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RESPONSE OF TWO FABA BEAN CULTIVARS TO DIFFERENT N, P AND K LEVELS UNDER SANDY SOIL CONDITIONS
I. NODULATION, FLOWERING AND SHEDDING ATTRIBUTES

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ABSTRACT: Two seasons (2000/2001 and 2001 /2002) investigation was conducted in sandy soil at El-Khattara Experimental Farm of the Faculty of Agriculture, Zagazig University, to find out the response of two faba bean cultivars (Sakha 1 and Giza Blanca) to two N (10 and 20 kg N / fed), three P (0, 15.5 and 31.0 kg P_2O_5 / fed) and two K levels (0 and 24 kg K_2O / fed).

Nodulation in the two faba bean cultivars was enhanced due to the increase of N and P levels, as well as , the addition of K particularly to Sakha 1 . This was expressed in the number of nodules / plant, single nodule dry weight, and the percentage of dry weight of nodules to total root dry weight. Sakha 1 had larger number of nodules, but of lighter single nodule dry weight, than Giza Blanca. Also, the response to phosphorus was much higher than to the increase of either N or K level. This response was mostly quadratic and of greater magnitude in the high N or K- fertilized than in the low N or K- unfertilized ones, with more clear effect in Sakha 1 than in Giza Blanca.

The number of flowers / plant was decreased due to the increase of N, P or K level. However, flower, young pod and total shedding percentages were decreased. This decrease was much more pronounced due to each P increment for the high N fertilized plants of Giza Blanca or the K fertilized plants of Sakha 1 .

Significant positive association was found within each of the two faba bean cultivars between the seed yield / fed and all the nodulation criteria under study. However, the two cultivars varied in the contribution of these nodulation attributes. In Sakha 1, the total root dry weight accounted the main source of seed yield variation (40.98%) followed by the nodules dry weight / plant (24.92%). However, in Giza Blanca the nodules dry weight and number/plant shared this contribution (33.54% and 31.99%, respectively) followed by the total root dry weight / plant (26.66%). Therefore, the total contribution of root and nodulation growth attributes were much higher in Giza Blanca (92.2%) than in Sakha 1 (70.07).

INTRODUCTION

Cultivation of faba bean under sandy soil conditions is faced by a number of yield limiting factors among them is the poor population of native *Rhyzobium leguminosarum* (Loutfi *et al*,1980) and hence an expected decrease in nodulation and nitrogen fixation. In addition , these soils are of a poor fertility level from macro and micronutrients. However, the extension of field crop cultivation in these soils has become a must to minimize the food gap which is wide due to the ever growing population. To face these yield limiting factors, seed inoculation was recommended to activate atmospheric N fixation (El-Karmity, 1990). This activation could be enhanced through the addition of low doses from nitrogen (Eaglesham *et al.*, 1983 and Said,1998) along with addition of phosphorus (Alexander, 1961) as it increases root growth (Russel , 1973) and hence more sites are available for nodulation (Cassman *et al*, 1980).

Root nodules may utilize from 10 to 30% of the total photosynthates produced by the host plant (Schubert and Ryle, 1980). Potassium was found to support translocation of these photosynthates from leaves to nodules (Haeder, 1977) in addition to its role in activating some enzymes involved in N fixation (Evans and Sorger ,1966).

Under Egyptian conditions, significant increase in faba bean root dry weight was reported by Ahmed *et al* (1992) due to the addition of 31.0 kg P_2O_5 / fed .The nodules number and weight were found to increase due to P biofertilization with *Mycorrhizae* as reported by Nahed, El-Wafai and Dahdouh(1992).

Similar results were reported due to addition of 30 kg N/ fed by Derar and Gendy (1994) and the addition of N, P and K with the use of *Mycorrhizae* by Khalifa and Badr (1992).

Yield is a complex character determined by several variables that affect plant growth through the season. Hence, it is essential to detect the best characters having the great influence on yield and their relative contribution to variation of yield (Fayed,1987).

Therefore, the present study was undertaken to find out the response of Giza Blanca (drought tolerant cv.) and Sakha 1 cultivars to different N, P and K levels under sandy soil conditions with respect of nodulation, flowering and shedding attributes.
Correlation and path analyses were also investigated.

MATERIALS AND METHODS

This investigation was carried out for two seasons (2000 / 2001 and 2001 / 2002) in sandy soil at El–Khattara Experimental Farm of the Faculty of Agriculture, Zagazig University. The study aimed to find out the response of two faba bean cultivars (Sakha 1 and Giza Blanca) to two N (10 and 20 kg N / fed), three P(0, 15.5 and 31.0 kg P_2O_5 /fed) and two K levels (0 and 24 kg K_2O / fed) and their interactions.

A separate experiment was devoted for each faba bean cultivar in the two seasons. The 12 combinations of N, P and K were allocated in a complete blocks design of four replications. Planting was on the first week of November in the two seasons, in rows 50 cm apart. Seeding was in hills 15 cm apart for Sakha 1 and 20 cm apart for Giza Blanca as the former had lighter seed index (80 -90 gm) than the latter (110 – 120 gm). Accordingly, total populations of 112,000 and 84,000 plants / fed were maintained for Sakha 1 and Giza Blanca, respectively. Seeds were inoculated with the proper inoculum of *Rhyzobium leguminosarum br.viceae* at the rate of 2.5 gm / kg of seeds. Since flowering was after 50 days in Sakha 1 and 70 days in Giza Blanca, harvest was made in the last week of April in the former and first week of May in the latter.

Nitrogen in the form of ammonium sulphate (20.5 % N), phosphorus in the form of super phosphate (15.5% P_2O_5) and potassium in the form of potassium sulphate (48 % K_2O) were mixed and hand band placed 1" to 1.5 " below the seeding level at planting.

Each plot included 7 rows of 3m length . The two outer rows were left as borders . The two outer rows to a three central ones , were devoted for determination of nodulation, flowering and shedding attributes .

At flowering , six plants from three successive hills ,from the specified rows , were hand pulled after making a proper groove .The recovered roots and nodules were oven dried for a constant weight at 70°C . The following nodulation attributes were recorded :

1-Root dry weight / plant(gm).
2-Nodules,dry weight / plant (gm).
3-Total root dry weight /plant (gm) (1+2).
4-Number of nodules / plant.
5-Single nodule dry weight (mg) (2 / 4).
6-Percentage of dry weight of nodules to total root dry weight (2 / 3 x100).
7-Leaf area index (using disk method).

Since commence of flowering, the number of flowers , young pods and mature pods were recorded on ten plants in five successive hills in a prescribed bordered row . These numbers were recorded in one week intervals up to harvest where the following flowering attributes were recorded and calculated according to Atta (1991):

1-Number of flowers / plant.
2-Number of young pods / plant.
3-Number of mature pods / plant.
4-Flower shedding percentage(1-2 / 1 x 100).
5- Young pod shedding percentage (2-3 / 2 x 100).
6- Total shedding percentage (1-3 / 1 x 100).

Flood irrigation was scheduled at three to five days intervals. Hand weeding was practiced up to time of flowering. Faba bean was preceded by a fallow in the two seasons . The soil was sandy of an alkaline reaction . (pH of 8.57) and organic matter content of (0.70 %) . The averages of available N , P and K contents of the upper 20 cm soil depth of the experimental site were 17.4 , 4.6 and 83.5 ppm, respectively .

Data were statistically analyzed according to Snedecor and Cochran (1967) . The response to the three P levels for the high and low N fertilized plants , as well as , for the K and K – unfertilized ones was calculated using orthogonal polynomial tables . Interaction tables are provided with response equations and, as well, the predicted maximum average ($\hat{Y}$ max) which could be obtained due the addition of the predicted maximum P level (X max) using the following equations according to Abdul Galil *et al* (2003) :

$\hat{Y}$ max $= Y_0 + b^2 / 4c$

X max = b / 2c (u) (kg P_2O_5 / fed).

where: Y_0 = average yield recorded at the lowest P level.

b = the linear coefficient of the response equation .

c = the quadratic coefficient of the response equation .

u = unit of phosphorus (15.5 kg P_2O_5 /fed) .

Capital and small Duncan letters were used in interaction tables to judge the significant differences among rows and columns means, respectively at the 5% level of significance according to Duncan,(1955).

Within each faba bean cultivar, the correlation between seed yield / fed and all the root and nodule growth attributes was calculated . Also , a path analysis was performed to define the contribution of these attributes to seed yield variation according to Svåb, (1973) .

A test of heterogeneity of the experimental error of the two seasons was made. Data reported, herein, are those of the combined analysis of the two seasons for each faba bean cultivar.

RESULS AND DISCUSSION

A. Root and nodule growth attributes:

A.a. Nitrogen level effect:

It is evident from Table (1) that doubling the level of N to 20 kg N / fed resulted in a significant increase in all the root and nodule growth attributes of the two faba bean cultivars. The increase in root dry weight was from 2.094 to 2.836 gm in Sakha 1 (35.4%) and from 2.332 to 3.240gm in Giza Blanca (38.9%). The increase in nodule dry weight was from 1.033 to 1.868 gm in the former (80.8%) compared with an increase from 1.204 to 1.973 gm in the latter (63.9%).Therefore , the total root dry weight was increased from 3.127 to 4.705gm (50.5%) and from 3.537 to 5.213 gm (47.4%) in the two faba bean cultivars, respectively. These differences were also reflected in the percentage of dry weight of nodules to total root dry weight which was increased from 32.38 to 39.85% in Sakha 1 and from 33.93 to 37.69% in Giza Blanca. This was observed , also, in the number of nodules / plant where this number was much more increased in Sakha 1 than in Giza Blanca. This number was increased from 36.80 to 45.90(24.7%) in Sakha 1 and from 25.00 to 26.19 (4.8%) in Giza Blanca due to doubling the level of N. Consequently, Sakha 1 had lighter single nodule dry weight where the increase of N level caused an increase in this weight from 27.85 to 41.05 mg (47.4%) in the former and from 48.12 to 77.23 mg (60.5%) in the latter.

These results support the view that the increase of N level might have had increased photosynthates, and hence their availability for root and nodule growth. This was more clear in Sakha 1 than Giza Blanca according to the percentage increase in nodules dry weight due to the increase of N level which was higher in the former than in the latter. The data further indicate that the increase in the number of nodules / plants, was not on the expense of single nodule dry weight where both were increased, significantly due to the increase of N level . This indicates that high N fertilized plants did not suffer from either inter root - nodule or intra - nodule competition . In soybean, Cassman *et al* (1980) found that high N fertilized plants carried a very large number of small nodules(5 to15mg / nodule) due to the aforementioned competitions. Under the present study, the single nodule dry weight in Sakha 1 and Giza Blanca (35 and 63 mg , respectively) show that they were heavy enough to carry on an active N fixation .

These date are in harmory with those reported by Derar and Gendy (1994) as they found significant increase in nodule number and weight due to addition of 30 kg N / fed.

A.b. Phosphorus level effect :

Results in Table (1) clearly show that the increase of P level from zero to 31.0 kg P_2O_5 / fed was accompanied by a significant increase in each of the nodulation criteria in the two faba bean cultivars. The response, as expressed by the regression coefficient, of the root dry weight / plant was 0.495 gm in Sakha 1 compared with 0.245gm / plant in Giza Blanca due to each P increment. This response was 0.266 and 0.238 gm / plant in nodules dry weight / plant in the two cultivars, respectively. Therefore, the response of total root dry weight amounted to0.762in Sakha1 compared with only 0.482 gm /plant in Giza Blanca. Also , the percentage of dry weight of nodules to total root dry weight responded to each P increment but in Giza Blanca only where the average response was 1.70%. However , the number of nodules / plant responded to each P increment in the two cultivars where the response was 3.68 and 4.87 nodule / plant in Sakha 1 and Giza Blanca, in respective order. Moreover, the single nodule dry weight was also increased due to each P increment in Sakha 1 but not in Giza Blanca. This response was 3.35 per each P increment.

The present results clearly indicate that almost all nodulation criteria responded to the increase of P level up to the higher one (31.0 kg P_2O_5 / fed) tried in this study. The data further indicate that nodulation improvement was more pronounced in Sakha 1 than in Giza Blanca. Certainly phosphorus has a great role in root multiplication and hence more root sites were available for nitrogen fixing bacteria to set nodules (Cassman *et al*,1980). The increase of P level was in favour of nodule rather than root growth as the percentage of their weights to total root weight was consistently increased with each P increment. Moreover, Giza Blanca made use of P in nodulation rather than nodule growth, whereas the reverse was true in Sakha 1. This statement is based on the magnitude of response of nodule number and single nodule dry weight due to the increase of P level.

This was not true regarding the effect of N level increase on nodulation and nodule growth in the two faba bean cultivars. In Sakha 1 the N increment improved both the nodule number (24.7%) and single nodule dry weight (47.4%). Whereas, in Giza Blanca it improved single nodule dry weight (60.5 %) rather than nodule number (4.8%). This refers to differential response to N and P levels by the two cultivars with regard to nodulation and nodule growth. These results are in accordance with those reported by some authors regarding the improvement of root growth and nodulation in faba bean due to the addition of phosphorus (Ahmed *et al* , 1992 and Nahed, El- Wafai and Dahdouh 1992) .

A.c . Potassium level effect:

It is obvious from Table (1) that addition of K resulted in a significant increase in each of the nodulation criteria of Sakha 1 only. The root dry weight / plant was increased from 2.330 to 2.599 gm (11.5%) . Also, the nodules dry weight / plant was increased significantly where the average increase was from 1.318 to 1.583 gm (20.1%) .Therefore, the total root dry weight / plant was increased from 3.649 to 4.182 gm (14.6%) due to addition of K as compared to the check K treatment. Similar increase was observed in the percentage of dry weight of nodules to total root dry weight where it was increased from 34.94 to 37.28%. As far as the number of nodules / plant , addition of K increased this number in the two faba bean cultivars where the average increase was from 40.77 to 41.93 (2.9%) in Sakha 1 compared with an increase from 24.60 to 26.59 (8.1%) in Giza Blanca . This addition increased the single nodule dry weight of Sakha 1 only where the increase was from31.57 to 37.34 mg (18.3%).

According to these results it could be concluded that Sakha 1 was in more need than Giza Blanca to K addition in order to improve its root and nodule growth. The reason could be the larger number of nodules that was carried by the former than by the latter, and, as well, a differential preference in dry matter partitioning between the root and top of the two faba bean cultivars. It seems that Giza Blanca had more active top sink whereas, Sakha 1 had more active root and nodule sink.

These results support those reported by other regarding the favorable effect of added K on root and nodule growth (Khalifa and Badr, 1992) .

A.d.Interaction effect:

The N × P interaction affected significantly the root and nodules dry weights / plant , and hence the total root dry weight / plant of Sakha 1. The number of nodules was also affected by this interaction (Table 1-a).

It is evident from Table (1-a)that the increase of root, nodules and total root dry weights / plant of Sakha 1 due to the increase of P level was more consistent and was caused by the linear component at the high N level. However , this increase was caused mainly by the quadratic component at the low N level where the 2nd P increment had more effect than the 1st one in this respect. These results clearly indicate that high N fertilized plants could make better use of P than low N fertilized ones. In other words N and P had complementary roles in maximizing the root and nodules dry weights of Sakha 1.

Regarding the N x P interaction on the number of nodules / plant of Sakha 1.It is shown in Table(1-a) , also, that this number showed diminishing increase due to the increase of P level for the high N fertilized plants , but however, nondiminishing increase in the low N fertilized ones. Therefore, the number of nodules / plant of Sakha 1 could be maximized to 49.96 nodule / plant due to the addition of 26.10 kg P_2O_5 / fed . This could be attributed to the high rate of increase in this number due to the increase of P level for the high N fertilized plants. This also could be served to explain the consistent increase in the nodules and hence the total root dry weight / plant due to the increase of P level for the high N fertilized plants of this cultivar

The N x K interaction affected the single nodule dry weight and the percentage of dry weight of nodules to total root dry weight of Sakha 1 (Table 1- b). It was evident that K addition for the low N fertilized plants secured significant increase in the two aforementioned nodulation attributes. This was also true when K was added to the high N fertilized plants but the increase did not reach the level of significance . This differential response could be attributed to differential preference in priorities of dry matter partitioning. It seems that low N fertilized plants had weaker top and hence stronger nodule sink than the high N fertilized ones. Therefore addition of K to the formers was in favour of the stronger sink.

No additional information could be detected from the P x K interaction which affected the nodules and total root dry weights and as well the single nodule dry weight of Sakha 1.This interaction affected also the number of nodules / plant of Giza Blanca .It was obvious that K-fertilized plants made better use of added P than the K-unfertilized ones in all nodulation criteria respects.

Therefore no separate tables were devoted for this interaction .

B. Flowering and flower shedding attributes and leaf area index:

B.a. Nitrogen level effect:

Doubling the level of N to 20 kg N/fed. though decreased the number of flowers/plant, it was effective to decrease the flower shedding percentage and hence increased the number of young pods / plant. This N level increase, decreased significantly the young pod shedding and total shedding percentages but increased LAI. This was true in the two faba bean cultivars where the decrease in flower number / plant was from 58.40 to 52.69 (9.9%) in Sakha 1 and from 60.74 to 59.24 (2.5%) in Giza Blanca. However, the flower shedding percentage decrease was from 73.58 to 69.58% in the former and from 78.21 to 77.44% in the latter. Therefore, the number of young pods / plant was increased from 15.10 to 15.79 (4.6%) and from 12.96 to 13.33 (2.9%) in the two cultivars, respectively (Table2) .. It was evident also, that doubling the level of N to 20 kg N/fed caused a significant decrease in the young pod shedding percentage of Giza Blanca only where the average decrease was from 49.54 to 47.76%. Accordingly, the total shedding percentage was decreased from 87.74 to 85.56% in Sakha 1and from 88.33 to 87.38% in Giza Blanca. However, LAI was increased from 3.80 to 5.79 (52.4%) in Sakha 1and from 4.84 to 5.42 (12%) in Giza Blanca (Table2).

These results are quite interesting as they clearly show that the two faba bean cultivars were in urgent need for the increase of N level to 20 kg N /fed. This increase improved all root and nodule growth criteria (Table 1) and hence could account for the improved flowering and fruiting attributes observed herein in Table 2. The improvement of root growth was reflected in better use and uptake of plant nutrients and hence improved photosynthesis and availability of enough assimilates to keep on faba bean plants larger number of young pods / plant due to the decrease in flower shedding. The decrease in the number of flowers / plant due to the increase of N level could be attribute to a delay in flowering and synchronization in termination of flowering due to the increase of air temperature with the advance the growing season . In the two faba bean cultivars this delay was about one week by the high N fertilized plants particularly those of Sakha 1 (Data are not presented) .

The present findings are in accordance with those reported by AbdEl - Rahim *et al*, 1983)as they found that flowering and flower shedding in faba bean was decreased due to addition of N .

B.b. Phosphorus level effect:

The increase of P level up to 31.0 kg P_2O_5 /fed had a significant effect on each of the flowering and fruiting attributes tabulated in Table (2).

The number of flowers / plant was consistently decreased due to each P increment in the two faba bean cultivars .Due to each P increment the response was - 5.64 and - 5.52 flower / plant in Sakha 1 and Giza Blanca, respectively. The flower shedding percentage was also decreased where the average response was - 4.03% in the former compared with - 4.83% in the latter. Therefore the number of young pods / plant was increased with response of 0.62 and 1.76 pod/plant due to each P increment, in the two cultivars, respectively. On the other hand, the young pod shedding percentage was decreased where the response was - 3.40% in Sakha 1 and - 1.58% in Giza Blanca . Therefore the total shedding percentage was decreased with response of – 2.96% in the former and – 2.59% in the latter. Results in Table (2) show, also that the increase of P level yielded significant increase in LAI in the two faba bean cultivars where the response was 1.01 and 1.14 with each P increment in the two faba bean cultivars, respectively.

These results clearly indicate that all improvements observed in root and nodule growth criteria due to increase of P level (Table1) were reflected in flowering and fruiting of the two faba bean cultivars. The results further indicate that increments of P were almost equally effective on flower shedding and total shedding percentages of the two faba bean cultivars. However, these increments had more favorable effects on the number of young pods / plant and LAI of Giza Blanca than those of Sakha 1 .

The present results are in agreement with those reported by others regarding the effect of P level increase in flower and young pod shedding(Moursi *et al*, 1976 and Atta, 1991), as well as , LAI(Mowafy, 1989 and Ibrahim and Esmail, 1994 and Yousrya, ,Metwally 1995).

B.c. Potassium level effect:

Table (2) shows that addition of 24 kg K_2O/ fed. decreased significantly the number of flowers / plant in Sakha 1 was from 57.73 to 53.36 (7.6%) and in Giza Blanca from 61.65 to58.32 (5.4%). Also,this addition decreased the flower shedding percentage from 72.65 to 70.51% in the former and from 78.50 to 77.14 % in the latter. However , the number of young pods / plant was not significantly increased due to this addition , but the young pod shedding percentage was decreased from 55.19 to 51.53% and from 50.28 to 47.02% in the two faba bean cultivars, respectively. Therefore, the total shedding percentage was decreased in Sakha 1from 87.72 to 85.58% and in Giza Blanca from 88.62 to 87.09 %. Potassium addition increased significantly LAI in the two faba bean cultivars from 4.55 to 5.04 (10.77%) in Sakha 1 and from 4.89 to 5.36 (9.61%) in Giza Blanca.

These data clearly indicate that addition of K improved flowering and fruiting in the two faba bean cultivars, through significant decrease in the flower and young pod shedding and hence total shedding . This addition increased also LAI, but was without significant influence on the number of young pod / plant. These improvements were, almost, with similar magnitudes in the two faba bean cultivars.

Since potassium has a great role in dry matter partitioning (Haeder ,1977) the increase of LAI and the decrease of total shedding clearly indicate that photosynthates of the K fertilized plants were enough to keep a larger number of flowers against fall . Though the number of young pods/ plant was not significantly increased due to K addition , the decrease of the total shedding , refers to a possible significant increase in the number of mature pods/plant at harvest.

These results are in accordance with those reported by others regarding the favorable effect of K on flowering and fruiting of faba bean (Hussein *et al* , 1986 and Magda and Sanaa,1995).

B. d. Interaction effect:

The N x P interaction affected the number of flowers / plant and flower shedding percentage of Giza Blanca. The young pods shedding and total shedding and LAI of the two cultivars were affected also by this interaction and are shown in Table (2-a).

The young pod shedding percentage showed different trends of decrease due to the increase of P level for the high and low N fertilized plants. These trends were also different between the two cultivars. For reason of simplicity the comparison will be made for the response of high N fertilized plants of the two faba bean cultivars to the increase of P level . In Giza Blanca the decrease of either young pod shedding or total shedding percentage due to the increase of P level was mainly linear and of higher magnitude than in Sakha 1 . In the latter cultivar this decrease was mainly quadratic where the 2nd P increment had higher effect in this respect than the 1st one . It seems evident that young pod and total shedding in Giza Blanca were more responsive to the increase of P level than those of Sakha 1. This could be attributed to the more response of LAI of the former than in the latter to the increase of P level by either the high or the low N fertilized plants(Table 2-a). These results clearly indicate that Giza Blanca had larger photosynthetic surface and hence more photosythates were available to keep larger number of young pods against fall with greater magnitude in Giza Blanca than in Sakha 1.

The N x K interaction affected the number of flowers / plant of Sakha 1 and flower shedding of Giza Blanca. This interaction affected also the number of young pods / plant in the two cultivars. However, no particular clear trends could be detected from these interaction and hence they are not presented or discussed .

The P x K interaction affected significantly the number of flowers and their shedding of Giza Blanca, as well as , the number of young pods and their shedding of Sakha 1. The most important P x K interaction was that affecting the total shedding percentage of the two cultivars as shown in Table (2 - b). It was evident from that the total shedding percentage showed a significant decrease with each P increment but with higher magnitude in the K- fertilized than in the K- unfertilized plants. Also , the rate of decrease in this shedding was much higher in Sakha 1 than in Giza Blanca. In the former each P increment secured 4.07% decrease in total shedding compared with a decrease of 2.67% only in Giza Blanca. This response was mainly linear as indicated by the response equations.

From the N x K and P x K interactions it could be concluded that Giza Blanca was in more need for the increase of N level to maximize the effect of P increments in minimizing the total shedding percentage . Whereas , Sakha 1 was in more need for K addition to minimize this percentage through the P level increase. These results

refer to a differential response by the two faba bean cultivars to the increase of P level and could be attributed to cultivar differences with regard the most active sinks. In Sakha 1 roots and their nodules were the active sink whereas in Giza Blanca the top was the active sink. It is well known that N activates the aboveground mass of crop plants whereas K activates the translocation of photosynthates towards active sinks (Haeder, 1977) . Therefore the role of P in minimizing total shedding complemented the role of N in Giza Blanca, but however, the role of K in Sakha 1.

C . Simple correlation and path coefficient analyses :

Positive and significant association was recorded between seed yield / fed and each of ; total root dry weight / plant , root dry weight / plant , nodules dry weight / plant and number of nodules / plant in both Sakha 1 and Giza Blanca cultivars (Table 3).

Data presented in Table (4) show direct and indirect effects of root and nodulation growth attributes as percentage of seed yield variation in both cultivars. It is clear that the highest direct effect on seed yield of Sakha 1 was accounted by the total root dry weight / plant followed by nodules dry weight / plant with relative importance of 21.76 and 11.09 , respectively . Whereas , both root dry weight / plant and number of nodules / plant exhibited a little effect in this respect.

Regarding the indirect effect it is worthy to note that the maximum indirect effect on seed yield variation , was for total root dry weight / plant via nodules dry weight / plant followed by total root dry weight / plant via root dry weight / plant and then root dry weight / plant via nodules dry weight / plant with values of 30.403 , 3.77 and 2 .53% , respectively . Whereas the other indirect effects were negligible in this respect. Generally , according to the total contribution the most root and nodules growth attribute was total root dry weight / plant followed by nodules dry weight , root dry weight and then number of nodules / plant with values of 40.98 , 24.92 , 3.93 and then 0.24 % , respectively.. However , the highest direct effect on Giza Blanca seed yield was accounted for nodules dry weight / plant followed by total root dry weight / plant and number of nodules / plant with relative importance of 18.13 , 12.971 and 7.44% , respectively . Whereas , root dry weight / plant exhibited a little effect in this respect . Regarding the maximum indirect effect on seed yield variation was for total root dry weight / plant via nodules dry weight / plant followed by nodules dry weight / plant via number of nodules / plant and then total root dry weight via number of nodules / plant with values 30.607 , 12.916 and then 10.0802 % respectively . Whereas the other indirect effects were negligible in this respect . Moreover , nodules dry weight / plant had the highest total contribution on Giza Blanca seed yield variation followed by number of nodules / plant , total root dry weight / plant , and then root dry weight / plant with values of 33.537 , 31.999 , 26.663 and then 0.0006%, respectively. Therefore, the total contribution of root and nodulation growth attributes were much higher in Giza Blanca (92.2002%) than in Sakha 1 (70.07%) .

These data are in harmory with those reported by Fayed , (1987) who found that root dry weight correlated significantly with pods yield of groundnut .

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Table (1) : Root and nodule growth attributes of Sakha 1 (S.1) and Giza Blanca (G.B) faba bean cultivars as affected by N, P and K levels and their interactions (combined of the two seasons).

Main effects and interactions	Root dry weight /plant (gm)		Nodules dry weight / plant (gm)		Total root dry weight / plant (gm)		Nodule / total root dry weights percentage (%)		Number of nodules /plant (No)		Single nodule dry weight (mg)	
	S.1	G.B	S.1	G.B	S.1	G.B	S.1	G.B	S.1	G.B	S.1	G.B
N level effect: (N)												
10.0 (kg N/fed)	2.094b	2.332b	1.033b	1.204b	3.127b	3.537b	32.38b	33.93b	36.80b	25.00b	27.85b	48.12b
20.0 (kg N/fed)	2.836a	3.240a	1.868a	1.973a	4.705a	5.213a	39.85a	37.69a	45.90a	26.19a	41.05a	77.23a
F test	**	**	**	**	**	**	**	**	**	**	**	**
Difference %	35.4	38.9	80.8	63.9	50.5	47.4	--	--	24.7	4.86	47.40	60.50
P level effect: (P)												
0 (check)	2.065c	2.505c	1.212c	1.351c	3.277c	3.857c	35.52	34.36bc	36.89c	21.12c	32.45bc	64.68
15.5 (kg P_2O_5 / fed)	2.274b	2.859ab	1.396b	1.587b	3.670b	4.447b	37.16	35.30b	42.91ab	24.81b	31.77b	64.26
31.0 (kg P_2O_5 / fed)	3.055a	2.994a	1.744a	1.826a	4.800a	4.820a	35.65	37.76a	44.25a	30.86a	39.14a	59.07
F test	**	**	**	**	**	**	N.S	**	**	**	**	N.S.
Regression coefficient	0.495	0.245	0.266	0.238	0.762	0.482	--	1.70	3.68	4.87	3.35	--
K level effect:(K)												
0 (check)	2.330b	2.768	1.318b	1.556	3.649b	4.324	34.94b	35.46	40.77b	24.60b	31.57b	64.14
24.0 (kg K_2O / fed)	2.599a	2.804	1.583a	1.621	4.182a	4.425	37.28a	36.16	41.93a	26.59a	37.34a	61.20
F test	**	N.S.	**	N.S.	**	N.S.	*	N.S.	*	**	**	N.S.
Difference %	11.5	--	20.1	--	14.60	--	--	--	2.9	8.1	18.3	--
Interactions effects												
N x P (Table 1- a)	**	N.S.	*	N.S.	**	N.S.	N.S.	N.S.	**	N.S.	**	**
N x K (Table 1-b)	N.S.	N.S.	N.S.	N.S.	N.S	N. S.	*	N.S.	N.S.	N.S.	*	N.S
P x K(Not presented)	N.S.	N.S	*	N.S.	**	N.S.	N.S	N.S.	N.S.	**	*	N.S.
Cultivar average	2.465	2.786	1.451	1.589	3.916	4.375	36.12	35.51	41.35	25.60	34.45	62.68
t test	**		**		**		N.S.		**		**	

*and ** refer to 5% and 1% probability levels, respectively.   N. S Not Significant

Table (1- a) : Some nodulation criteria of Sakha 1 as affected by N x P interactions.

N level (kg N/fed)	P level (kg P_2O_5) 0	15.5	31.0	Response equation $\hat{Y} = a + b x + c x^2$
			Root dry weight / plant (gm)	
	C	B C	A	
10	1.673b	1.778b	2.831b	$1.673 - 0.368^{**}x + 0.470^{**}x^2$
	C	B	A	
20	2.457a	2.769a	3.282a	$2.457 + 0.413^{**}x$
			Nodules dry weight / plant (gm)	
	C	B C	A	
10	0.750b	0.925b	1.426b	$0.750 + 0.013^{**}x + 0.162^{*}x^2$
	C	B	A	
20	1.674a	1.868a	2.063a	$1.674 + 0.195^{**}x$
			Total root dry weight / plant (gm)	
	C	B	A	
10	2.423b	2.703b	4.256b	$2.423 - 0.356^{**}x + 0.640^{**}x^2$
	C	B	A	
20	4.132a	4.638a	5.345a	$4.132 + 0.607^{**}x$
			Number of nodules / plant	
	C	B	A B	
10	33.98b	37.53b	38.90b	$33.98 + 2.46^{**}x$
	C	B	A B	
20	39.81a	48.30a	49.60a	$39.81 + 12.08^{**}x - 3.59^{**}x^2$ 49.96 * 26.1 *

* The maximum predicted number of nodules / plant and the maximum predicted P level in kg P_2O_5 /fed.

Table (1 – b) : The percentage of dry weight of nodules to total root dry weight and single nodule dry weight of Sakha 1 cultivar as affected by N x K interaction .

N level (kgN/fed)	K level (kg K_2O / fed)		Differences %
	Dry weight of nodules total root dry weight percentage		
	B	A	
10	30.11 b	34.66 b	--
	AB	A	
20	39.78 a	39.92 a	--
	Single nodule dry weight (mg)		
	B	A	
10	23.37 b	32.34 b	38.4
	B	A	
20	39.77 a	42.34 a	6.5
Difference %	70.2	30.9	

Table (2) : Flowering and fruiting attributes of Sakha 1 (S.1) and Giza Blanca (G.B) cultivars as affected by N, P and K level and their interactions (combined of the two seasons).

Main effects and interactions	Number of flowers /plant (No)		Flower shedding (%)		Number of young pods / plant (No)		Young pod shedding (%)		Total shedding (%)		Leaf area index	
	S.1	G.B	S.1	G.B	S.1	G.B	S.1	G.B	S.1	G.B	S.1	G.B
N level effect: (N)												
10.0 (kg N/fed)	58.40a	60.74a	73.58a	78.21a	15.10b	12.96b	53.65	49.54a	87.74a	88.33a	3.80b	4.84b
20.0 (kg N/fed)	52.69b	59.24b	69.58b	77.44b	15.79a	13.33a	53.57	47.76b	85.56b	87.38b	5.79a	5.42a
F test	**	*	**	*	**	*	N.S.	*	**	**	**	**
Difference %	9.9	2.5	--	--	4.6	2.9	--	--	--	--	52.4	12.0
P level effect: (P)												
0 (check)	61.97a	65.03a	75.89a	82.12a	14.83c	11.56c	56.52a	50.27a	89.64a	90.28a	3.81c	4.00c
15.5 (kg P_2o_5 / fed)	53.96b	60.93b	71.01b	78.87b	15.46b	12.79b	53.64b	48.57ab	86.57b	88.17b	4.74b	5.11b
31.0 (kg P_2o_5 / fed)	50.69c	54.00c	67.83c	72.47c	16.07a	15.08a	49.72c	47.11bc	83.73c	85.11c	5.83a	6.28a
F test	**	**	**	**	**	**	**	*	**	**	**	**
Regression coefficient	-5.64	-5.52	-4.03	-4.83	0.62	1.76	-3.40	-1.58	-2.96	-2.59	1.01	1.14
K level effect:(K)												
0 (check)	57.73a	61.65a	72.65a	78.50a	15.47	13.21	55.19a	50.28a	87.72a	88.62a	4.55b	4.89b
24.0 (kg K_2o / fed)	53.36b	58.32b	70.51b	77.14b	15.42	13.08	51.53b	47.02b	85:58b	87.09b	5.04a	5.36a
F test	**	**	**	**	N.S.	N.S.	**	**	**	**	**	**
Difference %	7.6	5.4	--	--	--	--	--	--	--	--	10.8	9.6
Interaction effects												
N x P (Table 2- a)	N.S.	**	N.S.	**	N.S.	**	**	*	**	**	**	**
N x K (Not presented)	**	N.S.	N.S.	*	**	**	N.S.	N.S.	N.S.	N.S.	N.S	N.S.
P x K(Table 2- b)	N.S	**	N.S.	*	**	N.S.	**	N.S.	**	**	**	N.S.
Cultivar average	55.55	59.99	71.58	7.83	15.44	13.15	53.61	48.65	86.65	87.86	4.80	5.13
t test	**		**		**		**		**		**	

*** and ** refer to 5% and 1% probability levels, respectively.** **N.S Not Significant**

Table (2 – a) : Young pod and total shedding percentages, as well as ,LAI of the two faba bean cultivars

N level (kg N / fed)	P level (kg P_2O_5 / fed) 0	15.5	31.0	Response equation $\hat{Y} = a + b\,x + cx^2$
	Young pod shedding percentage (Giza Blanca)			
	A	A	A	
10	49.79 a b	50.27 a	48.54 a	Insignificant response
	A	B	B	
20	50.74 a	46.88 b	45.68 ab	$50.74 - 0.63^{**}x$
	Young pod shedding percentage (Sakha 1)			
	A	B	B	
10	55.94 a b	52.59 b	52.41a	$55.94 - 1.77^{**}x$
	A	B	C	
20	57.46 a	54.70 a	47.04 b	$57.46 - 0.30^{**} X - 2.46^{**}X^2$
	Total shedding percentage (Sakha 1)			
	A	B	C	
10	90.20 a	87.04 a	85.95 a	$90.20 - 2.13^{**}X$
	A	B	C	
20	89.08 b	86.11 b	81.49 b	$89.08 - 3.80^{**}X$
	Total shedding percentage (Giza Blanca)			
	A	B	C	
10	90.27 a b	89.34 a	85.38 a	$90.27 - 0.57^{**}X - 1.51^{**}X^2$
	A	B	C	
20	90.28 a	87.01 b	84.85 b	$90.28 - 2.72^{**}X$
	Leaf area index (Sakha 1)			
	C	B	A	
10	2.96 b	3.60 b	4.84 b	$2.96 + 0.35^{**}X + 0.30^{**}X^2$
	C	B	A	
20	4.67 a	5.88 a	6.83 a	$4.67 + 1.08^{**}X$
	Leaf area index (Giza Blanca)			
	C	B	A	
10	3.71 b	4.68 b	6.13 b	$3.71 + 0.7^{**}X + 0.246^{*}X^2$
	C	B	A	
20	4.29 a	5.54 a	6.42 a	$4.29 + 1.07^{**}X$

Table (2-b) : Total shedding percentage of the two faba bean cultivars as affected by P x K interaction and response equations .

K level (kgN_2O/fed)	P level (kgP_2O_5 / fed) 0	15.5	31.0	Response equation $\hat{Y} = a+bx+cx^2$
		Sakha 1		
	A	B	C	
0	90.15 a	87.78 a	85.24 a	$90.15-2.46^{**}x$
	A	B	C	
24	89.14 b	85.37 b	82.22 b	$89.14-3.46^{**}x$
		Giza Blanca		
	A	B	C	
0	90.62 a	89.18 a	86.05 a	$90.62-2.29^{**}x$
	A	B	C	
24	89.94 b	87.17 b	84.18 b	$89.94-2.88^{**}x$

Table (3) : Simple correlation coefficient between seed yield / fed and nodulation growth attributes of Sakha 1 (S.1)and Giza Blanca (G.B) cultivars (combined).

Characters	C.V	X_2	X_3	X_4	X_5	X_6	Seed yield /fed
Total root dry weight / plant (X_1)	S . 1	0.984**	0.978**	0.866**	0.716**	0.910**	0.714**
	G .B	0.991**	0.998**	0.513	0.837**	0.802**	0.600*
Root dry weight / plant (X_2)	S . 1		0.924**	0.441	0.585*	0.855**	0.778**
	G.B		0.960**	0.465	0.762**	0.806**	0.762**
Nodules dry weight / plant (X_3)	S . 1			0.879**	0.840**	0.939**	0.608*
	G .B			0.556	0.906**	0.780**	0.639*
Number of nodules / plant (X_4)	S . 1				0.694*	0.669*	0.665*
	G .B				0.646*	0.073	0.951**
Nodules / total root dry weights (%) (X_5)	S . 1					0.848**	0.213
	G. B					0.612*	0.688*
Single nodule dry weight (X_6)	S . 1						0.456
	G. B						0.046

Table (4) : Direct and indirect effects of root and nodulation growth attributes as percentage of seed yield variation in Sakha 1 (S.1) and Giza Blanca (G.B) cultivars (combined).

Characters	S . 1		C . D	
	C . D	R.I%	G . B	R.I%
Total root dry weidht/ plant	10.7163	21.76	1.1104	12.971
Root dry weight / plant	0.0831	0.167	0.000002	0.0002
Nodules dry weight / plant	5.4667	11.102	1.5521	18.130
Number of nodules / plant	0.0002	0.0003	0.6370	7.440
Total root dry weight / plant x root dry weight /plant	-1.8571	3.770	-0.002	0.0288
Total root dry weight / plant x nodules dry weight /plant	-14.9711	30.403	-2.6203	30.607
Total root dry weight / plant x no. of nodules / plant	0.0712	0.230	-0.8629	10.0802
Root dry weight / plant x nodules dry weight / plant	1.2455	2.530	0.0014	0.015
Root dry weight / plant x no. of nodules / plant.	-0.0032	0.007	0.0010	0.012
Nodules dry weight / plant x no . of nodules / plant	-0.0509	0.1007	1.1057	12.916
R^2	0.7007	70.07	0.922002	92.2002
Residual	0.2993	29.93	0.077998	7.7998
Total contribution				
Total root dry weight / plant	2.3374	40.98	-0.63240	26.66343
Root dry weight / plant	-0.2243	3.93	0.000022	0.00063
Nodules dry weight / plant	-1.4216	24.92	0.79543	33.53729
Number of nodules / plant	0.0083	0.24	0.75895	31.99885
Total	0.7007	70.07	0.922002	92.2002

إستجابة صنفان من الفول البلدى لمستويات مختلفه من النيتروجين والفوسفور والبوتاسيوم تحت ظروف الاراضى الرمليه
١- مؤشرات تكوين ونمو العقد الجذريه والتزهير والتساقط

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** وزارة التموين و التجاره الداخليه

أجريت تجربتان حقليتان خلال موسمي النمو ٢٠٠٠/٢٠٠١ و ٢٠٠١/ ٢٠٠٢ لدراسة إستجابة صنفي الفول البلدى جيزه بلانكا (دليل البذره ١١٠-١٢٠ جم) وسخا ١ (دليل البذره ٨٠-٩٠جم)لإضافة مستويين من النيتروجين (١٠ و ٢٠ كجم ن / فدان) وثلاث مستويات من الفوسفور (صفر ، ١٥,٥ و ٣١,٠ فو٢أ٥/ فدان) فى وجود أو غياب ٢٤كجم بو٢أ /فدان . خصصت لكل صنف تجربه مستقله فى تصميم القطاعات الكاملة العشوائيه من ٤ مكررات.

تم تتبع تأثير مستويات العناصر الغذائيه تحت الدراسه على صفات أعداد وأوزان العقد الجذريه ونسبة أوزانها الى وزن الجذر وصفات التزهير والإثمار وتساقط الأزهار والقرون الصغيره.

ويمكن تلخيص أهم النتائج التى تم الحصول عليها على النحو التالى:

١- تميز الصنف جيزه بلانكا بزيادة سعة مصب المجموع الخضرى ممثلا فى زيادة دليل مساحة الأوراق عند بداية التزهير بينما تميز الصنف سخا١ بسعة مصب العقد الجذريه ممثلا فى أعداد العقد الجذريه رغم انخفاض أوزانها الفرديه عن الصنف جيزه بلانكا عند بداية التزهير .

٢- أدت زيادة مستوى التسميد من أى من النيتروجين أو الفوسفور أو أضافة البوتاسيوم الى زيادة أعداد وأوزان العقد الجذريه ونسبة أوزانها الى وزن المجموع الجذرى وقد كانت إستجابة سخا ١ أعلى من إستجابة جيزه بلانكا بهذا الخصوص كما كان تأثير التسميد الفوسفاتى أعلى من تأثير التسميد النيتروجينى أو البوتاسى.

٣- تميز الصنف جيزه بلانكا عن سخا١ فى أعداد الأزهار/ النبات والذى أنخفض فى كل منهما بزيادة مستوى التسميد النيتروجينى والفوسفاتى والبوتاسى وقد صاحب ذلك انخفاض فى النسب المئويه لتساقط الأزهار والقرون الصغيره وبالتالى التساقط الكلى وكان الانخفاض متقارب فى الصنفين وإن زاد تساقط الأزهار فى جيزه بلانكا عن سخا١.

٤- أظهرت نتائج الارتباط وجود علاقه موجبه ومعنويه بين محصول البذور / فدان مع كل من الوزن الكلى الجاف للجذر / نبات، الوزن الجاف للجذر / نبات ، وزن العقد الجذريه الجاف / نبات وعدد العقد الجذريه / نبات فى الصنفين سخا١ وجيزه بلانكا. وأشارت نتائج تحليل معامل المرور أن الوزن الكلى الجاف للجذر/ نبات له الدور الأكبر (٤٠,٩٨ %) فى تباين محصول البذور/ فدان فى الصنف سخا١ يليه الوزن الجاف للعقد الجذريه / نبات (٢٤,٩٢%) ، فى حين اشترك كل من الوزن الجاف للعقد الجذريه وعددها فى إحداث هذا التباين فى الصنف جيزه بلانكا (٣٣,٥٤و ٣١,٩٩على التوالى) يليهما الوزن الكلى الجاف للجذر (٢٦,٦٦%). ومن ثم كونت مؤشرات نمو الجذر والعقد الجذريه تحت الدراسه ٩٩,٢٠% و ٧٠,٠٧% من تغيرات محصول البذور فى جيزه بلانكا وسخا ١ على التوالى بما يؤكد أهمية هذه المؤشرات فى تكوين محصول البذور تحت ظروف الأراضى الرمليه.