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Performance of Some Snap Bean Varieties as Affected by Different Levels of Mineral Fertilizers

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Abstract: This study was designed in order to evaluate the growth and yield performance of some French bean varieties (*Phaseolus vulgaris* L.) i.e. Royal Nel, Duel, Coby and Julia and their responses to different levels of NPK fertilization. The four mentioned varieties were fertilized with four NPK levels i.e. 20: 32: 24; 30: 48: 36; 40: 64: 48; or 50: 80: 54. Data showed that cvs. Royal Nel and Coby recorded the highest values in vegetative growth while cv. Julia was the lowest. Increasing the level of NPK resulted in a positive response in the vegetative growth. Coby and Royal Nel cultivars recorded the highest and lowest pod yield, respectively. Early and exportable yields were about 10 and 71% of total yield, respectively. Yield increased as the level of NPK increased meanwhile, pod quality i.e. pod length, thickness and fiber content were not significantly affected by the level of NPK application. With the same pattern of response to NPK level, genotype of each cultivar was the predominant factor in the interactive response.

Key words: Bean, *Phaseolus vulgaris* L., fertilizers, NPK, yield, quality

INTRODUCTION

The Egyptian horticultural sector is rapidly becoming oriented towards the international market. Egypt has the potential to increase its export levels and the success will lie in meeting the quality standards of the EU markets^[1]. Egypt is a large-scale producer and exporter of green beans and is ranked the world's seventh largest exporter of green beans with a market share 8%^[2]. Therefore expansion in green bean cultivation is growing rapidly and usually is taking place in the new reclaimed lands. The cultivated area of green bean in Egypt reached 21300 ha produced 215000 tons^[3].

The first step in producing high quality exportable yield is cultivating the right varieties because some varieties are more suitable for the European consumers than others. Pod quality attributes are the most important factors, which affect the percentage of exportable yield. Many investigators reported that the vegetative growth, total and exportable yield as well as pod quality of snap bean (*Phaseolus vulgaris* L.) are greatly affected by genotype of the variety^[4-7].

The performance of any crop depends not only on its genetic characteristics but also on the surrounding environmental conditions particularly the availability of nutrients. New reclaimed lands are characterized by the low fertility. Therefore addition of fertilizers is expected to have a big impact on crop performance. Growth, yield and yield attributes increased with increasing rates of nitrogen

up to 90 kg ha⁻¹^[8,9]. Further, pod yield was the highest with 120 kg P^[10]. Increasing NPK rates^[11] or increasing N:P fertilizer levels only^[12], increased yield of green bean compared to lower rates.

The interaction of fertilizers with cultivars has been found earlier. Yield increased with increasing N rates however, the responses to N fertilizer varied considerably among cultivars^[13]. In addition, Dry matter accumulation in various plant parts and in whole plants increased significantly due to cultivars and fertilizer rates^[14].

Introducing new cultivars to the Egyptian growers may not need a specific fertilizer recipe however; some tuning of existing fertilizer formula may be enough.

This study aimed at evaluating growth, yield and quality of some new snap bean varieties and their response to different levels of mineral fertilizers of NPK under the new reclaimed land conditions.

MATERIALS AND METHODS

Two field experiments were carried out during the two successive seasons of 2003 and 2004 in Wadi El-Mulaak area, Ismailia governrate to study the effect of different levels of mineral fertilizers of NPK on growth, yield and quality of some snap bean varieties under the new reclaimed land conditions.

The experiment included 16 treatments, which were the combination between four levels of mineral fertilizers and four snap bean varieties as follows:

Levels of mineral fertilizers (N:P:K) as kg/feddan (feddan= 0.42 ha): -20: 32: 24; 30: 48: 36; 40 : 64 : 48 and 50:80:54. All the amount of P and 25% of K fertilizers were applied during soil preparation. Meanwhile, the total amounts of N and the remaining of K fertilizers were divided into three equal doses. First portion was added three weeks after sowing, the second dose was added three weeks after the first application and the third dose was applied after the first pod picking. Fertilizers were applied in the forms of Ammonium sulfate, Calcium super phosphate, potassium sulfate for N, P and K, respectively.

Varieties of snap bean: Royal Nel, Duel, Coby and Julia.

The soil of the experimental site was sandy in texture. Split plot design with three replicates was followed. Main plots were devoted for varieties whereas; the levels of mineral fertilizers were assigned randomly in the sub-plots. Each experimental unit area was 12 m².

After preparing the soil for cultivation, ditches of 20 cm width were formed. Organic manure (5 ton compost/fed) was added through the ditches then was covered by sand and was irrigated. Seeds of snap bean varieties were sown on the last week of September of 2003 and 2004 seasons in 5 cm deep halls on both sides of the row at 7 cm apart. Agricultural practices other than the experimental treatments were carried out as recommended by the Ministry of Agriculture in Egypt.

Data recorded

Plant growth: Random samples of five plants were taken at 45 days after sowing from each plot to measure plant growth parameters i.e. plant height, number of leaves and branches as well as fresh and dry weights of plant.

Green pods yield: Pickings were carried out every three days to harvest green pods that reached its marketing stage specified for each variety (extra fine and fine). Pods were picked and classified into: Early yield (the first four pickings); Exportable yield and Total yield (as ton/fed).

Pod quality: At the second picking, a random sample of 100 pods from each experimental unit was used to measure pod length (cm), diameter (mm) and pod content of protein, carbohydrate and fiber whereas, pod content of protein, carbohydrate and fiber were determined according to the methods described by Chapman and Pratt^[15], Dubois *et al.*^[16] and Rai and Mndga^[17], respectively. Pod thickness (mm) was measured to determine the ratio of extra fine: fine yield in the collected samples.

The obtained data were statistically analyzed by the method described by Gomez and Gomez^[18].

RESULTS

Vegetative growth

Effect of snap bean varieties: Data in Table 1 show that snap bean varieties in both seasons significantly differed in their vegetative growth parameters. Plant height and number of leaves recorded the lowest values with cv. Julia. Meanwhile the highest values of the two parameters were recorded in cvs. Royal Nel and Coby for plant height and number of leaves, respectively. As for number of branches, data show that the highest values were recorded with cvs. Coby and Duel followed by Royal Nel. In both seasons, results also clarified that cv. Royal Nel gave the highest fresh and dry weights followed by cv. Coby. However, cv. Julia gave the lowest values of vegetative growth parameter.

Effect of the mineral (NPK) fertilizers application:

Data in Table 2 show that all recorded vegetative growth parameters responded significantly and positively to increasing the level of mineral fertilizers (NPK) application as shown in both seasons.

Table 1: Vegetative growth of snap bean plant as affected by genotype of variety

NPK (kg/fed)	Plant height	Number of		Fresh weight g/plant	Dry weight g/plant
		Leaves	Branches		
First season					
Royl Nel	39.14	9.38	3.68	20.08	4.47
Duel	32.61	8.77	4.31	16.37	3.67
Coby	31.43	11.40	4.41	18.97	4.00
Juela	23.26	6.84	3.30	9.38	2.61
LSD	1.27	1.53	0.51	0.47	0.39
Second season					
Royl Nel	46.72	11.59	4.92	24.31	5.77
Duel	38.79	10.77	5.75	20.19	5.06
Coby	37.71	13.84	5.95	23.28	5.67
Juela	27.83	8.95	4.54	12.93	4.08
LSD	1.27	1.26	1.03	1.21	0.59

Table 2: Vegetative growth of snap bean plant as affected by NPK fertilizer level

NPK (kg/fed)	Plant height	Number of		Fresh weight g/plant	Dry weight g/plant
		Leaves	Branches		
First season					
20:32:24	27.80	7.65	3.16	12.60	2.80
30:48:36	30.10	8.94	3.81	14.36	3.45
40:64:48	32.72	10.10	4.48	17.44	4.31
50:80:60	35.80	9.70	4.24	20.40	4.19
LSD	2.17	1.09	0.42	1.17	0.40
Second season					
20:32:24	32.86	9.67	4.38	15.34	3.91
30:48:36	35.96	10.90	4.99	18.45	4.61
40:64:48	38.77	12.12	5.79	21.71	5.63
50:80:60	43.46	12.47	6.01	25.22	6.43
LSD	2.46	0.98	0.53	1.16	0.45

Table 3: Vegetative growth of snap bean plant as affected by the interaction between snap bean variety and level of NPK fertilizer application

Treatments		Plant height	Number of		Fresh weight g/plant	Dry weight g/plant
Snap bean variety	NPK (kg/fed)					
			Leaves	Branches		
First season						
Royal Nel	20:32:24	31.33	8.07	3.00	15.22	3.29
	30:48:36	38.67	9.07	3.63	16.52	3.59
	40:64:48	41.12	10.30	4.09	21.53	5.38
	50:80:60	45.45	10.09	4.00	27.06	5.64
Duel	20:32:24	31.45	8.14	3.61	12.45	2.71
	30:48:36	31.45	8.31	4.00	14.24	3.50
	40:64:48	33.09	9.49	4.31	18.07	4.15
	50:80:60	34.45	9.12	5.31	20.70	4.34
Coby	20:32:24	29.13	8.13	3.50	14.14	3.14
	30:48:36	30.17	11.18	4.82	17.58	4.16
	40:64:48	31.25	13.14	5.00	20.67	4.77
	50:80:60	35.16	13.14	4.31	23.48	3.92
Julia	20:32:24	19.29	6.24	2.53	8.59	2.06
	30:48:36	20.13	7.22	2.81	9.09	2.56
	40:64:48	25.44	7.46	4.50	9.49	2.93
	50:80:60	28.16	6.42	3.34	10.37	2.88
LSD 5%		3.96	1.57	0.75	3.23	0.74
Second season						
Royal Nel	20:32:24	36.93	10.01	4.27	18.59	4.12
	30:48:36	46.40	10.88	4.69	21.35	4.87
	40:64:48	48.68	12.36	4.91	25.64	6.62
	50:80:60	54.87	13.11	5.80	31.67	7.47
Duel	20:32:24	36.74	9.76	4.67	14.81	3.92
	30:48:36	37.74	10.31	5.47	17.75	4.53
	40:64:48	39.37	11.39	6.17	22.35	5.31
	50:80:60	41.34	11.61	6.71	25.84	6.47
Coby	20:32:24	34.96	10.76	5.20	16.97	4.47
	30:48:36	35.53	13.41	5.78	22.10	5.33
	40:64:48	37.50	15.11	6.33	25.14	6.05
	50:80:60	42.86	16.10	6.51	28.91	6.84
Julia	20:32:24	22.82	8.16	3.37	10.97	3.14
	30:48:36	24.16	8.99	4.04	12.58	3.70
	40:64:48	29.53	9.62	5.73	13.72	4.52
	50:80:60	34.79	9.04	5.01	14.44	4.95
LSD 5%		4.72	1.37	0.61	3.14	0.60

Effect of the interaction treatments: Results clarified that snap bean varieties differed in their response to addition of NPK fertilizers. Generally, all studied cultivars recorded the highest vegetative growth parameters when supplied with the 3rd level (40:64:48) or 4th level of NPK (50:80:60) with no significant differences between the two levels in most of the parameters (Table 3). However, the interaction

effect of fertilizer rate and cultivars did not show any significant differences in number of leaves in both seasons. Whereas; plant height and number of branches were not significantly different in first and second seasons, respectively. Data also clarified that the highest vegetative growth parameters as fresh and dry weights of plant were recorded with cv. Royal Nel when supplied with 4th level of NPK fertilizers in both seasons.

Pod yield and its quality

Effect of snap bean variety: Data in Table 4 show that all varieties were significantly different among themselves. Coby cultivar recorded the highest pod yield and the lowest yield was recorded with cv. Royal Nel. Early and exportable yields showed the same pattern of total yield and were about 10 and 71% of total yield, respectively. Number of days until harvesting were not significantly affected by the cultivars in both seasons.

Pod length was the highest in cv. Royal Nel, which was significantly the longest compared to all other cultivars meanwhile, cv. Coby recorded the shortest pods. Royal Nel and Coby cultivars recorded the highest values of pod diameters compared to the other cultivars.

Although there were no significant differences among cultivars concerning protein contents in pods, carbohydrate content recorded a significant high value in Royal Nel. Other cultivars were not significantly different from each other's. Only cv. Julia recorded the lowest fiber content compared to other cultivars in second season.

Effect of mineral (NPK) fertilizer application: Data in Table 5 show that the total, early and exportable yield gradually and significantly increased with increasing the level of mineral fertilizers in both seasons. There was no significant difference between the third and fourth levels of NPK concerning these parameters.

Increasing the level of mineral fertilizers application significantly increased number of days to harvesting. Pod quality i.e. pod length, thickness and fiber content were

Table 4: Total, exportable and early yield, number of days for harvesting and pod quality of snap bean plant as affected by genotype of variety

CV	Yield (ton/fed)			No. of days to harvesting	Pods quality					
	Total	Early	Exportable		Weight (g)	Length (cm)	Thickness (cm)	Protein (%)	Carbo-hydrate g/dry wt.	Fiber (%)
First season										
Royl Nel	3.448	0.361	2.460	66.98	5.44	14.59	6.21	3.05	21.21	10.56
Duel	3.696	0.376	2.629	66.68	4.27	12.17	5.22	3.16	20.45	10.67
Coby	4.083	0.412	2.891	65.40	2.53	10.21	6.01	3.29	20.31	10.55
Juela	3.926	0.406	2.798	66.08	3.84	11.60	5.13	2.90	20.29	10.49
LSD	0.104	0.017	0.130	NS	0.17	0.34	0.81	NS	0.25	NS
Second season										
Royl Nel	4.114	0.430	2.986	72.63	6.02	16.75	6.99	3.20	22.73	11.58
Duel	4.427	0.447	3.246	72.35	4.72	14.03	6.00	3.33	22.36	11.45
Coby	4.891	0.487	3.545	70.92	2.85	11.75	6.87	3.43	22.18	11.08
Juela	4.761	0.484	3.441	71.74	4.26	13.41	5.90	3.13	21.94	11.03
LSD	0.168	0.027	0.225	NS	0.19	0.34	0.90	NS	0.45	0.37

Table 5: Total, exportable and early yield, number of days for harvesting and pod quality of snap bean plants as affected by NPK fertilizer level

NPK (kg/fed)	Yield (ton/fed)			No. of days to harvesting	Pods quality					
	-----				Weight (g)	Length (cm)	Thickness (cm)	Protein (%)	Carbohydrate g/dry wt.	Fiber (%)
	Total	Early	Exportable							
First season										
20:32:24	3.050	0.317	2.173	65.48	3.92	11.99	5.43	2.97	20.39	10.59
30:48:36	3.756	0.381	2.662	66.08	3.99	12.09	5.56	3.04	20.48	10.57
40:64:48	4.121	0.415	2.918	66.60	4.07	12.18	5.73	3.14	20.61	10.57
50:80:60	4.226	0.442	3.025	66.98	4.10	12.30	5.86	3.24	20.79	10.54
LSD	0.359	0.041	0.255	0.65	NS	NS	NS	0.13	0.12	NS
Second season										
20:32:24	3.610	0.373	2.724	71.09	4.32	13.78	6.14	3.12	21.75	11.52
30:48:36	4.490	0.445	3.236	71.68	4.42	13.91	6.38	3.21	22.06	11.35
40:64:48	4.971	0.519	3.552	72.17	4.53	14.07	6.59	3.31	22.50	11.24
50:80:60	5.123	0.511	3.705	72.71	4.58	14.18	6.66	3.45	22.90	11.01
LSD	0.444	0.056	0.342	0.99	NS	NS	NS	0.17	0.52	NS

Table 6: Total, early and exportable yield and pod quality parameters of snap bean plant as affected by the interaction between snap bean variety and level of NPK fertilizer application

Treatments		Yield (ton/fed)				No. of days to harvesting	Pods quality				
Snap bean variety	NPK (kg/fed)	Total	Early	Exportable	Length (cm)		Thickness (cm)	Protein (%)	Carbohydrate g/dry wt.	Fiber (%)	
First season											
Royal Nel	20:32:24	2.475	0.281	1.819	66.60	14.22	6.02	2.88	21.08	10.67	
	30:48:36	3.520	0.352	2.464	66.60	14.40	6.15	3.04	21.16	10.61	
	40:64:48	3.820	0.395	2.740	67.50	14.66	6.30	3.11	21.28	10.55	
	50:80:60	3.978	0.414	2.818	67.20	15.06	6.36	3.16	21.32	10.42	
Duel	20:32:24	3.075	0.314	2.152	65.70	12.07	5.08	3.06	20.18	10.52	
	30:48:36	3.690	0.376	2.649	66.60	12.15	5.13	3.13	20.30	10.60	
	40:64:48	3.993	0.399	2.795	66.90	12.21	5.24	3.17	20.43	10.72	
	50:80:60	4.025	0.416	2.917	67.50	12.24	5.44	3.26	20.88	10.85	
Coby	20:32:24	3.319	0.332	2.323	64.20	10.17	5.62	3.22	20.11	10.63	
	30:48:36	4.080	0.411	2.923	65.10	10.23	5.92	3.26	20.23	10.56	
	40:64:48	4.347	0.435	3.110	65.70	10.24	6.20	3.32	20.41	10.52	
	50:80:60	4.586	0.472	3.210	66.60	10.20	6.32	3.35	20.49	10.47	
Julia	20:32:24	3.330	0.340	2.398	65.40	11.51	4.98	2.70	20.18	10.53	
	30:48:36	3.732	0.387	2.613	66.00	11.58	5.04	2.75	20.23	10.50	
	40:64:48	4.324	0.432	3.027	66.30	11.63	5.19	2.97	20.31	10.49	
	50:80:60	4.317	0.465	3.155	66.60	11.69	5.30	3.19	20.45	10.44	
LSD 5%		0.558	0.052	0.386	0.55	0.26	0.15	0.13	0.17	0.20	
Second season											
Royal Nel	20:32:24	3.003	0.309	2.283	72.23	16.36	6.71	3.05	22.23	11.77	
	30:48:36	4.157	0.420	2.957	72.53	16.53	6.94	3.15	22.39	11.67	
	40:64:48	4.584	0.501	3.322	72.90	16.86	7.14	3.26	22.98	11.54	
	50:80:60	4.714	0.489	3.382	72.88	17.25	7.18	3.35	23.33	11.33	
Duel	20:32:24	3.623	0.379	2.749	71.26	13.85	5.78	3.18	21.79	11.71	
	30:48:36	4.461	0.480	3.213	72.53	14.01	5.93	3.29	22.15	11.56	
	40:64:48	4.729	0.506	3.421	72.73	14.11	6.10	3.39	22.63	11.46	
	50:80:60	4.896	0.424	3.601	72.90	14.18	6.19	3.46	22.88	11.06	
Coby	20:32:24	3.849	0.398	2.854	69.94	11.63	6.39	3.35	21.52	11.36	
	30:48:36	4.830	0.453	3.541	70.40	11.77	6.84	3.42	21.84	11.09	
	40:64:48	5.317	0.545	3.798	70.96	11.84	7.10	3.42	22.37	11.01	
	50:80:60	5.570	0.552	3.986	72.38	11.76	7.17	3.55	22.96	10.85	
Julia	20:32:24	3.963	0.407	3.011	70.93	13.30	5.70	2.90	21.46	11.25	
	30:48:36	4.512	0.425	3.235	71.28	13.35	5.82	2.98	21.85	11.09	
	40:64:48	5.256	0.526	3.666	72.08	13.47	6.00	3.18	22.03	10.98	
	50:80:60	5.313	0.578	3.853	72.68	13.51	6.10	3.45	22.42	10.81	
LSD 5%		0.581	0.088	0.454	0.71	0.26	0.17	0.14	0.21	0.17	

not significantly affected by the level of NPK application. On the contrary, protein and carbohydrates contents significantly increased with increasing the level of fertilizers application.

Effect of the interaction treatments: The interaction showed that although all cultivars responded in the same

pattern to NPK fertilizer rates, cv. Coby was the superior in total yield production only with the highest rate of NPK (Table 6). Generally, within each cultivar there was no significant difference between the highest two levels of NPK fertilizers. Royal Nel and Duel cultivars recorded the lowest production compared to other cultivars under each NPK level. Early and exportable yields showed the same

trends. Number of days until harvesting increased as the level of NPK increased and was exactly the same trend for all varieties except Royal Nel. The latter recorded the highest number of days under all levels of NPK fertilization and was not significantly different than Duel under the highest two levels of NPK. Coby cultivar recorded the lowest number of days compared to all other cultivars.

Only pod length of Royal Nel that responded significantly and positively to the different levels of NPK. Differences in this respect were only significant between cultivars. With all cultivars, the highest NPK level resulted in bigger pod diameter compared to the lowest NPK level for each cultivar (Table 6). The highest NPK level resulted in the highest content of protein in each cultivar with the highest content recorded in cv. Coby while the lowest recorded in cv. Julia. Royal Nel recorded the highest carbohydrates content while cv. Coby recorded the lowest with the same positive effect of NPK levels on this parameter for all cultivars. While cvs Coby and Julia were not significantly different from each other nor affected by NPK level, cv. Royal Nel responded negatively to increasing NPK level concerning fiber contents. Only cv. Duel that showed a positive trend to the increment in NPK level concerning fiber content in pods.

DISCUSSION

The potential of Egyptian bean production exported to EU market is too high however; it has to compete with other producers. This competition will be in favor of the one who can produce and supply the consumer demands with a guaranteed quality level with which they can maximize the market windows with a quality product. The main challenges lies in producing the fine and extra-fine beans which are preferred by the European consumers. The tested cultivars, which were used in current study, are characterized as Extra-fine/fine cultivars.

The observed differences in vegetative growth of cultivars are mainly due to the genotype of each cultivar. This result was in harmony with previous findings^[4-7] where it was reported that the vegetative growth of snap bean are greatly affected by genotype of variety.

Supply of nutrients plays an important role in growth and yield of plants. Nitrogen is an essential constituent of protein and chlorophyll, where phosphorus fertilization contributes to early crop development and maturity, whereas potassium influences both yield and pod quality. In this study, increasing NPK levels resulted in increment in vegetative growth particularly number of leaves which might result in higher leaf area hence, higher assimilate production which reflected on yield.

The quality of green bean expressed as protein and carbohydrate contents was enhanced with increasing NPK levels. This can be explained on the basis of the above explanation where increasing assimilate production means higher carbohydrates going to the pods. This is supported by Marschner^[19] who reported that potassium has a crucial role in the translocation and storage of assimilates. This explanation agrees also with other findings^[20,21] where it was concluded that the amount of photosynthate available for biomass production is related to the current leaf area and the photosynthetic rate of the crop in consideration.

Growth and yield of any crop is a function of its genotype expressed under growing environmental conditions including nutrients availability. The obtained results revealed that the effect of increasing NPK levels had the same pattern with all cultivars meanwhile, the genotype was the dominant factor that affects the final performance of each cultivars. This has been supported earlier^[13,14].

CONCLUSIONS

Under experimental conditions French bean cultivars i.e. Royal Nel, Coby, Duel and Julia are promising cultivars for producing extra-fine and fine pods for exportation because they match the consumer demands in EU market. However attention must be paid to the time of pod picking which must not exceed 3-4 days interval.

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