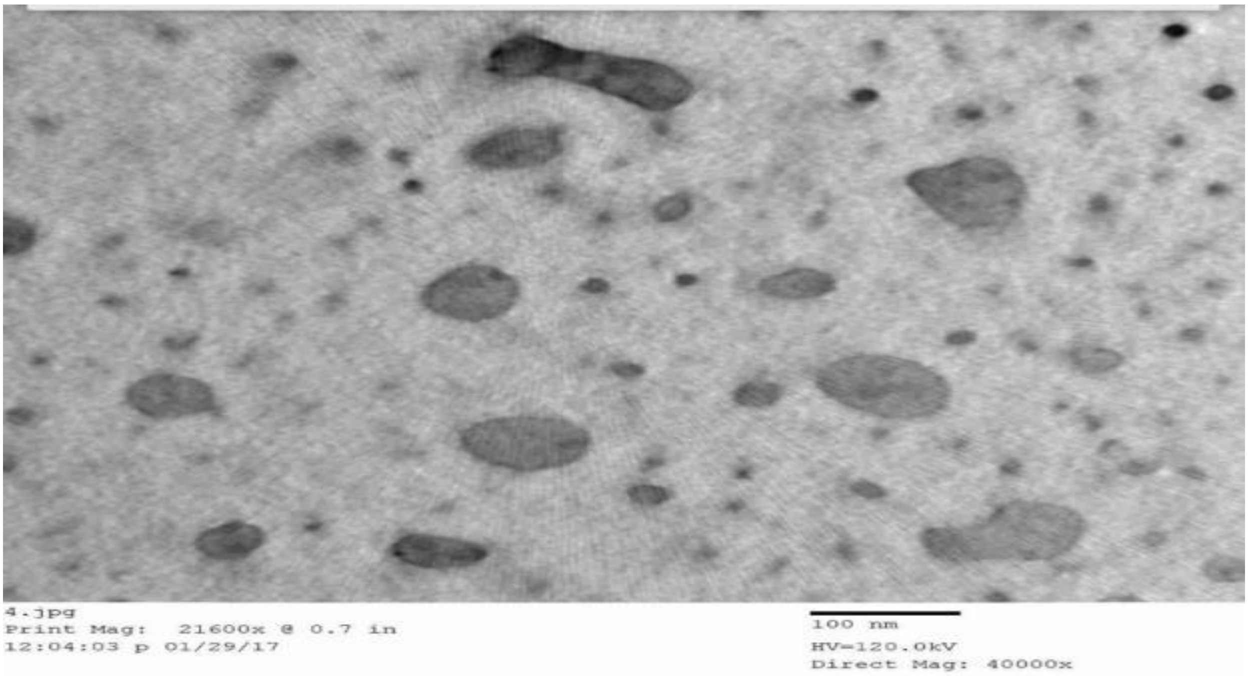

Fig. 1. Transmission electron microscopy (TEM) image of urea loaded with synthesized nanoparticles of chitosan.

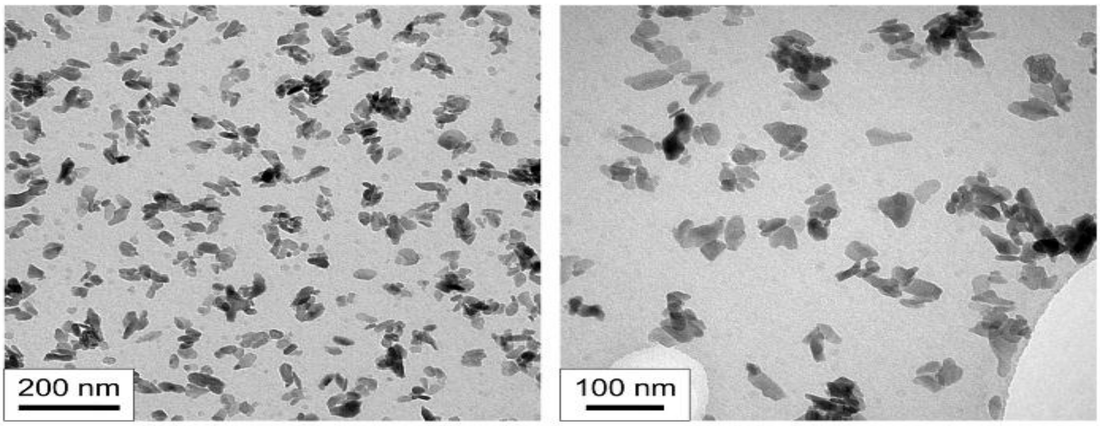

Fig. 2. Transmission electron micrographs (TEM)of nano scale hydroxyapatite (nHA).

b- **Nano potassium: -** Potassium loaded hydroxyapatite Nanoparticles. The source of potassium is (Mono potassium Phosphate-MKP K_2O 34%). Average particle size: 30 X 70 nm.

2- **Control (without spray)**

Data recorded: -

1- Vegetative growth characteristics

At full blooming stage (60 days from sowing) three plants from each experimental plot were taken and the following data were recorded.

Plant height, number of leaves/plants, number of branches/plants, fresh and dry weight/ plant

2- Photosynthetic pigments: - the chlorophyll a, b and carotenoids from the fifth mature leaf from top was measured at 60 days from seed sowing were determined calorimetrically as described in **A.O.A.C (1990).**

Chemical constituents of plant foliage: - were determined in the dry weight of plant foliage at 60 days from seed sowing and then used to the following chemical constituents, total nitrogen, phosphorous, potassium, calcium and Magnesium percentages were determined according to **ADAS/MAFF (1987), Watanabe and Olsen (1965) and Chapman and Pratt (1961),** respectively**.**

3- Yield measurements: - at harvest, 70 days after seed sowing, green pods from each experiential unit were picked, weighed and the following yield components were estimated.

a- Early bods yield :- the yield which was collected from the first four harvests was expressed as early yield (early yield/ plant and m^2).

b- Total pods yield :- included all the green pods which were picked all over the harvesting periods (total yield / plant and m^2).

c- Marketable yield%: (marketable yield/ total yield)100

4- Chemical pods quality was determined as follow: -

- ✓ Total nitrogen:- it was assayed according to **Pregl (1945),** using the micro- kjeldahl apparatus. A factor of 6.25 was used for conversion of total nitrogen to protein percentage.
- ✓ Phosphorus and potassium concentration as mentioned before in chemical constituents of leaves.
- ✓ Fibers:- it was determined as g/100 g dry weight sample according to **(A.O.A.C.,1990).**
- ✓ Total carbohydrate:- it was determined in dry weight sample according to **Mgnetskietal. (1959).**

Statistical analysis:

The field data were statistically analyzed using the analysis of variance method according to **Snedecor and Cochran (1991).**L.S.D values at the 5% level of probability was used in order to compare between means of treatments.

Results and Discussions

1. Vegetative growth characteristics.

Data presented in Table (4) show the effect of NPK mineral fertilizers (100,80and 60%) at recommended dose as a soil application and foliar spray with different two sources of NPK either in the form of 20:20:20 mineral form NPK and in the form of nano NPK beside control treatment as well as their interaction on vegetative growth parameters of snap bean plants growing under greenhouses during the two seasons of study.

It is evident from data in Table (4) that, there were significant differences in most studied morphological vegetative growth parameters of snap bean plants among the used different levels of NPK mineral fertilizer. In addition, using 100%,80% of NPK fertilizer at the recommended dose (39 kg Ammonium nitrate + 15.15 l Phosphoric acid + 12.6 Potassium sulphate/ greenhouse 360 m^2) of mineral fertilizer reflected significantly and the highest values in all measured vegetative growth aspects (plant height, number of leaves, total fresh and dry weight/plant as well as leaf area)of bean plants compared with 60% NPK fertilization at the recommended dose of mineral fertilizer which gave the lowest values in the two seasons of study. On the contrary, such differences did not reach the level of significance in case of number of branches per plant in the first season only. Such increments in vegetative growth parameters in case of using 100% and 80% in fertilization may be due to its highest content of nutrient elements which may be attributed to the main role of macro- nutrients (N, P and K) on formation of protoplasmic material, cells division and elongations and bio – chemicals interaction which might affect the rate of plant growth. Obtained results are in agreement with those reported by **Kakon *et. al. (*2016), Fouda (2017), Abdela *et. al.* (2018), Kwizera *et. al.*(2019) and Temegne *et. al.*(2019).**

As for the effect of foliar spray treatments, the same data in Table (4)indicate that spraying snap bean plants with NPK 20:20:20 at rate of 2ml/l and nano NPK at 2ml/l of each element starting after 21 days from sowing and every two weeks by interval during growth season increased all measured growth aspects expressed as plant height, number of leaves and branches/plant, fresh and dry weight of plant and leaf area per plant compared with the control treatment in the two seasons of study. In this regard, spraying the plants with nano NPK gave the significant highest values of plant height, total fresh and dry weight and leaf area/plant in both seasons. On the other hand, the increment in case number of leaves per plant did not reach the level of significant Obtained data may be due to that nano and compound NPK increase content of macro nutrients content as shown in fig. (1,2) which affect positively growth rate of snap bean plants. Foliar feeding combination of N, P and K as nano fertilizer showed improvements of growth because nano fertilizer are easily absorbed by the epidermis of leaves them translocated to stems which facilitated the uptake of active molecules and enhanced growth. Obtained results are coincided with those mentioned **by Amira *et al.*(2016) and Kwizera *et al.* (2019)** in case of NPK in the form of 20:20:20 **and Eleyan (2018) and Rathnayaka et al. (2018) ,** in case of NPK on nano form.

With regard to the effect of the interaction between soil addition fertilizers and foliar spray treatments, the same data in Table(4) indicate that fertilizing the plants with 80% NPK applied at the recommended dose of mineral fertilizer combined with nano NPK form at 2 ml/l of each element sprayed every 14 days during the growth season and gave the highest values in all growth aspects followed by soil fertilized with 100% plus foliar spray of NPK in nano form compared with other interaction treatments. Obtained result are true during both seasons of study.

2. Chemical composition of plant foliage

Concerning to the effect of NPK fertilization treatments, it's clear from such data in table (5) that fertilizing snap bean plants with 100% , 80% and 60%of recommended dose show no significant differences in all determined chemical constituent of chlorophyll a, b, carotenoids and potassium percentage in the first season and carotenoids in the second one. In this regard, 100% most improved significantly nitrogen, phosphor, calcium and magnesium percentages compared with 80 or 60% in both seasons of study. In addition, such increments in N, P and K content as a result of increments in increasing the amounts of added mineral fertilizers may be due to the increase of such nutrient in roots biosphere and consequently increases its uptake and accumulation of such macro- nutrients. Also, the increase in contents photosynthetic pigment molecules might be attributed to the main role of used macro- nutrients (NPK) as constituents and assimilates rate for precursors of carbohydrates in leaves. Obtained results are coincided with those mentioned **by Amira *et al.* (2016)**,**Fouda (2017) and Rehab *et al.(*2018)**

Concerning the effect of foliar spray treatments, the same data in Table (5) indicate that, spraying bean plants after 21days form sowing and every two weeks with normal NPK or NPK in nano form tended to the increase in most studied chemical constituents of plants that reached the level of significance during both seasons compared with control. In addition, spraying plants with nano NPK gave significantly the highest values of the most measure aspects, followed by 20:20:20 of normal NPK, meanwhile respect untreated plants posed the least values in this respect. Obtained results are similar to those reported by **Hayyawi (2018)**, **heba *et. al.* (2019)** and **Eleyan (2018)**.

As for the effect of the interaction the same data in Table(5) indicate that fertilizing the plants with 100% of mineral NPK fertilizer combined with spraying the plant with nano NPK reflected the highest values in most measure i.e., chlorophyll a, a+b, carotenoids, nitrogen, potassium, phosphor, calcium and magnesium content in the two seasons of study. On the other hand, fertilizing snap bean with 60% of recommended dose of NPK and without foliar spray (control treatments) gave the lowest values in all assayed aspects during both seasons of study.

3. Green pods yield and its components.

Data in Table (6) indicate that, there were significant differences in total produced green pods yield and its components expressed as early, marketable as well as total pod yield /$m^2$and pod yield per plant between the used fertilizer levels i.e., 100%,80%,60% NPK from the recommended dose in the two seasons of study. In this respect, such differences reached the level of significance between 100% and 80% from one side and compared with 60% from the other side in all case of green pods yield and its components during the two seasons of study. In this connection, using 60% from recommended dose reflected the lowest values in produced green pods yield. Such increments in produced pods yield per plant, early yield/m^2 and marketable yield /m^2 may be due to the highest macro- elements content in 100% and 80% that can add more amounts of macro- elements in easily soluble and available forms which increased its contents in plant foliage which lead to improve plant growth and consequently increase pods produced per plant , early yield and marketable yield per square meter. Obtained results are in agreement with those reported by **Kakon *et al*. (2018)** and **Mbeke *et al*.(2014)**.

As for the effect of spray treatments on total produced pods yield and its components, such data in Table (6) show that, spraying snap bean plants after 3weeks form planting and every 2weeks by interval during the growth seasons with20:20:20 NPK 2ml/l and nano NPK 2ml/l of each element significantly increased total produced pods yield and its components except early yield in second season. In this connection, spraying NPK in nano form on bean plants reflected the highest produced total pods yield and its components expressed as plant yield and total yield per plant and square meter followed by normal form 20:20:20 NPK compared with the control one during the two seasons of study. In this regard, the superiority of using nano NPK on total produced yield and its components may be attributed to the characteristics of nano metric materials in the speed of entry to plant cell and absorption which lead to increase plant growth and consequently increase pods formation. Similar results were reported by **Inayat *et. al.(*2014), Sathe *et. al*. (2015)** and **Shruthi *et al. (2013*)** in case of normal NPK 20:20:20 application **and Rehab *et al.(*2018) ,heba *et al.* (2016), Rathnayaka *et al.* (2018)** and **Heba *et al.* (2019) .** in case of nano NPK form application**.**

As for the effect of the interaction between soil addition treatments and foliar spray treatments on total produced green pods yield and its components data in Table (6) reveal that spraying bean plants with NPK in nano form plus fertilizing the plants with either 100% or 80% mineral fertilizer from recommended dose reflected the highest values in total produced green pods yield and its components whereas, fertilizing snap bean plants with 60% of NPK recommended dose without foliar spay(control) gave the least values of produced yield.

4. Chemical pods quality.

With regard to the effect of fertilization treatments, data in Table (7) show that there were a differences among the fertilization treatments in all measured chemical pods quality expressed as total carbohydrate, protein, fiber, phosphor, potassium and TSS percentages during both seasons of study. In this regard, Fertilizing snap bean plants with using 100% and 80% of mineral NPK fertilizer at the recommended dose gave the highest value in all assayed chemical constituents without significant differences among them except in case of carbohydrate, protein, phosphor, potassium and TSS percentages in both seasons of study compared with using 60%NPK.The lowest fiber percentage was recorded as a result of using 80% from recommended dose as soil addition during two season, without significant with 100%. Such results may be due to the main role of these macro- elements in mineral fertilization on assimilation and formation of carbohydrates, protein, fiber, phosphor and potassium content. Obtained results are coincided with those reported by **El-Nemr (2002) ,El-Awadi*et al.* (2011) ,Fouda (2017)**

As for the effect of foliar spray Data in **Table (7)** revealed that spraying snap bean plant with two sources of mineral fertilizer form (20:20:20 and nano NPK) increased all measured chemical quality traits compared with the control treatment during the two seasons of study. Such increments reached the level of significance in all measure under study. In addition, spraying the plants with nano NPK exhibited the highest values in all measure aspects under study during the two season compared with 20:20:20 NPK. while the lowest fiber percentage was recorded as a result of using nano NPK during the two seasons of growth. In this respect, **Shruthi *et al.* (2013)** reported similar results.

As for the effect of the interaction the same date in Table (7) indicate that fertilizing bean plants with 100% of NPK recommended dose with spraying the plants by nano NPK reflected the highest values of all measure chemical quality parameters in both season followed by fertilizing bean plant with 80% of recommended dose with spraying the plants by nano NPK with significant increased in all measure aspects in both season of study.

Table 4. Effect of mineral fertilizers level and foliar spray treatments as well as their interactions on vegetative growth parameters of snap bean plants during the two seasons 2017-2018 and 2018 -2019.

Treatments		2017-2018						2018-2019					
		Plant height (cm)	NO. of leaves/ plant	No. of veg. Branch es /plant	Total fresh weight (g/plant)	Total dry weight (g/plant)	Leaf area/ plant (cm^2)	Plant height (cm)	NO. of leaves/ plant	No. of veg. Branch es /plant	Total fresh weight (g/plant)	Total dry weight (g/plant)	Leaf area/ plant (cm^2)
Soil App.	100% N,P,K	306.3	16.14	2.12	307.3	30.91	115.6	286.7	13.92	2.09	225.3	30.83	101.98
	80%N,P,K	305.9	16.03	1.90	294.2	29.80	115.4	286.3	15.29	1.98	208.7	28.47	87.88
	60%N,P,K	293.3	14.19	1.67	277.5	27.69	91.0	273.3	14.08	1.51	191.1	27.14	84.34
	LSD	11.94	0.89	Ns	10.91	1.12	3.81	12.28	0.93	0.33	8.03	2.22	4.34
Foliar Spray	20:20:20	298.7	16.06	2.03	295.6	29.22	114.2	279.4	14.16	2.08	215.5	30.50	87.41
	Nano N,P,K	320.0	15.52	2.27	313.6	31.47	123.0	300.0	14.96	2.07	224.0	32.22	104.81
	Control	286.8	14.82	1.38	269.0	26.45	84.9	266.8	13.92	1.43	184.8	23.70	81.92
	LSD	7.51	0.80	0.32	12.50	1.22	5.81	10.86	Ns	0.24	8.60	1.66	3.91
100% NPK	20:20:20	291.1	16.67	2.33	323.0	30.63	129.0	272.2	13.13	2.23	224.1	31.69	90.50
	Nano N,P,K	337.8	16.20	2.47	326.2	32.50	136.0	317.8	14.77	2.33	241.2	33.42	129.27
	Control	290.0	15.57	1.57	272.8	29.60	81.8	270.1	13.87	1.70	210.3	27.37	86.17
80% NPK	20:20:20	302.8	16.20	1.87	278.9	30.73	122.5	283.9	14.57	2.20	214.1	31.02	83.97
	Nano N,P,K	325.0	16.90	2.53	330.3	31.90	133.7	305.0	16.53	2.43	231.1	30.69	97.80
	Control	290.0	15.00	1.30	273.4	22.97	90.0	270.0	14.00	1.30	181.0	23.71	81.73
60% NPK	20:20:20	302.2	15.20	1.90	284.9	26.30	91.0	282.2	14.77	1.80	208.3	28.80	87.77
	Nano N,P,K	297.2	13.47	1.80	284.1	30.00	99.2	277.2	13.57	1.43	201.9	32.60	87.37
	Control	280.5	13.9	1.3	263.7	26.77	82.7	260.5	13.90	1.30	163.1	20.01	77.87
L.S.D		13.01	1.40	0.55	21.66	2.04	10.07	18.81	2.15	0.42	27.95	4.79	23.32

Table 5. Effect of mineral fertilizers levels and foliar spray treatments as well as their interactions on chemical constituents of plant foliage of snap bean plants during the two seasons 2017- 2018 and 2018 -2019.

Treatments		2017-2018									018-2019								
		Chlorophyll (a) (mg/100g f.w)	Chlorophyll(b) (mg/100g f.w)	Chlorophyll(a+b) (mg/100g f.w)	Carotenoids (mg/100g f.w)	N%	P%	K%	Ca%	Mg%	Chlorophyll (a) (mg/100g f.w)	Chlorophyll(b) (mg/100g f.w)	Chlorophyll(a+b) (mg/100g f.w)	Carotenoids (mg/100g f.w)	N%	P%	K%	Ca%	Mg%
Soil App.	100% N,P,K	8.59	5.29	13.88	2.7	3.05	0.62	1.73	0.82	0.42	8.94	5.31	14.25	3.38	3.13	0.61	1.75	0.83	0.42
	80%N,P, K	8.40	4.88	13.28	2.8	2.87	0.59	1.73	0.73	0.37	7.63	4.95	12.58	3.62	2.86	0.60	1.81	0.73	0.37
	60%N,P,K	7.50	4.55	12.05	2.6	2.57	0.48	1.52	0.60	0.32	7.01	4.28	11.29	3.09	2.55	0.49	1.68	0.62	0.33
	LSD	ns	ns	0.90	ns	0.04	0.001	ns	0.04	0.04	1.61	0.66	1.41	ns	0.21	0.001	0.08	0.04	0.04
Foliar Spray	20:20:20	7.54	4.86	12.42	2.8	2.85	0.56	1.69	0.72	0.37	7.75	4.73	12.48	3.64	2.92	0.56	1.87	0.72	0.36
	Nano N,P,K	9.53	4.99	14.52	2.9	2.95	0.61	1.76	0.77	0.41	8.15	6.64	14.79	3.37	2.94	0.61	1.88	0.78	0.41
	control	7.41	4.87	12.28	2.4	2.69	0.53	1.52	0.66	0.34	7.68	5.17	12.85	3.07	2.70	0.53	1.48	0.67	0.35
	LSD	1.12	ns	ns	0.40	0.01	0.001	ns	0.03	0.001	Ns	1.32	1.50	ns	0.19	0.03	0.04	0.03	0.03
100% NPK	20:20:20	7.95	5.32	13.27	2.7	3.03	0.63	1.45	0.84	0.41	7.90	5.21	13.11	3.51	3.29	0.60	1.81	0.84	0.41
	Nano N,P,K	10.04	4.94	14.98	2.9	3.12	0.64	1.96	0.87	0.43	10.17	4.70	14.87	3.47	3.09	0.62	1.98	0.88	0.44
	control	7.77	5.60	13.37	2.4	2.99	0.61	1.79	0.75	0.34	8.76	6.01	14.77	3.15	3.01	0.61	1.46	0.77	0.42
80% NPK	20:20:20	7.22	4.41	11.63	2.9	2.91	0.59	1.89	0.71	0.36	7.80	4.27	12.07	3.81	2.89	0.61	1.92	0.70	0.34
	Nano N,P,K	10.38	5.71	16.09	2.9	3.00	0.61	1.73	0.80	0.41	7.46	5.09	12.55	3.68	3.00	0.61	1.73	0.81	0.41
	control	7.59	4.53	12.12	2.6	2.70	0.57	1.57	0.68	0.42	7.62	5.49	13.11	3.38	2.70	0.57	1.78	0.69	0.36
60% NPK	20:20:20	7.46	4.86	12.32	2.9	2.60	0.47	1.74	0.61	0.34	7.54	4.70	12.24	3.61	2.56	0.48	1.89	0.64	0.34
	Nano N,P,K	8.16	4.31	12.47	3.0	2.72	0.58	1.60	0.64	0.38	6.83	4.12	10.95	2.97	2.71	0.59	1.94	0.65	0.38
	control	6.87	4.47	11.34	2.0	2.39	0.41	1.21	0.56	0.25	6.65	4.02	10.67	2.69	2.38	0.41	1.21	0.56	0.26
L.S.D		2.66	ns	4.76	0.60	0.002	0.002	0.49	0.056	0.001	2.60	Ns	3.33	1.06	0.34	0.05	0.08	0.05	0.05

Table 6. Effect of mineral fertilizers and foliar spray treatments as well as their interactions on green pods yield and its components of snap bean plants during the two seasons 2017 and 2018.

Treatments		Early yield (g/m^2)	Marketable yield/m^2	Total Pod yield (g/m^2)	Pod yields (g/plant)	Early yield (g/m^2)	Marketable yield/m2	Total Pod yield (g/m^2)	Pod yields (g/plant)
Soil App.	100% N,P,K	769.73	5816	6114	1219.1	776.2	6060	6226	1265.2
	80%N,P,K	815.87	5646	6054	1201.0	748.0	5803	5989	1224.5
	60%N,P,K	687.97	5358	5796	1121.6	642.8	4759	5271	1054.4
	LSD	65.81	210.10	290.20	44.49	105.50	263.00	427.00	85.44
Foliar Spray	20:20:20	782.50	5694	5963	1193.2	776.2	6000	6156	1288.2
	Nano N,P,K	749.70	5859	6170	1217.3	748.9	6120	6275	1292.0
	Control	708.10	5267	5831	1130.4	759.0	5460	5671	1163.7
	LSD	50.97	266.50	192.70	60.22	ns	243.00	198.10	57.13
100% NPK	20:20:20	789.20	5999	6157	1242.3	778.3	6260	6473	1295.8
	Nano N,P,K	838.30	6186	6353	1301.0	806.1	6120	6267	1311.0
	Control	681.70	5265	5832	1113.9	744.1	5800	5938	1188.9
80% NPK	20:20:20	789.20	5839	6007	1142.3	742.3	5850	5931	1297.3
	Nano N,P,K	906.70	5818	6157	1263.2	797.0	6240	6452	1275.8
	Control	660.80	5283	6000	1089.1	704.7	5320	5586	1100.5
60% NPK	20:20:20	749.80	5246	5727	1195.5	774.8	4819	5355	1071.4
	Nano N,P,K	751.70	5575	6000	1197.5	790.6	4900	5455	1091.1
	Control	653.30	5253	5663	1080.1	713.0	4560	5003	1000.7
L.S.D		88.29	510.00	333.70	104.30	85.66	254.00	343.10	98.94

Table 7. Effect of mineral fertilizers level and foliar spray treatments as well as their interactions on chemical fruit quality of snap bean plants during the two seasons 2017 - 2018 and 2018- 2019.

Treatments		2017-2018						2018-2019					
		Carbohydrates %	Protein %	Fiber %	p%	k%	T.S.S%	Carbohydrates %	Protein %	Fiber %	p%	k%	T.S.S%
Soil App.	100% N,P,K	25.38	19.44	9.43	0.68	2.11	6.85	25.52	19.41	9.64	0.68	2.11	6.59
	80%N,P,K	24.13	18.04	9.43	0.60	1.94	6.19	24.13	18.17	9.44	0.60	1.94	6.43
	60%N,P,K	21.64	18.13	9.47	0.64	1.74	6.01	21.86	18.17	9.83	0.62	1.74	6.16
	LSD	0.11	0.21	ns	0.04	0.04	0.18	0.11	0.21	0.32	0.04	0.04	0.15
Foliar Spray	20:20:20	23.79	19.02	9.52	0.62	1.97	6.74	23.82	19.11	9.72	0.62	1.97	6.47
	Nano N,P,K	25.29	20.07	9.68	0.65	2.02	6.78	25.29	20.11	9.42	0.67	2.02	6.66
	Control	22.07	16.53	9.12	0.63	1.81	5.62	22.41	16.53	9.76	0.62	1.81	6.04
	LSD	0.42	0.25	0.18	0.001	0.03	0.21	0.42	0.26	0.18	0.001	0.03	0.22
100% NPK	20:20:20	26.05	19.77	9.20	0.66	2.10	6.50	26.20	19.80	9.42	0.66	2.14	6.45
	Nano N,P,K	26.86	21.37	9.96	0.71	2.16	7.47	26.80	21.30	9.30	0.71	2.16	6.65
	Control	23.24	17.20	9.12	0.68	2.08	5.65	23.57	17.13	10.20	0.68	2.06	6.35
80% NPK	20:20:20	23.99	17.70	9.48	0.60	2.00	6.40	24.03	17.87	9.70	0.61	2.00	6.55
	Nano N,P,K	26.09	19.73	9.70	0.68	2.07	7.45	26.07	19.83	9.37	0.68	2.05	6.97
	Control	22.31	16.70	9.10	0.51	1.76	5.67	22.33	16.80	9.24	0.55	1.77	6.09
60% NPK	20:20:20	21.34	19.60	9.89	0.59	1.80	6.39	21.23	19.67	10.03	0.58	1.81	6.42
	Nano N,P,K	22.93	19.10	9.39	0.62	1.83	6.37	23.00	19.20	9.60	0.63	1.85	6.37
	Control	20.67	15.70	9.13	0.66	1.58	5.55	21.34	15.63	9.85	0.65	1.60	5.70
L.S.D		0.74	0.46	0.32	0.001	0.05	0.29	0.62	0.90	0.34	0.05	0.08	0.22

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تأثير التسميد الارضي بمستويات مختلفة من النتروجين والفوسفور والبوتاسيوم مع الرش بمصادر مختلفة من العناصر الكبرى علي نمو وانتاجيه وجوده الفاصوليا الخضراء النامية تحت الصوب

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1-قسم البساتين- كلية الزراعة – جامعة بنها

2-قسم الزراعات المحمية – معهد البساتين – مركز البحوث الزراعية

اجريت تجربة حقلية خلال الموسم النيلي لعامي 2017-2018 و 2018- 2019 في مزرعة خاصه بقريه دملو- محافظه القليوبية. لدراسة تأثير التسميد الارضي بمعدل (100و80و60%) من المعدل الموصي به وكذلك التسميد الورقي بمصدرين مختلفين للنتروجين والفوسفور والبوتاسيوم(NPKفي صوره مركب 20:20:20و NPKفي الصورة النانو متريه) والتفاعل بينهما وتأثير ذلك على النمو الخضري والتركيب الكيميائي للمجموع الخضري للنبات والمحصول الثمري ومكوناته وكذلك ايضا جودة الثمار الناتجة للفاصوليا الخضراء صنف موراليدا النامية تحت الصوب وقد اشتملت التجربة علي9 معامله تم تصميمها في قطع منشقه حيث تم توزيع المعاملات السمادية الأرضية في القطع الرئيسية ومعاملات الرش في القطع الفرعية .

وقد اظهرت النتائج المتحصل عليها ان التسميد بالسماد المعدني بمعدل 100% و 80% كإضافة ارضيه مع الرش بمركب NPKفي الصورة النانو متريه بمعدل 2 مل /لتر خلال موسم النمو ادي الي زياده جميع مواصفات النمو الخضري التي تم قياسها وكذلك المحصول الناتج ومكوناته وصفات الجودة للثمار الناتجة مقارنه بمعامله الكنترول .وكانت اقل النتائج المتحصل عليها ناتجه من التسميد بمعدل 60% مع عدم الرش بالمركبات تحت الدراسة.

ويمكن بذلك التوصية باستخدام السماد 100و80% اضافه ارضيه بالمعدل الموصي به للسماد المعدني مع الرش بمركب NPKفي الصورة النانو متريه وذلك لزياده النمو الخضري والمحصول الثمري الناتج.

الكلمات الدالة:

الفاصوليا الخضراء – مركب NPK 20:20:20 – نانو NPK –- النمو الخضري- المحصول الثمري- جودة الثمار- الصوبة البلاستيكية.