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EFFECT OF ROW SPACING AND FERTIGATION ON YIELD AND ITS COMPONENTS OF COMMON BEAN (*Phaseolus vulgaris*) UNDER FURROW IRRIGATION SYSTEM.

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ABSTRACT

This study aimed to investigate the response of Nebraska (dry seeds bean cv) and Paulista (green pods bean cv) to different row spacing and fertigation under surface irrigation system. Mean plant performances were recorded for the characteristics of plant growth, yield and its components as well as chemical compounds of seeds and green pods. The studied treatments were 1) Row-common fertilization, 2) Row-fertigation, 3) Bed–common fertilization-outside ridges, 4) Bed-common fertilization-inside ridges, 5) Bed-fertigation-outside ridges and 6) Bed-fertigation-inside ridges. The results showed that the highest values were recorded by treatment 2 (row-fertigation) for the characteristics of plant height, seed protein content, seed emergence, number of pods per plant, pod length, pod diameter, number of seeds per pod, number of seeds per plant, first, second class and total seed weight per plant; and treatment 5 (bed–fertigation–outside ridges) for the characteristics of number of branches per plant, carbohydrate content, third class seed weight per plant, first, second, third class and total seed weight per area unit (g/m^2) on Nebraska cv. While, treatment 2 (row-fertigation) recorded the highest values for the characteristics of dry matter per fresh pod, vitamin C content, seed protein content, carbohydrate content, seed emergence, number of pods per plant, green pod weight per plant, number of seeds per pod, number of seeds per plant, seed index (1000 seed weight), first class and total seed weight per plant; and treatment 5 (bed–fertigation–outside ridges) recorded the highest values for pod diameter, pod thickness and first class seed weight per area unit (g/m^2) on Paulista cv. Farmers may be recommended to apply bed–fertigation treatment both outside and inside ridges to grow common bean of both dry seeds and green pods that provides higher population density (low row spacing) and (fertigation) which ensure high yield with good quality and high exploitation of fertilizers.

Key words: *fertigation, Phaseolus vulgaris, row spacing, surface irrigation system, yield and its components.*

1.INTRODUCTION

Common bean (*Phaseolus vulgaris*) is one of the most produced vegetable crops in Egypt either for local market or exportation. Some of the problems that meet common bean production in Egypt are the high costs of fertilizers while the yield and income of the crop is not meeting the costs, the low exploiting of sowing area unit, seed bedding and row spacing do not take in considering the difference among cultivars and plant developing in the field and the bad way of quantity and quality of applying fertilizers that result in no homogeneity in the distribution and loosing some amount of fertilizers. The yield and its components, either quantity or quality, depends on good agricultural practices. The most important of these practices are soil preparation and fertilization which mean preparing good seed beds and applying the best amounts of fertilization. Preparing the seed beds includes bed spacing while fertilization includes the method and amount of applying. It is very important to get the most benefit and return of the agricultural area by using the most exploitable fertilization amount and area. Also, it is important to condense the sowing area to get more yields with keeping the quality of that yield as well as to get high income by decreasing the sowing costs. Many researchers studied the effect of row spacing and fertigation on yield and its components. Aminifard *et al.* (2010) found that plant density affected significantly plant growth and yield of pepper, while Goreta *et al.* (2005) reported that the growth, yield and fruit size of watermelon were affected by row spacing and plant density. Fertigation of nutrients with very great dilution in each irrigation increased the fertilizer use efficiency (Solaimalai *et al.,* 2005). Fertigation through surface irrigation means that the fertilizer is delivered by the surface water. The system should be such that the application and distribution is efficient and uniform, with minimal surface runoff at the lower end of the field, and minimal deep percolation below the crop root zone. Fertigation in general, when well-managed, can provide relatively uniform and timely applications of agricultural chemicals based on soil physical and chemical characteristics, and crop requirements. It can reduce soil compaction by limiting the need for tractors in the field. It reduces operator exposure to direct contact with agricultural chemicals, eliminates mechanical crop damage caused by ground sprayers, saves energy, and reduces environmental hazards. On the other hand, reduced yields or even crop failure may result from poor fertilizer distribution, with the consequent loss of income to farmers. In spite of the above advantages, there has been relatively little use of fertigation in surface irrigation. The inherent management problems associated with this irrigation method, particularly with furrows, may be a primary cause. Uniformity, runoff, and deep percolation are the major factors to be controlled in furrow fertigation, whereas poor fertilizer management will often result from low irrigation uniformity. The majority of furrow irrigation systems are operated with high runoff losses, and deep percolation can occur even with high irrigation uniformity, Sabillon and Merkley, 2004. With surface irrigation, the practice of fertigation becomes much more complex because the water is distributed over the field surface. With surface irrigation, the best timing of fertilizer injections into the water at the head (upstream) end of a field is not easily determined. Slight changes in the injection start and end times can dramatically affect the efficiency and uniformity of fertilizer application. The training of farm labor in operational and management procedures such as the timing of application, concentrations and types of chemicals are needed in order to make fertigation through surface methods a widespread tool in modern irrigated agriculture (Sabillon and Merkley, 2004).

The current trial aimed to 1) studying the effect of bed spacing and the way and amounts of fertilization on the yield quality and quantity, 2) studying the effect of plant condensing on yield quality and quantity either dry seed or green pod yield, 3) studying the increasing of fertilization efficiency quantity and quality, 4) comparing the common way of fertilization to fertigation way where it could decrease the sowing costs through decreasing of labor costs and fertilizer costs and finally, 5) studying the possibility of developing a new simple fertigation system which could be more easier, cheaper and adequate to the Egyptian small holder farmers.

2.MATERIALS AND METHODS

The current trial was carried out during 2005 and 2006 seasons at Kaha Vegetable Research Farm, Kalubia Governorate. The study aimed to find out the effect of some agricultural practices for improving productivity of common bean (*Phaseolus vulgaris*). The chemical analysis of the soil (Table 1) was determined by the procedures outlined in Jackson (1967).

The experiment included:

1- Two common bean cultivars, Nebraska as dry seed cultivar and Paulista as green pods cultivar.

2- Two fertilization treatments, fertigation method and the common method (Figures 1 and 2); Nine watering times were provided to the dry seed yield and six watering times to the green pod yield through the whole season. The common treatment per feddan was 150 kg super phosphate + 15 kg ammonium sulfate during soil preparation, 100 Kg ammonium sulfate + 50 Kg super phosphate + 50 Kg potassium sulfate at the first watering after sowing date and 100 Kg ammonium sulfate + 50 Kg potassium sulfate at flowering date. The fertigation treatment was 15000 ppm (N) + 5000 ppm (P) + 30000 ppm (K) + 3000 ppm (Mg). This fertilizing formula used to be applied by common bean growers and as well as applying high potassium fertilizer during the season according to the rate of 0.1 g per liter of irrigating water each time of watering (Solaimalai *et al.* 2005). Table 2 shows the quantities of fertilizers that were applied to the square meter of area for fertigation and common fertilization methods. The plant density was doubled in the fertigation method comparing to the common method while, the quantities of fertilizers for fertigation method were lower than the common method. The fertilizers applied were the local produced fertilizers.

3- Two ways of seed bedding, 60 cm width row

Table (1): Soil chemical analysis of each experimental treatment.

Treatment*	PH M/cm	E.C M/cm	$CaCO_3$ %	Soluble cations (M/L)				Soluble anions (M/L)				Macro elements (ppm)			Micro elements (ppm)			
				Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO^{-3}	Cl^{-2}	SO_4^{-2}	N	P	K	Fe	Cu	Zn	Mn
0	8.4	0.39	3.6	1.0	0.65	2.19	0.48	-	1.9	0.9	1.5	38	30	558	4.1	2.8	1.75	2.7
1	7.9	0.50	7.8	0.8	0.4	3.00	0.30	-	0.4	1.0	3.1	20	25	592	2.8	1.1	0.7	1.7
2	7.8	0.65	6.5	1.4	0.4	3.00	0.70	-	0.6	1.0	3.9	35	20	1152	3.2	1.6	0.8	2.5
3	7.7	0.47	3.8	0.8	0.4	2.57	0.53	-	0.8	1.0	2.5	15	20	728	3.0	1.4	0.8	2.7
4	7.5	1.40	7.0	4.4	3	4.80	1.10	-	0.4	1.5	11.4	60	31	1120	2.8	1.3	0.9	3.6
5	7.7	0.58	5.8	1.2	0.8	3.00	0.50	-	0.6	1.0	3.9	20	36	728	3.6	1.3	0.8	3.0
6	7.6	1.03	5.4	1.4	2.2	5.64	0.86	-	0.6	2.0	7.5	60	25	776	4.2	1.4	1.0	3.5

*** 0= soil chemical analysis before adding fertilizers, 1= row-common fertilization, 2= row-fertigation, 3= Bed–common fertilization-outside ridges, 4= Bed-common fertilization-inside ridges, 5= Bed-fertigation-outside ridges and 6= Bed-fertigation-inside ridges.**

Table (2): Comparison between quantities of fertilizers as mineral elements that were applied to one square meter of area for fertigation and common fertilization methods during the whole season.

Mineral element	Fertigation (48 plants/m^2)	Common fertilization (24 plants/m^2)
N	7.824	11.006
P	2.610	6.667
K	15.660	9.762
Mg	1.566	-
Ca	5.755	-
Fe	0.176	-
Mn	0.064	-
Zn	0.014	-
Cu	0.004	-
B	0.092	-
Mo	0.012	-

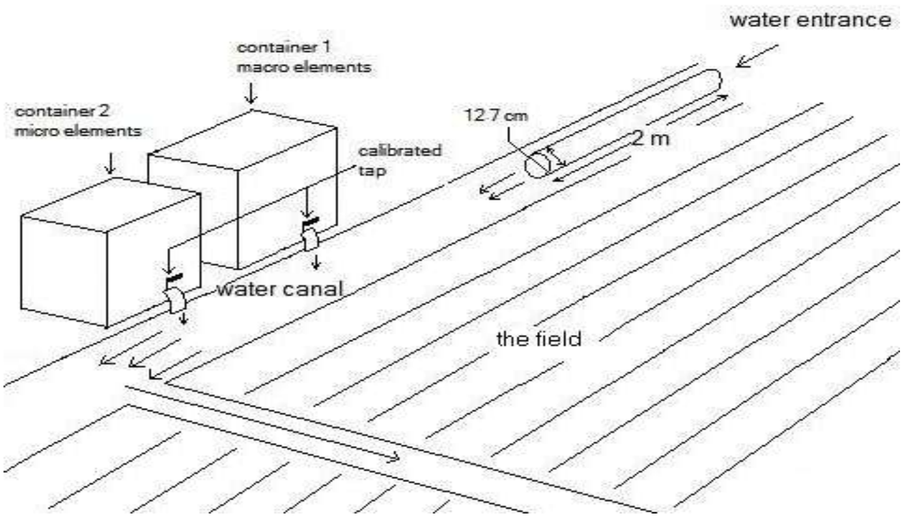

Fig. (1): Field outline, used pipe to calibrate the flow rate and the used containers to apply the fertigation treatment.

Fig. (2): Practical application of the fertigation method under surface irrigation system in the field.

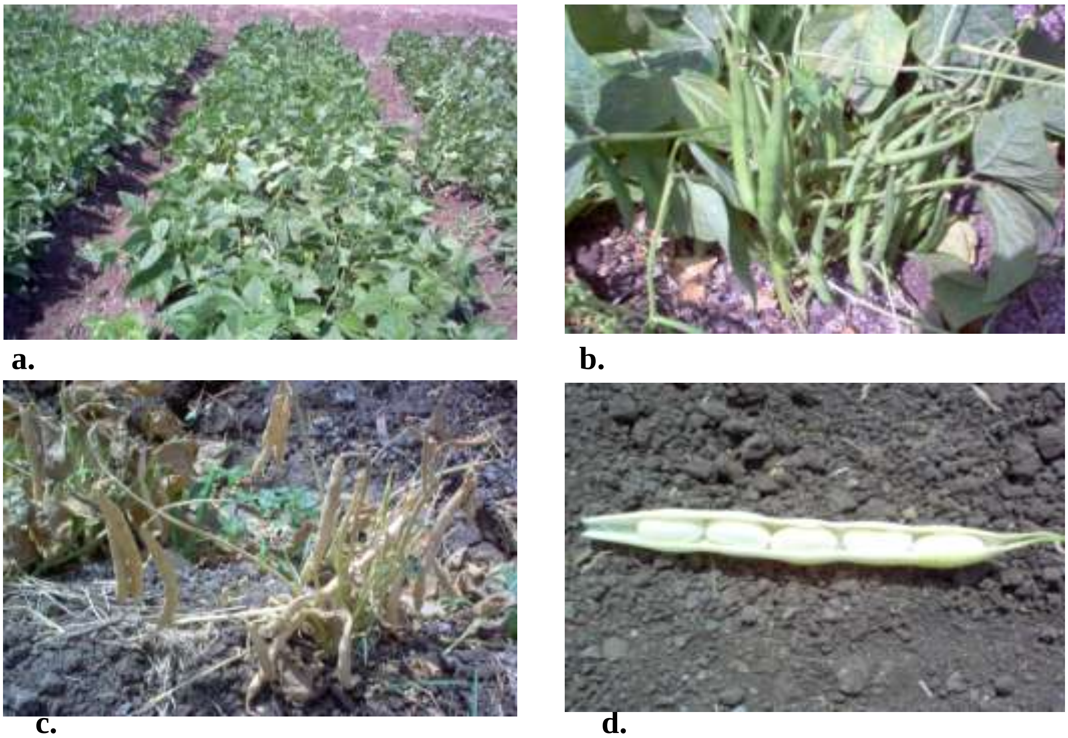

Fig.(3): Showing the bed-fertigation outside and inside treatment (a.), the higher green pod yield (b.), dry seed yield (c.) and seed setting in pods (d.).

with one ridge and 120 cm width bed with 4 ridges (two outside and two inside ridges), Figure 3a. To calculate the flow rate (liter/minute) in respect to the fertigation method a PVC pipe of 2 m length and 12.7 cm diameter was used and the pipe volume calculated as a volume of cylinder (cylinder volume = $\pi .(r/2)^2. L$, where $\pi = 3.14$, r = pipe diameter and L = pipe length). The water flow speed was calculated as meter per second according to the formula of speed calculation (speed = distance / time) and a plastic table tennis ball was used to calculate the time of flowing through both terminals of the pipe. Calculation of flow rate was used in applying suitable injection rate that provided adequate fertilization injecting at homogenized, speed and frequent rate into irrigating water. A complete randomized block design with three replicates was used. The experimental plot area was 14.4 square meters and consisted of 8 rows of three meters length and 60 cm width for the common method and 4 beds of three meters length and 120 cm width for the condensed method, while a 2 m wide isolating bed was applied between plots to prevent treatments overlap. Seeds were sown at 7 cm between hills. The plant density was 24 plants/m^2 for the row treatment and 48 plants/m^2 for the bed treatment. Data were recorded for both Nebraska and Paulista cultivars on 5 plants for the characteristics of plant height, number of branches, number of pods/plant, pod length, pod diameter, pod thickness, number of seeds/pod, number of seeds/plant, seed protein content, carbohydrate content, seed emergence, seed index (1000 seed weight), first class seed weight/plant, second class seed weight/plant, third class seed weight/plant, total seed weight/plant, first class seed weight/area unit, second class seed weight/area unit, third class seed weight/area unit, total seed weight/area unit, first class seed weight/area unit, second class seed weight/area unit and third class seed weight/area unit (%). Data were recorded for Paulista cultivar only for the characteristics of pod fresh weight, dry matter/fresh pod, vitamin C content, green pod weight/plant and green pod weight/area unit. The seeds were sieved and graded by using thieves of 7.33, 6.73, 5.66 and 4.76 mm for Nebraska seeds and 4.76 and 3.36 mm for Paulista seeds. Chemical analysis and determination for protein, vitamin C and carbohydrate content were done according to AOAC (1980). Two ways randomized block analysis (combined analysis) was used to statistically analyze the data according to Minitab personal computer software of Minitab Inc, 2006. Also, data were tested for least significant differences 5% (Snedecor and Cochran, 1989**)** to compare the averages of the determined parameters.

3.RESULTS AND DISCUSSION

3.1.Effect of row spacing and fertigation on yield and its components of Nebraska

The mean squares of response of common bean (Nebraska cv. dry seed bean) plants to some agricultural practices on vegetative growth and some chemical characteristics are shown in Table 3. The obtained results showed clearly that there were significant differences for the characteristics of plant height, seed protein content and seed emergence while there was no significant difference for the number of branches per plant. Table 4 shows the mean performances for the characteristics of plant height, number of branches per plant, seed protein content, carbohydrate content and seed emergence. Treatment 2 (row-fertigation) showed the highest measurements for the characteristics of plant height, seed protein content and seed emergence (33.268 cm, 35.546 % and 97.000 %, respectively), while treatment 5 (bed–fertigation–outside ridges) showed the highest measurements for the characteristics of number of branches per plant and carbohydrate content (6.313 and 14.651 %, respectively). These results are in line with those obtained by Mendhe *et al.*, (2002). who mentioned that the plant density of 22.5 cm recorded highly significantly differences for yield and yield components on Urd bean. In addition, Sekhon *et al.* (2002) mentioned similar results on Mung bean where higher number of branches, pods per plant and grain yield were obtained under low spacing (30 x 10 and 45 x 7 cm) and that increased yield.

Table 5 shows the mean squares of characteristics number of pods per plant, pod length, pod diameter, pod thickness, number of seeds per pod, number of seeds per plant and seed index (1000 seed weight). The obtained results showed obviously that there were highly significant differences for the characteristics number of pods per plant and number of seeds per plant. The mean performances of the plants (Table 6) for the previously mentioned characteristics showed the highest traits were for the treatment 1 (row–common fertilization) for pod thickness (1.056 cm), while treatment 2 (row–fertigation) showed the highest results for the characteristics number of pods per plant (18.298),pod length (13.692cm), pod diameter (1.062 cm), number

Table (3): Mean squares of response of dry seed bean plants (Nebraska cultivar) to the effect of row spacing and fertigation on yield and its components.

Source of variance	DF	Plant height	Number of branches/ plant	Seed protein content	Carbohydrate content	Seed emergence
Blocks	2	0.126 ns	0.076 ns	1.822 ns	0.287 ns	2.083 ns
Treatments	5	24.016 *	0.899 ns	171.126 **	31.905 **	122.933 **
Season	1	2.778 ns	0.005 ns	3.743 *	0.001 ns	1.778 ns
Treatments x Season	5	9.232 ns	0.279 ns	2.706 **	0.168 ns	3.044 ns
Error	22	7.012	0.678	0.62	0.772	1.417

*,** significant at 0.05 and 0.01 propability level, respectively. ns = not significant

Table (4): Means of response of dry seed bean plants (Nebraska cultivar) to the effect of row spacing and fertigation on yield and its components.

Treatments*	Plant height (cm)	Number of branches/plant	Seed protein (%)	Carbohydrate (%)	Seed emergence (%)
1	30.148 ab	5.897 a	25.915 d	11.020 b	94.500 b
2	33.268 a	6.058 a	35.546 a	14.242 a	97.000 a
3	30.853 a	5.722 a	25.329 d	10.250 b	88.333 c
4	27.139 b	5.214 a	20.437 e	9.100 c	85.667 d
5	31.409 a	6.313 a	32.082 b	14.651 a	94.833 b
6	30.598 a	5.554 a	28.572 c	10.225 b	88.667 c
LSD 5%	3.171	0.986	0.943	1.052	1.425

* 1 = common row - fertilization, 2 = common row - fertigation, 3 =Bed - common fertilization - outside ridges,
4 = Bed - common fertilization - inside ridges, 5 = Bed - fertigation - outside ridges and 6 = Bed - fertigation - inside ridges
Mean values followed by different letter are significantly at the 5% level.

Table (5): Mean squares of response of dry seed bean plants (Nebraska cultivar) to the effect of row spacing and fertigation on yield and its components.

Source of variance	DF	Number of pods/Plant	Pod length	Pod diameter	Pod thickness	Number of seeds/Pod	Number of seeds/Plant	Seed index(1000 seed weight)
Blocks	2	4.496 ns	0.259 ns	0.014 ns	0.001 ns	0.987 ns	385.111 ns	24026.524 ns
Treatments	5	74.229 **	0.620 ns	0.010 ns	0.017 ns	0.932 ns	2171.056 **	134452.750ns
Season	1	1.222 ns	0.293 ns	0.0003 ns	0.007 ns	0.063 ns	245.096 ns	276772.130 ns
Treatments x Season	5	7.206 ns	0.921 ns	0.008 ns	0.001 ns	0.546 ns	341.258 ns	150686.370 ns
Error	22	7.237	0.747	0.015	0.008	0.598	323.532	103063.43

*,** significant at 0.05 and 0.01 propability level, respectively. ns = not significant

Table (6): Means of response of dry seed bean plants (Nebraska cultivar) to the effect of row spacing and fertigation on yield and its components.

Treatments*	Number of pods/Plant	Pod length (cm)	Pod diameter (cm)	Pod thickness (cm)	Number of seeds/Pod	Number of seeds/Plant	Seed index (1000 seed weight, g)
1	16.227 a	13.208 a	0.937 a	1.056 a	4.380 a	72.011 a	215.816 a
2	18.298 a	13.692 a	1.062 a	0.955 ab	4.5 a	82.216 a	342.241 a
3	11.980 b	13.057 a	0.969 a	0.928 b	3.655 a	43.657 c	454.948 a
4	9.069 b	13.146 a	0.987 a	0.903 b	3.595 a	33.413 c	643.742 a
5	16.603 a	13.138 a	0.979 a	0.973 ab	4.107 a	68.642 ab	331.078 a
6	12.188 b	12.690 a	0.980 a	0.942 ab	3.702 a	47.851 bc	493.328 a
LSD 5%	3.221	1.035	0.145	0.106	0.926	21.537	384.392

* 1 = common row - fertilization, 2 = common row - fertigation, 3 =Bed - common fertilization - outside ridges,
4 = Bed - common fertilization - inside ridges, 5 = Bed - fertigation - outside ridges and 6 = Bed - fertigation - inside ridges
Mean values followed by different letter are significantly at the 5% level.

of seeds per pod (4.5) and number of seeds per plant. (82.216). The highest trait was shown by treatment 4 (bed-common fertilization–inside ridges) for the characteristic seed index (643.742). These results are in line with Basbag *et al.* (2002) who mentioned that the highest seed yield was obtained from 40 cm row spacing on Narbon bean (*Vicia narbonensis*), and Mendhe *et al.* (2002) who stated higher number of pods per plant from 22.5 cm row spacing treatment on Urd bean. In addition, Shirtliffe and Johnston (2002) found that increasing plant population did not affect 1000 seed weight (seed index) on dry bean (*Phaseolus vulgaris*). Also, Atallah *et al.* (2002) reported significant results on cucumber for the number of fruits per plant under fertigation treatment

Mean squares and plant performances for the characteristics first, second, third class and total seed weight per plant are shown in Tables 7 and 8. The obtained results showed significant differences of treatments for the characteristics of first class seed weight per plant and total seed weight per plant, while there were no significant differences of seasons for the same previously mentioned characteristics. There was affection of seasons over treatments because of there were significant differences in (treatment x season) interaction (Table 7). The highest results were for the treatment 2 (row–fertigation) for the characteristics first, second class and total seed weight per plant (16.939, 8.612 and 26.334 g, respectively) and for the treatment 5 (bed–fertigation–outside ridges) for the third class seed weight per plant (0.808 g). The obtained results are compatible with the data stated by Basbag *et al.* (2002), Mendhe *et al.* (2002), Sekhon *et al.* (2002) and Uday *et al.* (2002), who mentioned higher seed yield on Narbon bean (*Vicia narbonensis*) under treatment of 40 cm row spacing, higher grain yield of Urd bean using 22.5 cm of spacing with higher plant population, higher grain yield of Mung bean (*Vigna radiata*) due to planting geometries 30 x 10 and 45 x 7 cm and higher seed yield of moth bean (*Vigna aconitifolia*) due to closer spacing (30 x 15 cm). These authors mentioned that these data might be due to higher efficiency of photosynthetsis and chlorophyll contents .Also, it could be due to higher carbohydrate and seed protein contents that were clearly noticed on the data of those two treatments 2 (row–fertigation) and 5 (bed–fertigation–outside ridges). In addition, Sagheb and Hobbi (2002) found that tomato yield was significantly increased by the fertigation treatments that enhanced and increased the water and nutrient use efficiency.

Mean squares of the characteristics first class and total seed weight per area unit (g/m^2) showed highly significant differences (Table 9). Means of plant performances under the different treatments are shown in Table 10. The highest traits were first, second, third class and total seed weight per area unit (587.568, 337.130, 38.619 and 1037.817 g/m^2, respectively) of treatment 5 (bed–fertigation–outside ridges), while treatment 3 (bed–common fertilization–outside ridges) showed the highest measurements for the characteristics second and third class seed weight per area unit (40.262 and 4.7 %). Treatment 6 (bed–fertigation–inside ridges) showed the highest mean for the characteristics first class seed weight per area unit (68.678 %). The obtained results are in accordance with the data stated by Sekhon *et al.* (2002), Mendhe *et al.* (2002) and Shirtliffe and Johnston (2002).

It is clear that treatment 2 (row–fertigation) and 5 (bed–fertigation–outside ridges) showed the highest mean plant performance in most important characteristics, where treatment 2 (row–fertigation) affected the characteristics plant height, seed protein content, seed emergence, number of pods per plant, pod length, pod diameter, number of seeds per pod, number of seeds per plant, first, second class and total seed weight per plant. Treatment 5 (bed–fertigation–outside ridges) affected the characteristics number of branches per plant, carbohydrate content, third class seed weight per plant, first, second, third class and total seed weight per area unit(g/m^2).

3.2.Effect of row spacing and fertigation on yield and its components of Paulista

The mean squares of response of Paulista plants (green pods bean cv) showed highly significant differences for the characteristics dry matter per fresh pod, vitamin C content per pod, seed protein content, carbohydrate content and seed emergence(Table 11) under the current studied treatments, but the interaction between treatments and seasons did not show any significance which means there was no effect of seasons and treatments on each other. The mean of plant performances under the six studied treatments are shown in (Table 12). The highest measurements were the treatment 2 (row–fertigation) for the characteristics dry matter per fresh pod (21.894 %), vitamin C content per pod (9.490 mg /100 g fresh weight), seed protein content (31.212 %), carbohydrate content (11.908

Table (7): Mean squares of response of dry seed bean plants (Nebraska cultivar) to the effect of row spacing and fertigation on yield and its components.

Source of variance	DF	First class seed weight/Plant	Second class seed weight/Plant	Third class seed weight/Plant	Total seed weight/Plant
Blocks	2	11.360 ns	0.494 ns	0.374 ns	20.042 ns
Treatments	5	45.161 **	13.910 ns	0.020 ns	105.442 *
Season	1	0.062 ns	0.168 ns	0.0004 ns	1.711 ns
Treatments x Season	5	37.736 *	15.088 ns	0.055 ns	96.975 *
Error	22	9.768	7.269	0.132	27.852

*,** significant at 0.05 and 0.01 propability level, respectively. ns = not significant

Table (8): Means of response of dry seed bean plants (Nebraska cultivar) to the effect of row spacing and fertigation on yield and its components.

Treatments*	First class seed weight/Plant (g)	Second class seed weight/Plant (g)	Third class seed weight/Plant (g)	Total seed weight/Plant (g)
1	10.252 b	5.379 ab	0.701 a	16.332 b
2	16.939 a	8.612 a	0.782 a	26.334 a
3	9.542 b	6.874 ab	0.723 a	17.139 b
4	10.232 b	4.989 b	0.649 a	15.870 b
5	12.691 b	7.056 ab	0.808 a	21.722 ab
6	11.109 b	4.630 b	0.751 a	16.490 b
LSD 5%	3.742	3.228	0.434	6.319

* 1 = common row - fertilization, 2 = common row - fertigation, 3 =Bed - common fertilization - outside ridges, 4 = Bed - common fertilization - inside ridges, 5 = Bed - fertigation - outside ridges and 6 = Bed - fertigation - inside ridges

Mean values followed by different letter are significantly at the 5% level

Table (9): Mean squares of response of dry seed bean plants (Nebraska cultivar) to the effect of row spacing and fertigation on yield and its components.

Source of variance	DF	First class seed weight/Area unit	Second class seed weight/Area unit	Third class seed weight/Area unit	Total seed weight/Area unit	First class seed weight/Area unit	Second class seed weight/Area unit	Third class seed weight/ Area unit
Blocks	2	15135.001 ns	1831.430 ns	518.501 ns	32569.676 ns	84.412 ns	58.049 ns	12.501 *
Treatments	5	85303.516 **	37383.446 ns	517.025 ns	278629.130 **	139.989 ns	130.994 ns	2.052 ns
Season	1	9629.423 ns	3039.986 ns	2.889 ns	52654.405 ns	8.903 ns	13.783 ns	0.531 ns
Treatments x Season	5	44178.466 ns	31625.800 ns	108.139 ns	157202.960 *	128.441 ns	114.134 ns	3.407 ns
Error	22	16812.586	15928.443	247.234	56844.371	91.121	75.538	2.553

*,** significant at 0.05 and 0.01 propability level, respectively. ns = not significant

Table (10): Means of response of dry seed bean plants (Nebraska cultivar) to the effect of row spacing and fertigation on yield and its components.

Treatments*	First class seed weight/Area unit (g/m²)	Second class seed weight/Area unit (g/m²)	Third class seed weight/Area unit (g/m²)	Total seed weight/Area unit (g/m²)	First class seed weight/Area unit (%)	Second class seed weight/Area unit (%)	Third class seed weight/Area unit (%)
1	244.908 c	128.493 b	16.740 b	390.141 c	60.578 ab	35.043 ab	4.379 a
2	404.644 b	205.729 ab	18.690 ab	629.063 bc	63.812 ab	33.172 ab	3.016 a
3	455.894 ab	328.414 a	34.553 ab	818.862 ab	55.039 b	40.262 a	4.700 a
4	488.857 ab	238.351 ab	31.021 ab	758.228 ab	66.802 ab	28.901 ab	4.297 a
5	587.568 a	337.130 a	38.619 a	1037.817 a	62.723 ab	33.359 ab	3.919 a
6	530.769 ab	221.220 ab	35.869 ab	787.857 ab	68.678 a	27.058 b	4.264 a
LSD 5%	155.253	151.115	18.827	285.473	11.43	10.406	1.913

* 1 = common row - fertilization, 2 = common row - fertigation, 3 =Bed - common fertilization - outside ridges,
4 = Bed - common fertilization - inside ridges, 5 = Bed - fertigation - outside ridges and 6 = Bed - fertigation - inside ridges

-Mean values followed by different letter are significantly at the 5% level

Table (11): Mean squares of response of green pod bean plants (Paulista cultivar) to the effect of row spacing and fertigation on yield and its components.

Source of variance	DF	Plant hight	Number of branches/ plant	Dry matter/ Fresh pod	Vitamin C content	Seed protien content	Charpohydrate content	Seed emergence
Blocks	2	4.947 ns	0.491 ns	0.408 ns	0.382 ns	2.731 *	0.555 ns	0.333 ns
Treatments	5	12.704 ns	1.154 ns	11.008 **	6.783 **	133.131 **	20.592 **	76.467 **
Season	1	0.790 ns	0.056 ns	0.037 ns	0.334 ns	14.198 **	0.213 ns	1.000 ns
Treatments x Season	5	5.372 ns	0.322 ns	0.114 ns	0.375 ns	0.943 ns	0.200 ns	2.067 ns
Error	22	10.191709	1.387	0.373	0.18	0.637	0.413	2.303

***,** significant at 0.05 and 0.01 propability level, respectively. ns = not significant**

Table (12): Means of response of green pod bean plants (Paulista cultivar) to the effect of row spacing and fertigation on yield and its components.

Treatments*	Plant hight (cm)	Number of branches/ plant	Dry matter/Fresh pod (%)	Vitamin C content/pod (mg/100 g fresh weight)	Seed protien (%)	Charpohydrate (%)	Seed emergence (%)
1	27.167 a	6.583 a	18.146 d	7.197 c	23.748 d	9.0198 b	94.833 b
2	30.806 a	6.819 a	21.894 a	9.490 a	31.212 a	11.908 a	97.000 a
3	29.917 a	6.500 a	18.818 cd	8.900 b	21.996 e	8.250 bc	90.833 c
4	29.861 a	6.583 a	18.687 cd	7.348 c	18.937 f	7.600 c	87.833 d
5	30.778 a	7.417 a	20.102 b	8.890 b	29.915 b	11.818 a	94.833 b
6	31.139 a	7.472 a	19.141 c	7.057 c	26.239 c	8.725 b	89.667 c
LSD 5%	3.822	1.41	0.731	0.507	0.956	0.769	1.817

*** 1 = common row - fertilization, 2 = common row - fertigation, 3 =Bed - common fertilization - outside ridges, 4 = Bed - common fertilization - inside ridges, 5 = Bed - fertigation - outside ridges and 6 = Bed - fertigation - inside ridges - Mean values followed by different letter are significantly at the 5% level**

%) and seed emergence (97.000 %).While the highest measurements of the characteristics plant height (31.139 cm) and number of branches per plant (7.472) were recorded by the treatment 6 (bed–fertigation–inside ridges). These results are compatible with the data recorded by Srivastava and Srivastava (2003) who stated the highest plant height records on rice bean (*Vigna umbellata*). Mendhe *et al.* (2002) stated higher number of branches per plant on Urd bean and Ramakrishna *et al.* (2002) mentioned significant differences and higher records of dry matter on French bean (*Phaseolus vulgaris*). Atallah *et al.* (2002) on cucumber, Janat and Somi (2002) on cotton and Martinez *et al.* (1991) on sweet corn stated that fertigation improved water and nitrogen use efficiency and resulted in significant increase in dry matter.

High significant differences were showed by the characteristics number of pods per plant, green pod weight per plant, number of seeds per plant and seed index (1000 seed weight) as affected by the different treatments (Table 13). The mean plant performance for the characteristics number of pods per plant, pod length, pod diameter, pod thickness, average pod fresh weight, green pod weight per area unit, number of seeds per pod, number of seeds per plant and seed index showed in Table14. The treatment 2 (row –fertigation) recorded the highest means for the characteristics number of pods per plant (31.194), green pod weight per plant (109.525 g), number of seeds per pod (7.000), number of seeds per plant (216.944) and seed index (1000 seed weight, 128.847 g).Treatment 3 (bed – common fertilization – outside ridges) showed the highest mean for the character green pod weight per area unit (3812.652 g/m^2). The treatment 5 (bed –fertigation – outside ridges) for the characteristics pod diameter (0.746 cm) and pod thickness (0.695 cm). The treatment 6 (bed – fertigation – inside ridges) recorded the highest means for the characteristics pod length (15.283 cm) and average pod fresh weight (4.076 g). The recorded data are in line with those mentioned by Mendhe *et al.* (2002) who stated higher number of pods per plant under 22.5 cm row spacing on Urd bean. Sarkar *et al.* (2004) mentioned the highest number of pods per plant, highest pod length, highest 1000 seed weight (seed index) under spacing of 30 x 10 and 20 x 20 cm on mung bean. Srivastava and Srivastava (2003) stated the highest records for number of pods per plant, number of seeds per pod and 1000 grain weight (seed index) under 45

Table (13): Mean squares of response of green pod bean plants (Paulista cultivar) to the effect of row spacing and fertigation on yield and its components.

Source of variance	DF	Number of pods/Plant	Pod length	Pod diameter	Pod thickness	Avarege pod fresh weight	green pod weight/Plant	green pod weight/area unit	Number of seeds/Pod	Number of seeds/Plant	Seed index
Blocks	2	53.803 ns	0.259 ns	0.003 ns	0.004 ns	0.188 ns	1392.125 ns	2552886.300 ns	1.444 ns	1493.796 ns	78.784 ns
Treatments	5	199.406 *	0.828 ns	0.002 ns	0.001 ns	0.396 ns	1952.813 ns	2564684.400 *	0.807 ns	10904.989 **	1990.058 **
Season	1	111.713 ns	0.250 ns	0.001 ns	0.00004 ns	0.643 ns	526.153 ns	584089.400 ns	0.174 ns	3490.840 ns	59.995 ns
Treatments x Season	5	18.478 ns	0.592 ns	0.0005 ns	0.0002 ns	0.489 ns	421.561 ns	562164.180 ns	0.240 ns	1445.872 ns	397.389 ns
Error	22	55.477	0.559	0.001	0.001	0.226	811.255	947722.01	0.634	2478.597	393.846

***,** significant at 0.05 and 0.01 propability level, respectively. ns = not significant**

Table (14): Means of response of green pod bean plants (Paulista cultivar) to the effect of row spacing and fertigation on yield and its components.

Treatments*	Number of pods/Plant	Pod length (cm)	Pod diameter (cm)	Pod thickness (cm)	Avarege pod fresh weight (g)	green pod weight/Plant (g)	green pod weight/area unit (g/m²)	Number of seeds/Pod	Number of seeds/Plant	Seed index (1000 seed weight, g)
1	22.319 ab	14.658 ab	0.736 a	0.672 a	3.610 a	80.103 ab	1842.358 c	6.417 a	143.701 b	105.134 ab
2	31.194 a	14.275 b	0.739 a	0.689 a	3.456 a	109.525 a	2519.072 bc	7.000 a	216.944 a	128.847 a
3	23.139 ab	14.317 ab	0.724 a	0.676 a	3.668 a	82.884 ab	3812.652 a	6.083 a	140.917 b	93.558 bc
4	15.417 b	14.608 ab	0.697 a	0.653 a	3.969 a	61.547 b	2831.145 abc	6.083 a	94.563 b	75.693 c
5	17.972 b	14.842 ab	0.746 a	0.695 a	3.480 a	62.420 b	2871.337 abc	6.750 a	121.653 b	109.273 ab
6	0.028 b	15.283 a	0.712 a	0.670 a	4.076 a	68.330 b	3143.163 ab	6.583 a	112.292 b	90.866 bc
LSD 5%	8.918	0.896	0.045	0.043	0.57	34.104	1165.634	0.953	59.611	23.762

*** 1 = Common row - fertilization, 2 = Common row - fertigation, 3 =Bed - Common fertilization - outside ridges, 4 = Bed - Common fertilization - inside ridges, 5 = Bed - fertigation - outside ridges and 6 = Bed - fertigation - inside ridges.**

Table (15): Mean squares of response of green pod bean plants (Paulista cultivar) to the effect of row spacing and fertigation on yield and its components.

Source of variance	DF	First class seed weight/Plant	Second class seed weight/Plant	Total seed weight/Plant	First class seed weight/Area unit	Second class seed weight/Area unit	Total seed weight/Area unit	First class seed weight/Area unit	Second class seed weight/Area unit
Blocks	2	6.815 ns	5.444 ns	7.631 ns	10531.563 ns	12976.065 ns	13246.841 ns	107.317 ns	107.317 ns
Treatments	5	20.568 **	50.933 **	58.720 ns	63498.757 **	128535.880 **	203574.350 *	832.301 **	832.301 **
Season	1	2.498 ns	0.0009 ns	2.591 ns	765.180 ns	4210.004 ns	1385.527 ns	38.340 ns	38.340 ns
Treatments x Season	5	4.017 ns	10.752 ns	25.975 ns	4758.331 ns	13667.201 ns	30048.637 ns	81.724 ns	81.724 ns
Error	22	4.128	12.597	28.192	8145.355	22802.478	53319.802	77.367	77.367

***,** significant at 0.05 and 0.01 propability level, respectively. ns = not significant**

Table (16): Means of response of green pod bean plants (Paulista cultivar) to the effect of row spacing and fertigation on yield and its components.

Treatments*	First class seed weight/Plant (g)	Second class seed weight/Plant (g)	Total seed weight/Plant (g)	First class seed weight/Area unit (g/m²)	Second class seed weight/Area unit (g/m²)	Total seed weight/Area unit (g/m²)	First class seed weight/Area unit (%)	Second class seed weight/Area unit (%)
1	9.135 ab	5.890 b	15.0244 b	218.211 c	140.692 b	358.903 c	62.394 abc	37.606 bcd
2	11.323 a	10.778 a	22.101 a	270.474 bc	257.471 b	527.944 bc	52.082 c	47.918 b
3	9.639 ab	5.772 b	15.411 ab	460.501 a	275.771 b	736.273 ab	66.912 a	33.088 d
4	6.218 c	12.160 a	18.378 ab	297.096 bc	580.958 a	878.054 a	34.641 d	65.359 a
5	9.839 ab	5.897 b	15.736 ab	470.081 a	281.748 b	751.828 ab	63.827 ab	36.173 cd
6	7.288 bc	6.012 b	13.300 b	348.211 b	287.228 b	635.438 abc	54.977 bc	45.023 bc
LSD 5%	2.433	4.25	6.357	108.063	180.806	276.481	10.532	10.532

*** 1 = Common row - fertilization, 2 = Common row - fertigation, 3 =Bed - Common fertilization - outside ridges, 4 = Bed - Common fertilization - inside ridges, 5 = Bed - fertigation - outside ridges and 6 = Bed - fertigation - inside ridges.**

x 10 cm row spacing on rice bean (*Vigna umbellata*). In addition, Atallah *et al.* (2002) mentioned significantly increase in number of fruits per plant of cucumber under fertigation treatment. Table 15 shows the mean squares for the characteristics first, second class and total seed weight per plant, area unit (g/m^2) and area unit (%). Data showed clearly that there were high significant differences for all characteristics except for total seed weight per plant that showed no significant difference. The mean plant performances for the previously mentioned characteristics under the six studied treatments are shown in (Table 16). The highest means were shown by treatment 2 (row–fertigation) for the characteristics first class and total seed weight per plant (11.323 and 22.101 g), treatment 3 (bed–common fertilization–outside ridges) for the characteristic first class seed weight per area unit (66.912%),treatment4 (bed–common fertilization–inside ridges) for the characteristics second class seed weight per plant (12.160 g), second class and total seed weight per area unit (580.958 and 878.054 g/m^2) and second class seed weight per area unit (65.359 %) and treatment 5 (bed–fertigation–outside ridges) for the characteristic first class seed weight per area unit (470.081 g/m^2). The results are compatible with the data obtained by Srivastava and Srivastava (2003) who worked on rice bean (*Vigna umbellata*) and found the highest grain yield per area unit under 45 x 10 and 30 x 10 cm row spacing. Also, in accordance to Zuraiqi *et al.* (2002) tomato responded significantly to the low N rates applied by fertigation and produced an acceptable yield with a high efficiency of fertilizer use. It is clear that treatment 2 (row–fertigation) and 5 (bed–fertigation–outside ridges) showed the highest mean plant performance in most of the characteristics, where treatment 2 (row–fertigation) affected the characteristics dry matter per fresh pod, vitamin C content, seed protein content, carbohydrate content, seed emergence, number of pods per plant, green pod weight per plant, number of seeds per pod, number of seeds per plant, seed index (1000 seed weight), first class and total seed weight per plant. Treatment 5 (bed–fertigation–outside ridges) affected the characteristics pod diameter, pod thickness and first class seed weight per area unit (g/m^2).

Dividing the treatments 5 and 6 to outside and inside ridges was to test and prove that there was no difference between both outside and inside ridges in quality and quantity. There was no affection of the ridge location on plant performances. The same was recorded for both treatment 3 and 4. However, It is clear that treatment 5 and 6 were almost the same as well as treatment 3 and 4.

In addition, since treatments 2 (row–fertigation) and 5 (bed–fertigation–outside ridges) showed the highest values and results, practically treatment 5 (bed–fertigation–outside ridges) was better than treatment 2 (row–fertigation) where treatment 5 (bed–fertigation–outside ridges) and 6 (bed–fertigation–inside ridges) applicably the same.

The results proved the availability of doubling the used area unit and getting higher yield comparing to the common method in growing common beans. It is concluded that farmers are recommended to apply bed–fertigation treatment both outside and inside ridges to grow common bean (*Phaseolus vulgaris*) of both dry seeds and green pods that provides high population density (low row spacing) and (fertigation) ensure high yield with good quality and higher exploitation of fertilizers.

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تأثير مسافات التخطيط و التسميد مع الرى على محصول الفاصوليا ومكوناته تحت نظام الرى بالغمر

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ملخص

أجريت هذه الدراسة فى موسمين زراعيين بمزرعة بحوث الخضر بمدينة قها- محافظة القليوبية خلال عامى 2005 و 2006 لدراسة استجابة صنف الفاصوليا نبراسكا (صنف بذور جافة) و صنف الفاصوليا بولستا (صنف قرون خضراء) لمسافات خطوط زراعة مختلفة و لتسميد سائل (تسميد مع الرى). سجلت متوسطات أداء النباتات لكل من صفات نمو النبات و المحصول و مكوناته بالإضافة إلى المكونات الكيماوية للبذور والقرون الخضراء. المعاملات التى تم دراستها، 1) خط – تسميد اعتيادى، 2) خط – تسميد سائل، 3) مصطبة – تسميد اعتيادى – جانب خط خارجى، 4) مصطبة – تسميد اعتيادى – جانب خط داخلى، 5) مصطبة – تسميد سائل – جانب خط خارجى و 6) مصطبة – تسميد سائل – جانب خط داخلى. أظهرت النتائج أعلى القيم للمعاملة 2 (خط – تسميد سائل) بالنسبة إلى صفات طول النبات، محتوى البذور من البروتين، إنبات البذور، عدد قرون النبات، طول القرن، قطر القرن، عدد بذور القرن، عدد بذور النبات، وزن بذور النبات من الدرجة الأولى و الثانية و الكلى؛ و للمعاملة 5 (مصطبة – تسميد سائل) بالنسبة إلى صفات عدد أفرع النبات، محتوى البذور من الكربوهيدرات، وزن بذور النبات من الدرجة الثالثة، وزن بذور النبات لوحدة المساحة (جم/م^2) من الدرجة الأولى و الثانية و الكلى و ذلك للصنف نبراسكا. بينما سجلت المعاملة 2 (خط – تسميد سائل) أعلى القيم بالنسبة إلى صفات وزن المادة الجافة بالقرن الطازج، محتوى القرون من فيتامين ج، محتوى البذور من البروتين، محتوى البذور من الكربوهيدرات، إنبات البذور، عدد قرون النبات، وزن القرون الخضراء للنبات،عدد بذور القرن، عدد بذور النبات، مؤشر البذور (وزن 1000 بذرة)، وزن بذور النبات من الدرجة الأولى و الكلى؛ و سجلت المعاملة 5 (مصطبة – تسميد سائل) أعلى القيم بالنسبة إلى صفات قطر القرن و سمك القرن و وزن بذور وحدة المساحة (جم/م 2) من الدرجة الأولى و ذلك للصنف بولستا. يمكن توصية المزارع ليطبق المعاملة (مصطبة – تسميد سائل) لكل من الريشتين الخارجية و الداخلية لزراعة الفاصوليا لكل من محصول البذور الجافة و القرون الخضراء التى توفر كثافة نباتية عالية (مسافات خطوط اقل) وتسميد سائل (تسميد مع الرى) والذى يضمن محصول مرتفع مع جودة عالية واستغلال أعلى للأسمدة.

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