# RESULTS AND DISCUSSION

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## I. LABORATORY EXPERIMENT

This study was conducted to investigate the ability of ***Phaseolus vulgaris*** plants to form nodules when grown under sterilized conditions inoculated or uninoculated with the appropriate ***Rhizobium*** culture (strain No. 3612) as well as to study the effect of N application to inoculated and uninoculated plants on nodule formation, plant growth, total nitrogen and $NO_3$-N content.

The effect of inoculation and nitrogen application on number and weight of nodules formed on the roots of ***Phaseolus vulgaris*** plants grown under Leanard Jar conditions is presented in table (5).The results revealed that the plants failled to form any nodules when planted in sterilized soil free from ***Rhizobium*** bacteria. This failure to form nodules could be attributed to the absence of rhizobial cells in growth culture resulted from the sterilization process. On the other hand, the nodules were formed after inoculation with effective strain of ***Rhizobium phaseoli***. The number of nodules formed/plant as well as their weight were negatively affected by the rate of N application. The highest number and weight of nodules was obtained in the absence of N. Increasing nitrogen rate up to 33 mgN/kg resulted in a sharp decrease in both number and weight of nodules. The nodules number/plant was reduced from 136 in absence of N to 38 with the rate of 16.5 mgN/kg and to 6 with 33 mgN/kg. These results coroporate the results of Raggio and Raggio (1962), Subba-Rao and Vasanth (1965) which indicated that high concentrations (> 1 m M) of nitrate, nitrite, ammonium

**Table (5):** Effect of inoculation and nitrogen application on number and weight of nodules formed on the roots of ***Phaseolus vulgaris*** plant grown under Leanard Jars condition.

| N-rate (mg/kg) | No. of nodules/plant | | | Nodules dry weight/plant | | |
|---|---|---|---|---|---|---|
| | Uninoculation | Inoculation | Mean | Uninoculation | Inoculation | Mean |
| 0 | - | 136 | 68 | - | 0.5013 | 0.251 |
| 16.5 | - | 38 | 19 | - | 0.0925 | 0.046 |
| 33 | - | 6 | 3 | - | 0.0068 | 0.003 |
| Mean | - | 60 | | - | 0.234 | |

| L.S.D. | 5% | 1% | 5% | 1% |
|---|---|---|---|---|
| N: | 2.87 | 4.08 | 0.0013 | 0.0018 |
| I: | 2.34 | 3.33 | 0.0009 | 0.0013 |
| NxI: | 4.05 | 5.77 | 0.0016 | 0.0022 |

**Table (6):** Effect of inoculation and nitrogen application on root and shoot growth of ***Phaseolus vulgaris*** plants grown under Leanard Jars condition.

| N-rate (mg/kg) | Root dry weight/plant | | | Shoot dry weight/plant | | |
|---|---|---|---|---|---|---|
| | Uninoculation | Inoculation | Mean | Uninoculation | Inoculation | Mean |
| 0 | 0.628 | 0.522 | 0.575 | 0.500 | 0.898 | 0.699 |
| 16.5 | 0.650 | 0.589 | 0.619 | 0.770 | 0.915 | 0.843 |
| 33 | 0.857 | 0.855 | 0.856 | 1.108 | 1.100 | 1.104 |
| Mean | 0.712 | 0.655 | | 0.793 | 0.971 | |

| L.S.D. | 5% | 1% | 5% | 1% |
|---|---|---|---|---|
| N: | 0.0076 | 0.0108 | 0.0331 | 0.0471 |
| I: | 0.0063 | 0.0090 | 0.0268 | 0.0381 |
| NxI: | 0.0108 | 0.0152 | 0.0466 | 0.0663 |

N : Nitrogen
I : Inoculation

and urea restrict nodulation. Results of Tubb (1974) suggested that these N compounds induce high $NH_4$ concentrations in the roots which block the gene responsible for the synthesis of nitrogenase, the most important enzyme system for $N_2$ fixation. Also, these findings are in good agreement with those of Dean and Clark, (1980); Hill-Cottingham and Lloyd-Jones, (1980); Clark, (1980); Scherer and Danzeisen, (1980); Kisha et al., (1980); Heyland and Puhl, (1986) and El-Gizy, (1990), who reported that formation of nodules, nitrogenase activity and the symbiotic $N_2$-fixing potential of legume plants were drastically decreased by increasing the availability of nitrogen to plant roots.

Data of table (6) represent the effect of inoculation and N application on the root and shoot growth of ***Phaseolus vulgaris*** plants. The root dry weight was increased significantly with increasing N rate. However, the effect of inoculation on root weight was negative. The inoculation effect was diminished by increasing N rate. In absence of inoculation, the plants had the highest root weight as compared with inoculated ones. This was true with 0 and 16.5 mgN/kg. However, with the application of 33 mg/kg, no significant difference was found between the inoculated and uninoculated plants. This may be due to the inhibitive effect of the high rate of N on nodulation process.

Concerning the shoot dry weight, results revealed that shoot weight was increased with increasing N application to uninoculated and inoculated plants. At the rate of 0 and 16.5 mg/kg, the inoculated plants produced higher shoot weight comparing with uninoculated ones. The superiority of inoculated plants over the uninoculated ones may be because an the additional portion of nitrogen was supplied through the biological fixation of $N_2$. Such results are in harmony with those of several investigators who indicated that inoculation of leguminous plants enhanced vegetative growth and caused marked increase in nodule production (Ruschel et al., 1974; Ruschel and Ruschel, 1975; Ruschel and Saito, 1977; Semu et al., 1982; Lluch et al., 1983; Quintero et al., 1983; Zambolim et al., 1985 and El-Gizy, 1990). As discussed early in previous parameters, at the third rate of nitrogen (33 mg/kg) no significant difference was obtained between the inoculated and uninoculated plants. This because the number of nodules was very low to induce any differences.

Concerning the whole plant weight, data presented in table (7) revealed that the whole plant weight was affected positively and significantly by the inoculation and N application. The effect of N rate on weight was not related to the effect of inoculation. However, the effect of inoculation was affected by the N rate.

Regarding the root : shoot ratio, results showed that this ratio was decreased either with N rate or with inoculation. The heighest ratio was obtained in absence of N and inoculation, while the lowest ratio was obtained in absence of N and presence of inoculation.

It should be noted that increasing the dose of nitrogen from 0 to 33 mg/kg resulted in a corresponding increase on all growth parameters except root:shoot ratio, indicating that increasing N-rates tends to increase the vegetative growth of plant i.e. the foliage on the account of the root system. This agrees with what was reported by Karlen et al., (1985) who stated that

**Table (7):** Effect of inoculation and nitrogen application on whole plant growth and root:shoot ratio of ***Phaseolus vulgaris*** plants grown under Leanard Jars condition.

| N-rate (mg/kg) | Whole plant | | | Root: Shoot ratio | | |
|---|---|---|---|---|---|---|
| | Uninoculation | Inoculation | Mean | Uninoculation | Inoculation | Mean |
| 0 | 1.128 | 1.420 | 1.274 | 1.26 | 0.58 | 0.919 |
| 16.5 | 1.420 | 1.504 | 1.462 | 0.84 | 0.64 | 0.740 |
| 33 | 1.965 | 1.955 | 1.960 | 0.77 | 0.78 | 0.775 |
| Mean | 1.504 | 1.626 | | 0.957 | 0.667 | |

| L.S.D. | Whole plant 5% | Whole plant 1% | Root: Shoot ratio 5% | Root: Shoot ratio 1% |
|---|---|---|---|---|
| N: | 0.0265 | 0.0376 | 0.0350 | 0.0497 |
| I: | 0.0214 | 0.0305 | 0.0287 | 0.0408 |
| NxI: | 0.0372 | 0.0529 | 0.0495 | 0.0704 |

**Table (8):** Effect of inoculation and nitrogen application on total-N and $NO_3$ content in leaf blades of ***Phaseolus vulgaris*** plants grown under Leanard Jars condition.

| N-rate (mg/kg) | Total N | | | $NO_3$-N | | |
|---|---|---|---|---|---|---|
| | Uninoculation | Inoculation | Mean | Uninoculation | Inoculation | Mean |
| 0 | 2.04 | 2.67 | 2.355 | 0.03 | 0.07 | 0.050 |
| 16.5 | 2.58 | 2.73 | 2.655 | 0.07 | 0.10 | 0.085 |
| 33 | 3.11 | 3.08 | 3.095 | 0.14 | 0.14 | 0.140 |
| Mean | 2.577 | 2.827 | | 0.080 | 0.103 | |

| L.S.D. | Total N 5% | Total N 1% | $NO_3$-N 5% | $NO_3$-N 1% |
|---|---|---|---|---|
| N: | 0.1147 | 0.1631 | 0.0230 | 0.0327 |
| I: | 0.0936 | 0.1331 | 0.0189 | N.S. |
| NxI: | 0.1623 | 0.2308 | N.S. | N.S. |

N : Nitrogen
I : Inoculation

N fertilizer increased the vegetative growth of soybean plant on the expense of roots.

Concerning the effect of inoculation and nitrogen application on total - N and $NO_3$-N content in blades (Table 8), total-N was increased significantly as a result of increasing the application rate of nitrogen. Such increase was affected by the presence of nodules. The general effect of inoculation was positive, the N content was higher in the inoculated plants provided that the applied N did not exceed 16.5 mg N/kg. This result indicates that inoculated plants received additional N over the uninoculated and the biological process of fixation of $N_2$ was active wherever the concentration of mineral N was low.

Regarding $NO_3$-N content in blades, nitrate content was increased with inoculation especially with the first two rates of nitrogen compared to the uninoculated plants.

It could be concluded that inoculated treatment without nitrogen application exhibited a relatively high plant growth with highest nodulation, i.e., number and weight of nodules. Nitrogen addition to inoculated treatments decreased not only the number of nodules but also the total and individual weight of nodules. Inoculation of ***Phaseolus vulgaris*** plants had a positive signiicant effect on both plant growth and N-content in leaf blades.

## II. GREENHOUSE EXPERIMENT

This experiment aimed at throwing light on the ability of the inoculated ***Phaseolus vulgaris*** plants to utilize the atmospheric nitrogen through the biological fixation process under natural soil conditions.

To fulfil this aim a pot experiment was conducted using natural and fumigated soils. These soils were treated with different doses of nitrogen and the seeds were inoculated with the appropriate ***Rhizobium*** culture (Strain No. 3612).

Monitoring the formation of nodules as affected by inoculation and nirogen application revealed that the plants in all investigated treatments failed to form any nodules. This failure may be attributed to several factors, i.e. (1) the inhibitive effect of seed coat diffusates on nodulation process (Fawaz et al., 1970); (2) the adverse effects of bacteriophage on rhizobial populations in soil (Shil'nikova et al,, 1978); (3) the presence of mycotoxine-producing fungi in soil (Angle et al., 1981) and (4) the effect of pH, the nodulation was inhibited below pH 5.5 and above pH 6.8 and were not produced at 7.9 or above (Vencatasamy and Peerally, 1981). Other study by Wery, (1987), indicated that nodulation process was very sensitive to many other factors related to environmental conditions and cultural practices such as combined nitrogen, pesticides, biotic factors, soil salinity or drought stress.

Accordingly, microbiological experiment was executed as an attempt to find out the reasons of failure of nodulation by ***Phaseolus vulgaris*** plant. The obtained results revealed that neither soil organisms nor antagonistic substances had a marked inhibitive effect on the ***Rhizobium phaseoli*** growth indicating that such a failure could be undoubtedly attributed to the available native soil-N content, or pH effects. This could be easily realized by refering to the corresponding N and pH values in table (3). These results support the findings of Abou-El-Fadl et al., (1959) who observed that in soils where soil nitrogen level was 20 kg/fed, $N_2$-fixation by ***Phaseolus vulgaris*** had been completely inhibited. Maximum nodulation and $N_2$-fixation were achieved by Sirry et al., (1984) where 35 kgN/ha were applied to faba bean grown on coarse sand, sandy and saline soils. This amount of N was reduced to 24 kg/ha under calcareous alkali and/or clay soil conditions. Abdel-Ghaffar (1987) also showed that optimum dose of N-fertilizer required for the maximum $N_2$-fixation varied between 18-48 kgN/ha depending on the location and soil characteristics. In general, little attention was given to the available native soil-N in studying effect of N fertilizers, although the soil-N may influence the overall processes. This may explain the contradicting results on the effect of combined-N on nodulation and $N_2$-fixation.

It is worthy to conclude that ***Phaseolus vulgaris*** plants is not able to use the atmospheric nitrogen as a result of its failure to form nodules under common natural soil conditions. Thus the addition of nitrogen to ***Phaseolus vulgaris*** plants is an important factor to increase crop productivity than other legume crops.

# III.FIELD EXPERIMENTS

## A. Nitrogen application under submersion irrigation:

In this particular study, the objective was to investigate the effect of nitrogen fertilization under submersion irrigation condition on plant growth, yielding ability and some physical and chemical characteristics of pods. The nitrogen sources (ammonium nitrate, ammonium sulphate and urea) were applied at rates of 33 and 66 kgN/fed through the two application methods namely surface continuous band (SCB) and surface localized band (SLB).

### 1. Plant growth:

### 1.1. Morphological characters:

### 1.1.1. Plant height:

Data presented in table (9) reflected the influence of sources and rates of N fertilizers with the two adopted methods of application on plant height of ***Phaseolus vulgaris*** at bloom stage. The statistical comparisons revealed that plant height was not affected significantly by nitrogen source, rate and method of application in the two growing seasons. The source by rate interaction was significant in both seasons.The average of plant height was decreased as a result of increasing nitrogen rate with using ammonium nitrate. The opsite trend was obtained with using ammonium sulphate, plant height was increased with increasing the rate. This was true in both growing seasons. In case of using urea, there is no difference between the first and second rate of application in the first season, whereas negative effect was obtained with increasing the rate in the second one. Moreover, significant interactions were found with source by method and method by rate in the first season only. The interaction effects for source by rate and source by le (9): Effect of nitrogen fertilization under submersion condition on plant height (cm) of ***Phaseolus vulgaris*** in 1991 and 1992 seasons.

| | 1991 | | | | | | | | S | | | | | | | | | 1992 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| | 48 | 50 | 49 | 48 | 48 | 48 | 48 | 48 | 48 | 45.5 | 45.00 | 45.25 | 43.50 | 45.00 | 44.25 | 45.0 | 45.50 | 45.25 |
| | 48 | 48 | 48 | 50 | 48 | 49 | 48 | 48 | 48 | 45.0 | 45.00 | 45.00 | 44.50 | 45.00 | 44.75 | 44.50 | 44.00 | 44.25 |
| n | 48 | 49 | | 49 | 48 | | 48 | 48 | | 45.25 | 45.00 | | 44.00 | 45.00 | | 44.75 | 44.75 | |
| | 48.50 | | | 48.50 | | | 48.00 | | | 45.125 | | | 44.500 | | | 44.750 | | |

| | 1991 | | S | | 1992 | |
|---|---|---|---|---|---|---|
| I | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| B | 48.00 | 48.667 | 48.333 | 44.667 | 44.667 | 44.667 |
| B | 48.667 | 48.00 | 48.333 | 45.167 | 44.667 | 44.917 |
| an | 48.333 | 48.333 | | 44.917 | 44.667 | |

S.D.

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | N.S. | N.S. | N.S. | N.S. |
| R : | N.S. | N.S. | N.S. | N.S. |
| M : | N.S. | N.S. | N.S. | N.S. |
| SR : | 0.651 | 0.885 | 0.826 | N.S. |
| SM : | 0.651 | 0.885 | N.S. | N.S. |
| MR : | 0.531 | 0.722 | N.S. | N.S. |
| SMR : | N.S. | N.S. | N.S. | N.S. |

: Source
AN : Ammonium nitrate
AS : Ammonium sulphate
U : Urea

:: Rate
$R_1$ : 33 kgN/feddan
$R_2$ : 66 kgN/feddan

1: Method
SLB : Surface localized band
SCB : Surface continuous band

method in the first season were similar. These findings are in agreement with those reported by Barni et al., (1978), El-Gizy (1990) and Helal (1991), where nitrogen fertilizer did not significantly affect the average plant height of legumes and do not agree with those found by Essa and Dulaini (1985) and Eisa (1986), in which higher values of plant height were achieved as a result of nitrogen application. This contradiction could be attributed to the differences in the amount of N fertilizer and the environmental conditions prevailing in the area of production.

### 1.1.2. Number of leaves :

Data in table (10) show that the number of leaves was significantly affected by nitrogen source. Plants fertilized with ammonium nitrate had the highest number of leaves per plant, followed by those received ammonium sulphate, while those treated with urea had the lowest number of leaves.

Concerning the effect of N rate, increasing N rate from 33 to 66 kg N/fed increased the number of leaves per plant significantly in both seasons with all N sources. Using the second rate of N resulted in an increase in the number of leaves by about 40% with ammonium nitrate, 18% with ammonium sulphate and 44.8% with urea in the first season. In the second season, the number of leaves was increased by 49.7, 15.5 and 64% with ammonium nitrate, ammonium sulphate and urea, respectively. Furthermore, the difference among number of leaves per plant increased with increasing the rate of applied nitrogen in all treatments with significant positive effect compared to each other, in both seasons.

**Table (10): Effect of nitrogen fertilization under submersion condition on leaves number/plant of *Phaseolus vulgaris* in 1991 and 1992 seasons.**

| R | S: 1991 | | | | | | | | | S: 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| R1 | 9.1 | 9.3 | 9.20 | 9.4 | 9.4 | 9.40 | 6.3 | 6.2 | 6.25 | 7.30 | 7.40 | 7.35 | 8.00 | 8.10 | 8.05 | 5.00 | 5.00 | 5.00 |
| R2 | 13.0 | 12.8 | 12.90 | 11.2 | 11.0 | 11.10 | 9.0 | 9.1 | 9.05 | 11.00 | 11.00 | 11.00 | 9.20 | 9.40 | 9.30 | 8.30 | 8.10 | 8.20 |
| Mean | 11.05 | 11.05 | | 10.30 | 10.20 | | 7.65 | 7.65 | | 9.15 | 9.20 | | 8.60 | 8.75 | | 6.65 | 6.55 | |
| | 11.050 | | | 10.250 | | | 7.650 | | | 9.175 | | | 8.675 | | | 6.600 | | |

| M | S: 1991 | | | S: 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 8.267 | 11.067 | 9.667 | 6.767 | 9.500 | 8.133 |
| SCB | 8.300 | 10.967 | 9.633 | 6.833 | 9.500 | 8.167 |
| Mean | 8.283 | 11.017 | | 6.800 | 9.500 | |

**L.S.D.**

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 0.142 | 0.193 | 0.170 | 0.231 |
| R : | 0.116 | 0.157 | 0.139 | 0.189 |
| M : | N.S. | N.S. | N.S. | N.S. |
| SR : | 0.201 | 0.273 | 0.240 | 0.327 |
| SM : | N.S. | N.S. | N.S. | N.S. |
| MR : | N.S. | N.S. | N.S. | N.S. |
| SMR : | N.S. | N.S. | N.S. | N.S. |

A: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

Regarding the effect of application methods, the results did not show any differences between the two methods regardless of the source and rate of applied nitrogen in both seasons.

The source by rate interaction was the only significant one among the different interactions in both seasons. It was observed that nitrogen sources exhibited significant difference in the average number of leaves due to the different nitrogen rates. Such results are in good agreement with those obtained by Ishizuka, (1972); Bhangoo and Albritton, (1976) and El-Gizy, (1990), who found that nitrogen application led to a significant positive effect upon the number of leaves produced on legume plants. In contrast, Badr et al., (1974) pointed out that N-application did not exhibit any significant trend on number of branches/plant of faba bean. This contradiction could be attributed to the effect of the available nitrogen which differ among soils used as a seed beds in those studies. This interpetation was confirmed by the finding of Toan, (1970) who found in pot trials that addition of nitrogen to soybean increased the number of branches more on soil than on sand soil mixture.

The satisfactory effects of nitrogen supplementation on the number of leaves of ***Phaseolus vulgaris*** plant could be attributed to the fact that nitrogen encourage the meristematic activity for building more tissues and organs.

### 1.1.3. Leaf area index:

In both seasons, the leaf area index was affected significantly by N source and there were significant differences between the sources (table 11). The effect of N source on leaf area followed this order: urea> ammonium able (11): Effect of nitrogen fertilization under submersion condition on leaf area index ($cm^2$) of ***Phaseolus vulgaris*** in 1991 and 1992 seasons.

| R | 1991 | | | | | | | | S | 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| 1 | 40.00 | 40.00 | 40.00 | 67.31 | 58.22 | 62.765 | 71.11 | 71.05 | 71.080 | 37.75 | 37.80 | 37.775 | 47.0 | 47.1 | 47.05 | 67.81 | 67.79 | 67.80 |
| 2 | 51.05 | 51.11 | 51.080 | 61.00 | 61.08 | 61.04 | 66.31 | 66.27 | 66.29 | 43.92 | 44.0 | 43.96 | 58.70 | 58.64 | 58.67 | 58.2 | 58.07 | 58.135 |
| an | 45.525 | 45.555 | | 64.155 | 59.65 | | 68.71 | 68.66 | | 40.835 | 40.9 | | 52.85 | 52.87 | | 63.005 | 62.93 | |
| | 45.540 | | | 61.902 | | | 68.685 | | | 40.867 | | | 52.860 | | | 62.968 | | |

| M | 1991 | S | | 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 59.473 | 59.453 | 59.463 | 50.853 | 53.607 | 52.230 |
| SCB | 56.423 | 59.487 | 57.955 | 50.897 | 53.570 | 52.233 |
| Mean | 57.948 | 59.470 | | 50.875 | 53.588 | |

**L.S.D.**

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 3.824 | 5.198 | 0.266 | 0.361 |
| R : | N.S. | N.S. | 0.217 | 0.295 |
| M : | N.S. | N.S. | N.S. | N.S. |
| SR : | 5.409 | 7.351 | 0.376 | 0.511 |
| SM : | N.S. | N.S. | N.S. | N.S. |
| MR : | N.S. | N.S. | N.S. | N.S. |
| SMR : | N.S. | N.S. | N.S. | N.S. |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

sulphate > ammonium nitrate. The supperiority of urea was found to be corresponding to the minimum values of the average leaves number/plant indicating that such behaviour may be attributed to the increase of leaf area at the expense of the number of leaves produced/plant.

The effect of nitrogen rate on leaf area was not significant in the first season, but it was significant in the second one. Increasing N rate from 33 kg/fed to 66 kg/fed resulted in an increase in leaf area when the plants were supplied with ammonium nitrate in both seasons. At the same time in the second season, the leaf area of plants treated with 66 kgN as ammonium sulphate was increased by about 24.7% over those treated with 33 kgN/fed. Urea was the only nitrogen source that decreased the leaf area index when applied at the highest dose in both seasons. The leaf area was decreased with increasing the amount of urea by 6.7 and 14.3% in the first and second season, respectively.

Irrespective of the nitrogen source and rate, the analysis of variance for the obtained data of leaf area showed that the two adopted methods of application did not show any specific trend on the average leaf area/plant. This was true in the two growing seasons.

The performance of interaction showed that source by rate interaction was the only significant one in both seasons, and all the other interactions did not impose any significant trend in the two seasons. Such results were similar to those observed by Edje et al., (1975); Seiova and Posypanov, (1979); Zahran and El-Aishy, (1979); Lluch et al., (1983); Eisa, (1986); El-Gizy; (1990) and Helal, (1991).

### 1.2. Plant dry weight:

Data presented in table (12) revealed that N sources differed significantly in their effects on dry weight of plant in both growing seasons. The highest dry weight was obtained with ammonium nitrate and ammonium sulphate, but the lowest was recorded when nitrogen was applied as urea. This result may be attributed to the beneficial side effects of ammonium such as lowering the pH of the growing media.

Dry weight of plant increased significantly as N rate increased from 33 to 66 kgN/fed with all N sources in both seasons. Application of ammonium nitrate through surface continuous band (SCB) increased the dry weight by 20% compared with surface localized band (SLB) method. Such increase was reduced to about 7% in case of using ammonium sulphate and urea, in the first season. The same trend was obtained in 1992 season, the superiority of surface continuous band method was indicated over surface localized band method. The obtained transcendency effect of SCB-method on the plant dry weight may be attributed to the better distribution of nitrogen through the soil profile, or probably due to the adverse effects resulted from the accumulation of N salts in the rhizosphere zone as a result of localized band application. These results corporate the results of Fitts, (1955) in which a better distribution of ammonium nitrate and good crop response were obtained by applying ammonium nitrate in a side-dressing.

Regarding the effect of the interaction between the three variables, the analysis of varians showed that all possible interactions were significant in both seasons. The source by rate interaction was significant. Urea was the best nitrogen source when added at the rate of 66 kgN/fed, the concomitant

**Table (12):** Effect of nitrogen fertilization under submersion condition on plant dry weight (g) of *Phaseolus vulgaris* in 1991 and 1992 seasons.

| R | S 1991 | | | | | | | | | S 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 16.0 | 19.0 | 17.50 | 16.5 | 19.0 | 17.75 | 15.2 | 16.5 | 15.85 | 15.25 | 17.30 | 16.275 | 16.0 | 17.28 | 16.64 | 14.30 | 15.88 | 15.09 |
| $R_2$ | 16.5 | 20.0 | 18.25 | 18.00 | 18.00 | 18.00 | 18.0 | 19.0 | 18.50 | 15.80 | 18.85 | 17.325 | 16.70 | 16.80 | 16.75 | 16.65 | 17.45 | 17.05 |
| Mean | 16.25 | 19.50 | | 17.25 | 18.50 | | 16.60 | 17.75 | | 15.525 | 18.075 | | 16.350 | 17.040 | | 15.475 | 16.665 | |
| | 17.875 | | | 17.875 | | | 17.175 | | | 16.800 | | | 16.695 | | | 16.070 | | |

| M | S 1991 | | | S 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 15.900 | 17.500 | 16.700 | 15.183 | 16.383 | 15.783 |
| SCB | 18.167 | 19.00 | 18.583 | 16.820 | 17.700 | 17.260 |
| Mean | 17.033 | 18.250 | | 16.002 | 17.042 | |

**L.S.D.**

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 0.133 | 0.181 | 0.081 | 0.110 |
| R : | 0.109 | 0.148 | 0.066 | 0.090 |
| M : | 0.109 | 0.148 | 0.066 | 0.090 |
| SR : | 0.189 | 0.257 | 0.115 | 0.156 |
| SM : | 0.189 | 0.257 | 0.115 | 0.156 |
| MR : | 0.154 | 0.210 | 0.094 | 0.127 |
| SMR : | 0.267 | 0.363 | 0.162 | 0.221 |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

dry weight with that rate was 18.50 g/plant decreased to 15.85 g/plant with the first rate of urea (33 kgN/fed) where it became the least effective N source. Dry weight was increased slightly as ammonium nitrate and ammonium sulphate increased from the rate of 33 to 66 kgN/fed . The differences among the N sources were affected by N rate. At the first rate, appreciable differences were obtained in particular between urea and the other two sources. Such differences were minimized when the second rate was added. The method by rate interaction was significant in both seasons. The effect of N rates on dry weight varied with the method of application, in both seasons. The highest dry weight production/plant resulted from nitrogen addition at the rate of 66 kg/fed through the SCB-method.

The obtained results coincided with those of several invistigators who indicated that applied nitrogen stimulated the production of dry matter content of leguminous plants (Singh and Saxena 1973; Edje et al., 1975; Hashimota, 1977; Bassium, 1978; Graman et al., 1978; Zahran and El-Aishy, 1979; Leidi and Gomes, 1980; Osorio and Freire, 1982 ; Semu et al., 1982 and El-Masry, 1988). ***Phaseolus vulgaris*** plants treated with urea fertilizer had the lowest mean of dry weight/plant. These results are in harmony with the findings of Bezdicek et al., (1974), on soybean and Nathan et al., (1989), on ***Phaseolus vulgaris***.

The positive effects of nitrogen application on dry matter content of plant could be attributed to that nitrogen is known to have an increasing affect on the foliage of the green plants which is reflected in an increase in the photosynthetic area which is responsible for the accumulation of the dry matter in the plant.

## 2. Yielding ability:

### 2.1. Extra pods category:

The effect of N source, rate and method of application on yielding ability of Extra pods category is shown in table (13). Yield was affected significantly by the source of N in both growing seasons. The highest yield was recorded with ammonium nitrate form and the lowest yield was obtained with urea. Furthermore ammonium sulphate fertilizer application exhibited, in both seasons, promising results on Extra pods production. Finally, this effect can be arranged in the following order: ammonium nitrate > ammonium sulphate > urea.

Concerning the effect of rates, yield was increased as the rate of N application increased. Fertilizing with 66 kgN/fed increased the yield of Extra pods over the lower rate except with urea, the yield was decreased by increasing the rate. This was true in both seasons.

The influence of methods of application was significant. Surface continuous band was the best method as compared with the surface localized band. The two-ways interactions were significant, as well as the three-ways in both seasons. The source by rate interacton was highly significant in both seasons. The yield was increased dramaticaly with addition of ammonium nitrate at the rate of 66 kgN/fed compared with the addition of 33 kgN/fed in both seasons. Also, ammonium sulphate behaved similar to ammonium nitrate, yield was increased with increasing the amount of ammonium sulphate added. In contrast, using high quantities of urea to provide the 66 kgN/fed resulted in a sharp decrease in yielding ability of Extra pods category. The superiority of ammonium nitrate may be because the growth of plants is often improved when the plants are nourished with both $NO_3$ and $NH_4$ rather than with either $NO_3$ or $NH_4$ singly.

**Table (13):** Effect of nitrogen fertilization under submersion condition on Extra pods category (kg/fed) of ***Phaseolus vulgaris*** in 1991 and 1992 seasons.

| R | S: 1991 | | | | | | | | | S: 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 342 | 636 | 489 | 316 | 441 | 378.5 | 270 | 305 | 287.5 | 390 | 600 | 495 | 300 | 465 | 382.5 | 245 | 260 | 252.50 |
| $R_2$ | 503 | 831 | 667 | 410 | 467 | 438.5 | 160 | 185 | 172.5 | 530 | 780 | 655 | 430 | 480 | 455 | 105 | 115 | 110.00 |
| Mean | 422.5 | 733.5 | | 363 | 454 | | 215 | 245 | | 460 | 690 | | 365 | 472.5 | | 175 | 187.5 | |
| | 578.00 | | | 408.5 | | | 230.00 | | | 575.000 | | | 418.750 | | | 181.250 | | |

| M | S: 1991 | | | S: 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 309.333 | 357.667 | 333.5 | 311.667 | 355.00 | 333.333 |
| SCB | 460.667 | 494.333 | 477.5 | 441.667 | 458.333 | 450.000 |
| Mean | 385 | 426 | | 376.667 | 406.667 | |

**L.S.D.**

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 4.857 | 6.602 | 4.691 | 6.376 |
| R : | 3.966 | 5.390 | 3.832 | 5.206 |
| M : | 3.966 | 5.390 | 3.832 | 5.206 |
| SR : | 6.869 | 9.337 | 6.634 | 9.017 |
| SM : | 6.869 | 9.337 | 6.634 | 9.017 |
| MR : | 5.609 | 7.623 | 5.417 | 7.363 |
| SMR : | 9.715 | 13.204 | 9.382 | 12.752 |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

The source by method interaction was significant in both seasons. The results revealed that surface continuous band was the most effective method and the differences in the yield production between the two methods were more pronounced with ammonium nitrate. The yielding ability was affected by the method by rate interaction. The highest yield were obtained from the plants received high dose of nitrogen added as surface continuous band.

**2.2. Fine pods category**

Results shown in table (14) proved that ammonium nitrate fertilizer was the most superior source, while ammonium sulphate and urea fertlizers had almost the same effect, where the values of yield were approximately similar with a slight superiority of urea to ammonium sulphate. This was true in both seasons. The effect of sources on Fine pods category followed the following order: ammonium nitrate > urea > ammonium sulphate. Following the yield of Fine pods as affected by the different N rates, revealed that higher significant values, in both seasons, were concomitant with the highest level of applied nitrogen except with urea where high dose of nitrogen significantly retarded the pod production. The surface continuous band method still superior as it was with the above mentioned parameters.

The interactions were significant in both seasons. The source by rate interaction was significant except with ammonium sulphate source and rate, the difference was not significant. The Fine pods category increased from 1162.5 kg/fed to 1601 kg/fed with increasing ammonium nitrate rate. This relation between source and rate was not constant with other N sources. Increasing the rate of ammonium sulphate resulted in a slight decrease in yield. However, the yield was decreased from 1164.5 kg/fed to 979.5 kg/fed

**Table (14): Effect of nitrogen fertilization under submersion condition on Fine pods category (kg/fed) of *Phaseolus vulgaris* in 1991 and 1992 seasons.**

| R | 1991 AN SLB | 1991 AN SCB | 1991 AN Mean | 1991 AS SLB | 1991 AS SCB | 1991 AS Mean | 1991 U SLB | 1991 U SCB | 1991 U Mean | 1992 AN SLB | 1992 AN SCB | 1992 AN Mean | 1992 AS SLB | 1992 AS SCB | 1992 AS Mean | 1992 U SLB | 1992 U SCB | 1992 U Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $R_1$ | 1025 | 1300 | 1162.5 | 888 | 1087 | 987.5 | 1020 | 1309 | 1164.5 | 990 | 1210 | 1100 | 910 | 1130 | 1020 | 1000 | 1330 | 1165 |
| $R_2$ | 1280 | 922 | 1601 | 932 | 1036 | 984 | 860 | 1099 | 979.5 | 1150 | 1885 | 1517.5 | 945 | 1150 | 1047.5 | 850 | 1120 | 985 |
| Mean | 1152.5 | 1611 | | 910 | 1061.5 | | 940 | 1204 | | 1070 | 1547.5 | | 927.5 | 1140 | | 925 | 1225 | |
| Mean | 1381.750 | | | 985.750 | | | 1072.000 | | | 1308.750 | | | 1033.750 | | | 1075.000 | | |

| M | 1991 $R_1$ | 1991 $R_2$ | 1991 Mean | 1992 $R_1$ | 1992 $R_2$ | 1992 Mean |
|---|---|---|---|---|---|---|
| SLB | 977.667 | 1024 | 1000.833 | 966.667 | 981.667 | 974.167 |
| SCB | 1232 | 1352.333 | 1292.167 | 1223.333 | 1385 | 1304.167 |
| Mean | 1104.833 | 1188.167 | | 1095 | 1183.333 | |

**L.S.D.**

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 3.826 | 5.201 | 3.917 | 5.324 |
| R : | 3.124 | 4.247 | 3.198 | 4.347 |
| M : | 3.124 | 4.247 | 3.198 | 4.347 |
| SR : | 5.412 | 7.355 | 5.539 | 7.529 |
| SM : | 5.412 | 7.355 | 4.523 | 6.148 |
| MR : | 4.418 | 6.006 | 4.523 | 6.148 |
| SMR : | 7.653 | 10.402 | 7.834 | 10.648 |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

with increasing the rate of urea. Urea was the best N source when applied at the low rate, but it was the most inferior source when applied at the high dose. The determintal effect of the high rate may be due to the phytotoxicity of urea to seedling due to locally high concentration of ammonium released during the hydrolysis stage and/or the accumulation of nitrite during nitrification process.

### 2.3. Bobby pods category:

The influence of N source, rate and method of application on the production of Bobby pods category is shown in table (15). The nitrogen fertilizers applied generally increased the production of Bobby pods category in both growing seasons in the following order: ammonium sulphate > urea > ammonium nitrate. Regarding the effect of the N rate, the yield of Bobby pods tended to increase somewhat with the rate of N added. As obtained before, the surface continuous band method was superior to the surface localized band application.

The source by rate interaction was significant in both seasons (Table 15). There was a significant decrease in the yield of Bobby pods as a result of increasing the rate of ammonium sulphate and ammonium nitrate from 33 to 66 kg N/feddan. However, the yield was increased sharply with increasing the rate of urea. Similar effects of ammnium nitrate and urea on the yield of Bobby pods were obtained in the second growing seasons, but increasing the rate of ammonium sulphate from 33 to 66 kgN/fed increased the production of Bobby pods.

**Table (15): Effect of nitrogen fertilization under submersion condition on Bobby pods category (kg/fed) of *Phaseolus vulgaris* in 1991 and 1992 seasons.**

| R | S: 1991 | | | | | | | | | S: 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 1818 | 2464 | 21411 | 2422 | 2690 | 2556 | 1764 | 2167 | 1965.5 | 1700 | 2250 | 1975 | 2200 | 2500 | 2350 | 1800 | 2000 | 1900 |
| $R_2$ | 1622 | 2259 | 1940.5 | 2616 | 2300 | 2458 | 2580 | 2985 | 2782.5 | 1600 | 2170 | 1885 | 2510 | 2530 | 2520 | 2610 | 2770 | 2690 |
| Mean | 1720 | 2361.5 | | 2519 | 2495 | | 2172 | 2576 | | 1650 | 2210 | | 2355 | 2515 | | 2205 | 2385 | |
| | 2040.750 | | | 2507.00 | | | 2374.00 | | | 1930 | | | 2435 | | | 2295 | | |

| M | S: 1991 | | | S: 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 2001.333 | 2272.667 | 2137 | 1900 | 2240 | 2070 |
| SCB | 2440.333 | 2514.667 | 2477.5 | 2250 | 2490 | 2370 |
| Mean | 2220.833 | 2393.667 | | 2075 | 2365 | |

**L.S.D.**

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 4.700 | 6.388 | 4.573 | 6.216 |
| R : | 3.837 | 5.216 | 3.734 | 5.075 |
| M : | 3.837 | 5.216 | 3.734 | 5.075 |
| SR : | 6.647 | 9.034 | 6.468 | 8.791 |
| SM : | 6.647 | 9.034 | 6.468 | 8.791 |
| MR : | 5.427 | 7.376 | 5.281 | 7.178 |
| SMR : | 9.400 | 12.776 | 9.147 | 12.432 |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

The effect of nitrogen source on the yield of Bobby category was affected significantly by the method of application as indicated by the signifcancy of the source by method interaction. The most effective sources were urea and ammonium sulphate in the first and second season, respectively particularly when applied as a surface continuous band as compared with the surface localized band and the less effective one was ammonium nitrate when applied as localized band in both growing seasons. Both urea and ammonium nitrate were effective when applied as a surface continuous band, however, the effect of ammonium sulphate was enhanced when applied as a surface localized band, especially in the first growing season. The highest value of Bobby pods category was associated with urea especially when applied at 66 kgN/fed through the surface continuous band and the lowest one was accompanied with ammonium nitrate when applied at 66 kgN/fed as a surface localized band. This was true in both seasons.

Regarding the method by rate interaction (Table 15), the highest yield was achieved with applying nitrogen at the second rate as a surface continuous band and the lowest was concomitant to the first rate as a surface localized band. The two-way interactions between variables were significant in the first growing season. However, no significant interaction was found in the second one except the source by method interaction.

In general, the results indicated that urea was the least effective nitrogen source on both commercial (sum of Extra and Fine pods yield) and total (sum of Extra, Fine and Bobby pods yield) yield. This could be easily realized by refering to the corresponding exportable and total yield values in tables 13, 14 and 15. The observed inferiority of urea may be due to the improper surface application in the field, which leads to a great loss of ammonia through ammonia volatilization process. Balba (1964) found that the formation of $(NH_4)_2\ CO_3$ is accompanied with corresponding increase in the pH of the urea-soil system. The existence of high alkalinity after the application of urea is not favourable to the microorganisms which change $NH_4$ to $NO_2$ , and then to $NO_3$. Accordingly, $NO_2$ may tend to accumulate in a toxic level to plant. The reasons for superiorty of surface continuous band method were previously discussed.

The increase in yield of pods due to the application of nitrogen fertilizer could be interpreted with the fact that nitrogen has a prominent role in increasing the photosynthetic area and the vegetative growth of the plant. This might be reflected on increasing the productive growth and in turn the number of pods per plant. Such data are in harmony with those of many investigators who indicated that applicaton of nitrogen increased yield of ***Phaseolus vulgars*** plant (Edje et al., 1975; Doss et al., 1977; Cyril, 1977; Santos et al., 1979; Feitosa et al., 1980; Mullins et al., 1980; Cunha et al., 1980; Hera et al., 1985; Gligorevic, 1986; Nathan et al., 1989 and El-Gizy, 1990). On the other hand, nitrogen application had no effect on yield of legume plants as reporte by Kassem et al., (1977), on broad bean; Barni et al., (1978), on soybean and Ssali and Keya (1985), on common bean.

**3. Physical and chemical characteristics of pods:**

**3.1. Physical characteristics of pods:**

**3.1.1. Pod length:**

**3.1.1.1. Extra pods category:**

As indicated in table (16) the pod length of Extra grade was influenced by N-sources. The lowest average length of pod was recorded when nitrogen was applied in the form of ammonium nitrate with significant difference compare to the other two sources (ammonium sulphate and urea) which significantly did not exhibit any difference compared to each other, in both seasons. On the other hand, statstical comparison indicated that the pod length was not affected significantly by N-rate, in the two growing seasons.

With regard to the main effects of the two adopted methods of N-application on pod length, the obtained results revealed that the surface localized band was superior to the surface continuous band.

The interaction study showed that source by method was the only one that affected the length of Extra pods in both growing seasons, and all the other interactions did not exert statistical effect at the 0.05 probability level on this character in the second season.

### 3.1.1.2. Fine pods category:

Concerning the Fine grade, results shown in table (17) indicated that the least values of length trait were obtained by ammonium sulphate application with significant difference compared to the other two sources which significantly did not exert any difference compared to each other, in both seasons. Moreover, it was observed that N-rates did not induce any significant effect on average length of Fine category, in both seasons.

The length of Fine pods was affecte significantly by the method of application, especially in the first season. Such effect was not obvious in the second one. Furthermore, the surface localized method gave a relatively high effect on length trait for both Extra and Fine pods, in the two growing seasons.

**Table (16): Effect of nitrogen fertilization under submersion condition on pod length of Extra category (mm) of *Phaseolus vulgaris* in 1991 and 1992 seasons.**

| R | 1991 | | | | | | | | | 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | | | | | | | | | | | | | | | | | |
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 9.0 | 10.00 | 9.50 | 10.0 | 9.0 | 9.5 | 10.5 | 10.0 | 10.25 | 10.0 | 9.8 | 9.9 | 10.25 | 10.00 | 10.125 | 10.00 | 10.25 | 10.125 |
| $R_2$ | 10.5 | 9.0 | 9.75 | 10.0 | 10.5 | 10.25 | 10.0 | 9.0 | 9.50 | 10.2 | 9.8 | 10.0 | 10.00 | 10.30 | 10.15 | 10.00 | 10.00 | 10.00 |
| Mean | 9.75 | 9.50 | | 10.00 | 9.75 | | 10.25 | 9.5 | | 10.10 | 9.8 | | 10.125 | 10.15 | | 10.00 | 10.125 | |
| | 9.625 | | | 9.875 | | | 9.875 | | | 9.950 | | | 10.138 | | | 10.063 | | |

| M | 1991 | S | | 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 9.833 | 10.167 | 10.000 | 10.083 | 10.067 | 10.075 |
| SCB | 9.667 | 9.500 | 9.583 | 10.017 | 10.033 | 10.025 |
| Mean | 9.750 | 9.833 | | 10.05 | 10.05 | |

**L.S.D.**

| | | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|---|
| S | : | 0.138 | 0.188 | 0.092 | 0.126 |
| R | : | N.S. | N.S. | N.S. | N.S. |
| M | : | 0.113 | 0.153 | N.S. | N.S. |
| SR | : | 0.196 | 0.266 | N.S. | N.S. |
| SM | : | 0.196 | 0.266 | 0.131 | N.S. |
| MR | : | 0.160 | 0.217 | N.S. | N.S. |
| SMR | : | 0.277 | 0.376 | 0.184 | 0.251 |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

All the interaction effects did not impose any significant trend in both seasons except source by method and source by method by rate which showed significant effects in both the first and second seasons. The length of pods tended to decrease with adding the second rate of ammonium nitrate and ammonium sulphate compared with the first rate of both fertilizers. This trend was not the same with urea, a slight increase in pod length occured with using the second rate of urea especially in the first season.

**3.1.2. Pod diameter:**

**3.1.2.1. Extra pods category:**

Data recorded in table (18) show that, pod diameter was affected significantly by nitrogen sources. The effect of N fertilizers on pod diameter followed the order: ammonium nitrate > ammonium sulphate > urea. Such trend was also obtained in the second season.

As indicated with the previously discussed parameters, ammonium nitrate was the most superior N source and urea was the most inferor one. The superiority of ammonium nitrate may be because it is readily available to plants as soon as it dissolves in the soils solution. In addition because it contains nitrogen in both the nitrate and ammoniacal forms.

The results corroborate the results of Bezdicek et al., (1974), on soybean and Nathan et al., (1989), on ***Phaseolus vulgaris***, who found that ammonium nitrate was better than urea and gave significant increases in yield properties.

**Table (18): Effect of nitrogen fertilization under submersion condition on pod diameter of Extra category (mm) of *Phaseolus vulgaris* in 1991 and 1992 seasons.**

| R | S: 1991 | | | | | | | | | S: 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 6.2 | 6.2 | 6.20 | 5.7 | 5.7 | 5.70 | 5.8 | 6.0 | 5.90 | 6.5 | 6.3 | 6.40 | 6.0 | 5.8 | 5.90 | 5.6 | 5.6 | 5.60 |
| $R_2$ | 7.3 | 7.1 | 7.20 | 7.3 | 7.2 | 7.25 | 6.5 | 6.7 | 6.60 | 7.2 | 7.3 | 7.25 | 7.00 | 7.00 | 7.00 | 6.8 | 6.70 | 6.75 |
| Mean | 6.75 | 6.65 | | 6.50 | 6.45 | | 6.15 | 6.35 | | 6.85 | 6.80 | | 6.50 | 6.4 | | 6.20 | 6.15 | |
| Mean | 6.700 | | | 6.475 | | | 6.250 | | | 6.825 | | | 6.450 | | | 6.175 | | |

| M | S: 1991 | | | S: 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 5.900 | 7.033 | 6.467 | 6.033 | 7.000 | 6.517 |
| SCB | 5.967 | 7.00 | 6.483 | 5.900 | 7.000 | 6.450 |
| Mean | 5.933 | 7.017 | | 5.967 | 7.000 | |

**L.S.D.**

| | | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|---|
| S | : | 0.106 | 0.145 | 0.116 | 0.159 |
| R | : | 0.087 | 0.118 | 0.095 | 0.129 |
| M | : | N.S. | N.S. | N.S. | N.S. |
| SR | : | 0.151 | 0.205 | 0.164 | N.S. |
| SM | : | N.S. | N.S. | N.S. | N.S. |
| MR | : | N.S. | N.S. | N.S. | N.S. |
| SMR | : | N.S. | N.S. | N.S. | N.S. |

S: Source
AN : Ammonium nitrate
AS : Ammonium sulphate
U : Urea

R: Rate
$R_1$ : 33 kgN/feddan
$R_2$ : 66 kgN/feddan

M: Method
SLB : Surface localized band
SCB : Surface continuous band

In both growing seasons, pod diameter was increased significantly as N rate increased from 33 to 66 kgN/feddan. The effect of the methods of application was not significant in 1991 and 1992 seasons.

The only significant interaction in both seasons was the source by rate. The most effective N source when applied at the first level was ammonium nitrate followed by urea, whereas ammonium sulphate was the least effective one (1991 season). In 1992 season, the order was ammonium nitrate followed by ammonium sulphate and urea. At the second rate, ammonium nitrate and ammonium sulphate were the best N sources, while urea was inferior. This was true in both seasons.

**3.1.2.2. Fine pods category:**

With respect to Fine category, results shown in table (19) indicated that this character (pod diameter) exerted significant response for source and rate of the applied nitrogen fertiizers. ***Phaseolus vulgaris*** plants fertilized with ammonium nitrate had the highest pod diameter, followed by those treated with urea while the least values were obtained when nitrogen was applied in the form of ammonium sulphate.

Stimulation in diameter trait was clearly observed with increasing the rate of nitrogen. This response was significant in all treatments during both seasons. On the other hand, no significant effect was recorded due to methods of application in both seasons.

All the interaction effects between the three variables were insignificant in both seasons except method by rate interaction which imposed significancy at the 0.05 probability level, only in the second season..

Table (19): Effect of nitrogen fertilization under submersion condition on pod diameter of Fine category (mm) of *Phaseolus vulgaris* in 1991 and 1992 seasons.

| R | S | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1991 | | | | | | | | | 1992 | | | | | | | | |
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 7.8 | 7.8 | 7.8 | 7.4 | 7.4 | 7.4 | 7.5 | 7.7 | 7.6 | 8.0 | 7.8 | 7.90 | 7.4 | 7.4 | 7.40 | 7.6 | 7.5 | 7.55 |
| $R_2$ | 8.3 | 8.1 | 8.2 | 7.7 | 7.5 | 7.6 | 8.0 | 8.0 | 8.0 | 8.3 | 8.3 | 8.30 | 7.6 | 7.7 | 7.65 | 7.8 | 8.0 | 7.90 |
| Mean | 8.05 | 7.95 | | 7.55 | 7.45 | | 7.75 | 7.85 | | 8.15 | 8.05 | | 7.50 | 7.55 | | 7.70 | 7.75 | |
| | 8.00 | | | 7.50 | | | 7.80 | | | 8.100 | | | 7.525 | | | 7.725 | | |

| M | S | | | | | |
|---|---|---|---|---|---|---|
| | 1991 | | | 1992 | | |
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 7.567 | 8.00 | 7.783 | 7.667 | 7.900 | 7.783 |
| SCB | 7.633 | 7.867 | 7.750 | 7.567 | 8.000 | 7.783 |
| Mean | 7.600 | 7.933 | | 7.617 | 7.950 | |

L.S.D.

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 0.124 | 0.169 | 0.103 | 0.140 |
| R : | 0.101 | 0.138 | 0.084 | 0.114 |
| M : | N.S. | N.S. | N.S. | N.S. |
| SR : | N.S. | N.S. | N.S. | N.S. |
| SM : | N.S. | N.S. | N.S. | N.S. |
| MR : | N.S. | N.S. | 0.119 | N.S. |
| SMR : | N.S. | N.S. | N.S. | N.S. |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

### 3.1.3. Pod dry weight:

#### 3.1.3.1. Extra pods category:

The data presented in table (20) show the influence of source and rate of N fertilizer with the two adopted methods of application on dry matter percentage of Extra pods in 1991 and 1992 seasons. Application of ammonium nitrate fertilizer produced promising results on this character with significant difference, in both seasons, compared to the other two sources which did not exhibit any significant difference between them in the first season, whereas significant difference was obtained between ammonium sulphate and urea in the second season.

Increasing the dose of applied N from 33 to 66 kg N/fed was accompanied by a limited increase of about 7.5% in dry matter content of Extra category in both seasons. Significant increases in dry weight were found to be corresponding to the increase values of dry weight of the whole plant, which averaged 6.8% in both seasons (Table 12).

With regard to the effect of applicaton methods, pod dry weight was not affected significantly by the method of application during the two growing seasons.

The performance of interaction showed that source by rate was the only interaction that influenced pod dry weight in both seasons. The dry weight of Extra pods tended to increase somewhat with increasng N rate, the highest dry weight values were obtained with adding ammonium nitrate at the first and the second rates as compared to ammonium sulphate and urea. No significant effect on this character was recorded due to the interaction of source by method, in the first season, whereas high significant effect was obtained in the second season. Furthermore, the method by rate interaction

Table (20): Effect of nitrogen fertilization under submersion condition on pod dry weight of Extra category (%) of ***Phaseolus vulgaris*** in 1991 and 1992 seasons.

| R | S: 1991 | | | | | | | | | S: 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 14.50 | 14.53 | 14.515 | 14.03 | 14.11 | 14.07 | 14.23 | 14.35 | 14.29 | 12.71 | 12.68 | 12.695 | 12.53 | 12.60 | 12.565 | 12.14 | 12.08 | 12.110 |
| $R_2$ | 16.34 | 16.26 | 16.30 | 14.98 | 15.07 | 15.025 | 14.80 | 14.70 | 14.75 | 14.44 | 14.51 | 14.475 | 13.00 | 13.12 | 13.060 | 12.62 | 12.55 | 12.585 |
| Mean | 15.420 | 15.395 | | 14.505 | 14.590 | | 14.515 | 14.525 | | 13.575 | 13.595 | | 12.765 | 12.860 | | 12.380 | 12.315 | |
| | 15.408 | | | 14.548 | | | 14.520 | | | 13.585 | | | 12.813 | | | 12.348 | | |

| M | S: 1991 | | | S: 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 14.253 | 15.373 | 14.813 | 12.460 | 13.353 | 12.907 |
| SCB | 14.330 | 15.343 | 14.837 | 12.453 | 13.393 | 12.923 |
| Mean | 14.292 | 15.358 | | 12.457 | 13.373 | |

L.S.D.

| | (1991) 5% | (1991) 1% | (1992) 1% | (1992) 1% |
|---|---|---|---|---|
| S : | 0.055 | 0.075 | 0.039 | 0.053 |
| R : | 0.045 | 0.061 | 0.032 | 0.043 |
| M : | N.S. | N.S. | N.S. | N.S. |
| SR : | 0.075 | 0.106 | 0.055 | 0.075 |
| SM : | N.S. | N.S. | 0.055 | 0.075 |
| MR : | 0.064 | N.S. | N.S. | N.S. |
| SMR : | N.S. | N.S. | N.S. | N.S. |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

exerted statistical significant effects at the 0.05 probablity level only in the first season.

### 3.1.3.2. Fine pods category:

The results shown in table (21) revealed that this trait exhibited significant response to the source and rate of N fertilizers. The most effective N source on dry weight of pods was ammonium nitrate. The superiority of ammonium nitrate to ammonium sulphate and urea may be because the plants which contain less carbohydrates, such as peas and vetches utilize nitrate only when $CaCO_3$ is present, whereas barely, maize and pumpkins which are relatively rich in carbohydrates utilize ammonia (Russell, 1973). The obtained data coincide with many investigators who indicated that ***Phaseolus vulgaris*** plants grown on ammonium nitrate were higher in dry matter compared with those received ammonium sulphate or urea (Timpo, 1983 and Nathan et al., 1989). Also, there were significant differences among the N rates on this trait. Generally, dry weight of Fine pods gave the same trend as the Extra pods, exhibiting a positive response with increasing the nitrogen dose from 33 to 66 kg/feddan. On the other hand, the results showed no marked differences in percentage of the dry weight as affected by the methods of application in both seasons.

The dry weight of Fine pods was affected significantly by the source by rate interaction in both seasons, and all the other interactions did not impose any significant trend. Increasing the aplication rate of ammonium nitrate and urea from 33 to 66 kg N/fed resulted in an increase in the dry weight of Fine pods, whereas the dry weight tended to decrease with increasing ammonium sulphate.

From the prementioned results, it is worthy to note that, increasing the diameter of pod from Extra grade to Fine grade resulted in an average drop

Table (21): Effect of nitrogen fertilization under submersion condition on pod dry weight of Fine category (%) of *Phaseolus vulgaris* in 1991 and 1992 seasons.

| R | S: 1991 | | | | | | | | | S: 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M: SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | M: SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 8.38 | 8.25 | 8.315 | 8.18 | 8.20 | 8.190 | 8.28 | 8.35 | 8.315 | 7.20 | 7.35 | 7.275 | 7.25 | 7.30 | 7.275 | 7.00 | 7.07 | 7.035 |
| $R_2$ | 8.71 | 8.73 | 8.720 | 8.17 | 8.14 | 8.155 | 8.50 | 8.46 | 8.480 | 7.65 | 7.70 | 7.675 | 7.04 | 7.00 | 7.020 | 7.45 | 7.50 | 7.475 |
| Mean | 8.545 | 8.490 | | 8.175 | 8.170 | | 8.390 | 8.405 | | 7.425 | 7.525 | | 7.145 | 7.150 | | 7.225 | 7.285 | |
| | 8.518 | | | 8.173 | | | 8.398 | | | 7.475 | | | 7.147 | | | 7.255 | | |

| M | S: 1991 | | | S: 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 8.280 | 8.460 | 8.370 | 7.15 | 7.38 | 7.265 |
| SCB | 8.267 | 8.443 | 8.355 | 7.240 | 7.40 | 7.320 |
| Mean | 8.273 | 8.452 | | 7.195 | 7.390 | |

L.S.D.

| | (1991) 5% | (1991) 1% | (1992) 1% | (1992) 1% |
|---|---|---|---|---|
| S : | 0.053 | 0.073 | 0.101 | 0.137 |
| R : | 0.044 | 0.059 | 0.082 | 0.112 |
| M : | N.S. | N.S. | N.S. | N.S. |
| SR : | 0.075 | 0.102 | 0.142 | 0.193 |
| SM : | N.S. | N.S. | N.S. | N.S. |
| MR : | N.S. | N.S. | N.S. | N.S. |
| SMR : | N.S. | N.S. | N.S. | N.S. |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

in dry weight of Fine pods category by about 43% in both seasons. This result could be attributed to the variation in the content of moisture between the two grades.

### 3.2. Chemical characteristics of pods:

#### 3.2.1. Fibers content:

##### 3.2.1.1. Extra pods category:

Data of the fibers content in Extra pods throughout the two growing seasons as affected by the different N fertilization systems (Table 22) revealed that Extra grade pods had the least fibers content which ranged from 0.01 to 0.04%.

Neither nitrogen source and rate nor method of application had a marked effect on fibers content in Extra pods indicating that this category is free from fibers. In this connection, all the interaction effects did not show any significant difference in both growing seasons.

##### 3.2.1.2. Fine pods category:

Results of the fibers content of the Fine marketable pods are presented in table (23). It is worthy to note that fibers content was affected significantly by the N source, rate and the method of application in 1991 and 1992 seasons. In general, the highest content was associated with ammonium sulphate in both seasons followed by urea and the lowest value was recorded with ammonium nitrate. Plants treated with ammonium nitrate contained less fibers comparing with those fertilized with ammonium sulphate and urea. As fibers consist of cellelose and hemicellelose, the results are in agreement with those of Tisdale et al., (1985) who reported that amide-nitrogen (especially asparagine), amino nitrogen, total carbohydrates, soluble organic nitrogen and protein contents may be increased in plants supplied with $NH_4$.

**Table (22): Effect of nitrogen fertilization under submersion condition on pod fibers content of Extra category (%) of *Phaseolus vulgaris* in 1991 and 1992 seasons.**

| R | S: 1991 | | | | | | | | | S: 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.014 | 0.013 | 0.013 | 0.037 | 0.036 | 0.037 | 0.041 | 0.040 | 0.041 | 0.036 | 0.038 | 0.037 |
| $R_2$ | 0.013 | 0.012 | 0.012 | 0.012 | 0.013 | 0.012 | 0.013 | 0.013 | 0.013 | 0.030 | 0.031 | 0.031 | 0.035 | 0.034 | 0.035 | 0.027 | 0.031 | 0.029 |
| Mean | 0.013 | 0.013 | | 0.013 | 0.013 | | 0.013 | 0.013 | | 0.034 | 0.034 | | 0.038 | 0.037 | | 0.032 | 0.035 | |
| Mean | 0.013 | | | 0.013 | | | 0.013 | | | 0.034 | | | 0.038 | | | 0.033 | | |

| M | S: 1991 $R_1$ | 1991 $R_2$ | 1991 Mean | S: 1992 $R_1$ | 1992 $R_2$ | 1992 Mean |
|---|---|---|---|---|---|---|
| SLB | 0.013 | 0.013 | 0.013 | 0.038 | 0.031 | 0.035 |
| SCB | 0.013 | 0.013 | 0.013 | 0.038 | 0.032 | 0.035 |
| Mean | 0.013 | 0.013 | | 0.038 | 0.032 | |

**L.S.D.**

| | (1991) 5% | (1991) 5% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | N.S. | N.S. | N.S. | N.S. |
| R : | N.S. | N.S. | N.S. | N.S. |
| M : | N.S. | N.S. | N.S. | N.S. |
| SR : | N.S. | N.S. | N.S. | N.S. |
| SM : | N.S. | N.S. | N.S. | N.S. |
| MR : | N.S. | N.S. | N.S. | N.S. |
| SMR : | N.S. | N.S. | N.S. | N.S. |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

Regardless of N source, increasing the N rate from 33 to 66 kgN/fed decreased the content of fibers by 3.7 and 16.9% in 1991 and 1992 seasons, respectively. Fibers content was also affected significantly by the application method. The content was increased significantly when N fertilizers were added in surface localized band compared to the surface continuous band.

Concerning the interaction effects, the two way interactions as well as the three way interactions were significant in both seasons. Fibers content decreased significantly with increasing N rate with all N fertilizers. The highest fibers content was accompanied with the first rate of urea (4.56 and 5.63% in 1991 and 1992 seasons, respectively). However, with the second rate of N, the highest fibers content was recorded with ammonium sulphate (4.46 and 5.05% in 1991 and 1992 seasons, respectively). The results of source by rate interaction revealed that the effect of N source was affected by N rate, i.e., the highest fibers content was obtained with the first rate of urea and the second rate of ammonium sulphate. Regarding the significant source by method interaction, the least fibers content was obtained with ammonium nitrate when applied in a surface continuous band, while the highest content was achieved with ammonium sulphate and the surface localized band method.

Since the fibers content is not a desirable character so the inferiority of ammonium nitrate source, second rate of application and the surface continuous band method are considered to be advantageous. It could be concluded that ammonium nitrate and surface continuous band are still the best N source and method of application, respectively.

Table (23): Effect of nitrogen fertilization under submersion condition on pod fibers content of Fine category (%) of ***Phaseolus vulgaris*** in 1991 and 1992 seasons.

| R | S: 1991 | | | | | | | | | S: 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 4.70 | 4.04 | 4.370 | 4.62 | 4.43 | 4.525 | 4.66 | 4.45 | 4.555 | 5.303 | 5.225 | 5.264 | 5.405 | 5.300 | 5.353 | 5.810 | 5.450 | 5.630 |
| $R_2$ | 4.52 | 3.93 | 4.225 | 4.63 | 4.28 | 4.455 | 4.43 | 4.11 | 4.270 | 4.172 | 4.005 | 4.089 | 5.103 | 5.00 | 5.052 | 4.525 | 4.205 | 4.365 |
| Mean | 4.610 | 3.985 | | 4.625 | 4.355 | | 4.545 | 4.280 | | 4.738 | 4.615 | | 5.254 | 5.150 | | 5.168 | 4.828 | |
| | 4.297 | | | 4.490 | | | 4.412 | | | 4.676 | | | 5.202 | | | 4.998 | | |

| M | S: 1991 | | | S: 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 4.660 | 4.527 | 4.593 | 5.506 | 4.600 | 5.053 |
| SCB | 4.307 | 4.107 | 4.207 | 5.325 | 4.403 | 4.864 |
| Mean | 4.483 | 4.317 | | 5.416 | 4.502 | |

**L.S.D.**

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 0.040 | 0.055 | 0.008 | 0.011 |
| R : | 0.033 | 0.045 | 0.006 | 0.009 |
| M : | 0.033 | 0.045 | 0.006 | 0.009 |
| SR : | 0.057 | 0.077 | 0.011 | 0.016 |
| SM : | 0.057 | 0.077 | 0.011 | 0.016 |
| MR : | 0.046 | 0.063 | 0.009 | 0.013 |
| SMR : | 0.080 | 0.109 | 0.016 | 0.022 |

S: Source
- **AN : Ammonium nitrate**
- **AS : Ammonium sulphate**
- **U : Urea**

R: Rate
- **$R_1$ : 33 kgN/feddan**
- **$R_2$ : 66 kgN/feddan**

M: Method
- **SLB : Surface localized band**
- **SCB : Surface continuous band**

### 3.2.1.3. Bobby pods category:

Table (24) represents the results of fibers content in Bobby category as affected by N source, rate and method of application. The obtained results revealed that the highest values of fibers in both seasons were accompanied with the application of ammonium sulphate, while the least values were found with ammonium nitrate application. There was a clear difference between the effects of N rates. Increasing N dose from 33 to 66 kgN/fed resulted in a decrease in the content by 19.4 and 9.7%, in the first and second seasons, respectively. The fibers content was not affected significantly by the method of application in both growing seasons.

With regard to the interactions, all the interactions were significant in the first season only except the source by rate interaction which was significant in the two growing seasons. Results of source by rate interaction showed a sharp decrease in fibers content with increasing N rate. The effect of N sources applied at the first rate on the content of fibers, in both seasons, followed this order: ammonium sulphate > urea > ammonium nitrate. While with the second rate of application, the order was ammonium sulphate > ammonium nitrate > urea only in the first season. The highest reduction in fibers content resulted from increasing N rate, was recorded with urea and ammonium sulphate in the first and second seasons, respectively. The effect of rate tended to be independent of the effect of source and increasing N rate decreased the fibers content. Refering to the source by method interaction, adding ammonium nitrate or urea the two methods did not differ significantly in their effects on fibers content, but applying ammonium sulphate a significant difference between the two method was found.

**Table (24): Effect of nitrogen fertilization under submersion condition on pod fibers content of Bobby category (%) of *Phaseolus vulgaris* in 1991 and 1992 seasons.**

| R | S: 1991 | | | | | | | | | S: 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 48.33 | 49.00 | 48.665 | 60.00 | 58.88 | 59.44 | 54.10 | 53.85 | 53.975 | 32.107 | 32.00 | 32.053 | 38.509 | 38.474 | 38.491 | 35.00 | 35.00 | 35.00 |
| $R_2$ | 41.10 | 40.75 | 40.925 | 48.80 | 48.80 | 48.800 | 40.60 | 41.14 | 40.870 | 30.005 | 29.871 | 29.938 | 33.207 | 33.257 | 33.232 | 32.205 | 32.107 | 32.156 |
| Mean | 44.715 | 44.875 | | 54.400 | 53.840 | | 47.350 | 47.495 | | 31.056 | 30.936 | | 35.858 | 35.866 | | 33.603 | 33.553 | |
| | 44.795 | | | 54.120 | | | 47.422 | | | 30.996 | | | 35.862 | | | 33.578 | | |

| M | S: 1991 | | | S: 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 54.143 | 43.500 | 48.822 | 35.205 | 31.806 | 33.505 |
| SCB | 53.910 | 43.563 | 48.737 | 35.158 | 31.745 | 33.452 |
| Mean | 54.027 | 43.532 | | 35.182 | 31.775 | |

**L.S.D.**

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 0.114 | 0.154 | 0.534 | 0.726 |
| R : | 0.093 | 0.126 | 0.436 | 0.592 |
| M : | N.S. | N.S. | N.S. | N.S. |
| SR : | 0.161 | 0.218 | 0.755 | 1.026 |
| SM : | 0.161 | 0.218 | N.S. | N.S. |
| MR : | 0.131 | 0.178 | N.S. | N.S. |
| SMR : | 0.227 | 0.309 | N.S. | N.S. |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

From the abovementioned results, the fibers content ranged from 0.01 to 0.04%, 3.9 to 5.8% and 29.9 to 60% for Extra, Fine and Bobby categories, respectively. Since the fibers content was too high in Bobby pods, this category is practically unexportable. In addition, the pods will be full of threads compared to the other two categories. The obtained results are in a good agreement with those of several investigators who indicated that fibers content of green pods usually ranged irregularly from 0.01 to 17.8% (Ross et al., 1956; Anonymous, 1962 b; Eden, 1968; Hanafy, 1973; Rockland et al., 1977; El-Nahry et al., 1977; Antunes et al., 1979; Shehata and Thannoun, 1980; Rosario et al., 1980 and Noor et al., 1980).

The fluctuation of fibers content among the three pod categories may be due to the effect of pod maturity and climatic conditions; since the high temperature might contribute more fiber formation as a result of enhancing cell differentiation. This interpretation was corresponding with those recorded by Kaldy, (1966); Kemp et al., (1974); C.S.I.R.O., (1977); Mack and Varseveld, (1982) and Richard and Mack (1983).

**3.2.2. Protein content:**

**3.2.2.1. Extra pods category:**

***Phaseolus vulgaris*** plants treated with ammonium nitrate fertilizer were significantly higher in their pod-protein content than those received ammonium sulphate or urea (Table 25). The average protein contents were 24.3, 22.8 and 22.0% in the first season, and 20.5, 19.3 and 18.8% in the second one for ammonium nitrate, ammonium sulphate and urea, respectively. These results are in harmony with the findings of Hallsworth

(1972) on pea and Lawn and William (1974) on soybean, which indicated that protein content was increased considerably with the application of ammonium nitrate. Concerning the effect of the application rate on protein content, the results indicated that protein content was not affected significantly by increasing N rate from 33 to 66 kg N/feddan. Many investigators reported that protein content was unaffected by increasing N rate up to 224 kgN/ha (Lawn et al., 1974; Richards and Soper, 1982 and Kadir 1988). On the other hand, the surface continuous band as a method of N application gave superior results with significant effect compared with the another method of application with all N sources and rates in both seasons.

The effects of source by rate and source by method interactions were significant in both growing seasons. While the method by rate and source by method by rate were only significant in the second one. The statistical analysis indicated that the general effect of N rate on protein content was not significant. However, the source by rate was significant. The effect of N source was affected by increasing the rate of application, i.e., increasing the amount of ammonium sulphate and urea decreased protein content. In contrast, increasing the rate of ammonium nitrate increased protein content significantly. The significant effect of source by method interaction indicated that the effect of N source was affected by N rate or vis versa. The effect of ammonium sulphate and urea on protein content was not affected by the method of application. However, the protein content was increased when ammonium nitrate was added in a surface continuous band.

**Table (25): Effect of nitrogen fertilization under submersion condition on pod protein content of Extra category (%) of *Phaseolus vulgaris* in 1991 and 1992 seasons.**

| R | 1991 | | | | | | | | | S | 1992 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 20.21 | 23.42 | 21.518 | 24.19 | 24.02 | 24.105 | 23.16 | 23.01 | 23.085 | 19.25 | 19.42 | 19.335 | 19.85 | 20.15 | 20.00 | 19.20 | 19.25 | 19.225 |
| $R_2$ | 25.29 | 28.27 | 26.78 | 21.35 | 21.70 | 21.525 | 20.91 | 21.09 | 21.00 | 21.03 | 22.35 | 21.690 | 18.05 | 19.00 | 18.525 | 18.40 | 18.33 | 18.365 |
| Mean | 22.75 | 25.845 | | 22.77 | 22.860 | | 22.035 | 22.05 | | 20.140 | 20.885 | | 18.950 | 19.575 | | 18.800 | 18.790 | |
| | 24.298 | | | 22.815 | | | 22.042 | | | 20.513 | | | 19.263 | | | 18.795 | | |

| M | 1991 | | S | 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 22.520 | 22.517 | 22.518 | 19.433 | 19.160 | 19.297 |
| SCB | 23.483 | 23.687 | 23.585 | 19.607 | 19.893 | 19.750 |
| Mean | 23.002 | 23.102 | | 19.520 | 19.527 | |

**L.S.D.**

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 0.260 | 0.354 | 0.206 | 0.281 |
| R : | N.S. | N.S. | N.S. | N.S. |
| M : | 0.212 | 0.289 | 0.168 | 0.229 |
| SR : | 0.368 | 0.500 | 0.292 | 0.397 |
| SM : | 0.368 | 0.500 | 0.292 | 0.397 |
| MR : | N.S. | N.S. | 0.238 | 0.323 |
| SMR : | N.S. | N.S. | 0.413 | 0.561 |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- SLB : Surface localized band
- SCB : Surface continuous band

### 3.2.2.2. Fine pods category:

Concerning the Fine category, results shown in table (26) revealed that pod protein content was influenced by N sources. Ammonium nitrate fertilizer surpassed significantly the other two sources which did not show any significant difference in protein content of Fine pods compared to each other in the second season, whereas significant differences were obtained in the first one.

Protein content of Fine pods was negatively affected by the rate of applied nitrogen. In the first season, the protein content was decreased significantly with increasing N rate. However, a poor relationship between protein content and N rate was found in the second one. Such results are differed from those obtained by Kesavan and Morachan (1973); Chavez et al., (1977); Racca and Bodrera (1981); Newton and Robertson (1982); Shafshak et al., (1988) and Helal (1991), who reported that increasing the rate of nitrogen increased crude protein content in seeds of legume plants. However, such disagreement could be due the use of two different organs, being the green pods in the present study and the seeds in theirs, for N determination.

Regarding the methods of application, results indicated that the highest values of protein content were recorded for surface continuous band method and these values reached the level of significancy, only in the first season.

All the interaction effects were highly significant in the first season except the three way interaction which did not show any significant effect in both seasons.

**Table (26): Effect of nitrogen fertilization under submersion condition on pod protein content of Fine category (%) of *Phaseolus vulgaris* in 1991 and 1992 seasons.**

| R | S: 1991 | | | | | | | | | S: 1992 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AN | | | AS | | | U | | | AN | | | AS | | | U | | |
| | M | | | | | | | | | M | | | | | | | | |
| | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean | SLB | SCB | Mean |
| $R_1$ | 21.00 | 22.37 | 21.685 | 20.41 | 19.69 | 20.050 | 19.75 | 19.29 | 19.520 | 18.07 | 18.66 | 18.365 | 18.08 | 18.96 | 18.520 | 18.65 | 18.50 | 18.575 |
| $R_2$ | 19.25 | 21.70 | 20.475 | 19.08 | 19.60 | 19.34 | 20.30 | 20.65 | 20.475 | 19.75 | 19.66 | 19.705 | 17.00 | 17.75 | 17.375 | 18.00 | 17.88 | 17.940 |
| Mean | 20.125 | 22.035 | | 19.745 | 19.645 | | 20.025 | 19.970 | | 18.910 | 19.160 | | 17.540 | 18.355 | | 18.325 | 18.190 | |
| | 21.080 | | | 19.695 | | | 19.998 | | | 19.035 | | | 17.948 | | | 18.258 | | |

| M | S: 1991 | | | S: 1992 | | |
|---|---|---|---|---|---|---|
| | $R_1$ | $R_2$ | Mean | $R_1$ | $R_2$ | Mean |
| SLB | 20.387 | 19.543 | 19.965 | 18.267 | 18.250 | 18.258 |
| SCB | 20.450 | 20.650 | 20.550 | 18.707 | 18.430 | 18.569 |
| Mean | 20.418 | 20.097 | | 18.487 | 18.340 | |

**L.S.D.**

| | (1991) 5% | (1991) 1% | (1992) 5% | (1992) 1% |
|---|---|---|---|---|
| S : | 0.111 | 0.150 | 0.438 | 0.596 |
| R : | 0.090 | 0.123 | N.S. | N.S. |
| M : | 0.090 | 0.123 | N.S. | N.S. |
| SR : | 0.156 | 0.212 | 0.620 | 0.843 |
| SM : | 0.156 | 0.212 | N.S. | N.S. |
| MR : | 0.128 | 0.174 | N.S. | N.S. |
| SMR : | N.S. | N.S. | N.S. | N.S. |

S: Source
- AN : Ammonium nitrate
- AS : Ammonium sulphate
- U : Urea

R: Rate
- $R_1$ : 33 kgN/feddan
- $R_2$ : 66 kgN/feddan

M: Method
- **SLB : Surface localized band**
- **SCB : Surface continuous band**

By refering to tables 25 and 26, in both seasons, one can easily realize that the protein content of the green pods differed with categories. Generally the Extra pods was the richest category. The mean protein percentages were 24.3, 22.8 and 22.0% in the first season, and 20.5, 19.3 and 18.8% in the second one. Corresponding values for Fine pods category were 21.1, 19.7 and 20.0% in the first season, and 19.0, 17.9 and 18.3% in the second one. Evidently this variation may be due to the dilution effect.

*** Choice of the best fertilization treatment**

From the prementioned data, one can easily choose ammonium nitrate as the best fertilizer for string bean ***Phaseolus vulgaris*** production. Such a treatment gave the highest commercial export yield (1959.8 and 1883.8 kg/feddan) for 91 and 92 seasons with quite excellent pods characteristics compared with the other N-sources. Ammonium sulphate fertilizer, on the other hand, came in the second order where the commercial export yield reached 1394.3 and 1452.5 kg/feddan compared with urea where the yield did not exceed 1302 and 1256.3 kg/fed in 91 and 92 seasons, respectively.

**B. Nitrogen application through drip irrigation:**

This study aimed at evaluating the drip application of ammonium nitrate fertilizer as a method of increasing N fertilizer efficiency in irrigated ***Phaseolus vulgaris*** plants. Ammonium nitrate was injected through the trickle system or applied as surface continuous band through submersion system at the rate of 0,33 and 66 kg N/feddan.

## 1. Plant growth:

### 1.1. Morphological characters:

#### 1.1.1. Plant height:

Plant height was increased significantly as the rate of nitrogen increased from 0 to 33 kg N/fed either nitrogen was applied through the drip irrigation or as a surface continuous band under submersion irrigation (Table 27). Increasing N rate from 33 to 66 kg N/fed resulted in a slight decrease in plant height when the N was applied through the drip irrigation. The rate of 66 kg N/fed did not significantly differ from the rate of 33 kg N/feddan. This result means that the rate of 33 kg N/fed was sufficient to induce the maximum plant height. These findings agreed with those reported by Edje et al.,(1975) who found that plant height was significantly affected by N supply to ***phaseolus vulgaris*** plant. The rate of nitrogen fertilization affected plant height as previously reported by Bassuny (1982) and Eisa (1986) who indicated that application of nitrogen at the rate of 20 and 60 kg N/fed to bean and soybean respectively, significantly increased the plant height. However, Badr et al., (1974); Barni et al., (1978); El-Gizy, (1990) and Helal, (1991) showed that no significant effect on the height of some legume plants for nitrogen application.

Generally, the plant heights in drip irrigated plots were increased over the submerged ones by about 7.5, 15.6 and 8.7% for 0,33 and 66 kg N/fed, respectively. The positive effect of fertigation system may be due to the plants were protected from water stress, or because of nitrogen was more efficient when applied through the trickle-system.

**Table (27)** The influence of varying levels of ammonium nitrate under drip and submersion irrigation conditions on plant growth of ***Phaseolus vulgaris*** in 1993 season.

| Rate (kg N/fed) | Plant growth | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Drip irrigation system | | | | Submersion irrigation system | | | |
| | Plant height (cm) | Leaf area ($cm^2$) | Number of leaves/plant | Plant dry weight (g) | Plant height (cm) | Leaf area ($cm^2$) | Number of leaves/plant | Plant dry weight (g) |
| 0 | 43 | 32.20 | 6.50 | 17.52 | 40 | 30.70 | 6.53 | 16.72 |
| 33 | 52 | 45.00 | 9.82 | 18.28 | 45 | 38.00 | 9.78 | 17.00 |
| 66 | 50 | 57.00 | 13.00 | 20.11 | 46 | 51.00 | 13.00 | 18.25 |

| L.S.D. | 5% | 1% | 5% | 1% |
|---|---|---|---|---|
| Plant height | 4.14 | 6.86 | 4.14 | 6.86 |
| Leaf area index | 1.97 | 3.27 | 2.77 | 4.59 |
| Number of leaves | 0.38 | 0.63 | 1.59 | 2.63 |
| Plant dry weight | 0.96 | 1.60 | 0.90 | 1.49 |

### 1.1.2. Leaf area index:

Data presented in table (27) revealed that ***Phaseolus vulgaris*** plants which received 33 and 66 kg N/fed, generally had more leaf area as compared with those unfertilized ones. The leaf area was increased significantly with increasing N rate under drip and submersion irrigation regimes, the highest leaf area resulted from the application of 66 kg N/feddan. Many investigators reported that high nitrogen doses enhanced leaf area (Edje et al., 1975; Zahran and El-Aishy, 1979; Leidi and Gomes, 1980; Lluch et al., 1983; El-Gizy, 1990 and Helal, 1991). On the contrary, Pal and Saxena (1977) found that application of nitrogen to some legume lines at early stage of growth had no effect on leaf area.

### 1.1.3. Number of Leaves:

The number of leaves per plant as affected by N rate is shown in table (27). Plants treated with nitrogen fertilizer at the rate of 33 or 66 kg N/fed, were significantly higher in their number of leaves as compared to the unfertilized plants. The number of leaves per plant was increased significantly with increasing the application rate and the highest number was obtained with the highest N rate (66 kg N/fed) through the two irrigation systems. Such results were similar to those observed by Ishizuka (1972); Bhangoo and Albritton, (1976) and El-Gizy, (1990).

### 1.2. Plant dry weight:

The dry weight values as affected by nitrogen supply are presented in Table (27). Generally, data revealed that increasing the nitrogen fertilization dose enhanced the dry matter production under the two irrigation systems. Through drip irrigation regime, the dry matter value of the unfertilized plants was lower (17.52 g/plant) than those received 33 kg N/fed (18.28 g/plant). The highest dry matter was achieved with the 66 kg N/fed (20.11 g/plant). No significant difference was recorded between the control and 33 N treatments. The same trend was obtained in case of using submersion irrigation system. The dry weight of plant as an indicator for plant growth exhibited a possitive response towards trickle irrigation system of about 7.5 and 10.2% for the 33 N and 66 N treatments, respectively as compared with those irrigated by the other one.

Many investigators reported also that high doses of nitrogen fertilizer enhanced dry weight of legume plants (Singh and Saxena, 1973 a; Edje et al., 1975; Hashimoto, 1977; Zahran and El-Aishy, 1979; Hassan, 1981; Semu et al., 1982 and Osorio and Freire, 1982). On the other hand, Graman et al., (1978) reported that dry matter yield of faba bean was increased by N application up to 80 kg N/ha and then decreased when N rate was increased up to 120 kg N/hectare.

**2. Yielding ability:**

Under drip irrigation condition, there were continuous increaments in the yield of Extra and Fine pods with increasing N rate from 0 to 66 kg N/feddan (Table 28). The same trend was obtained in case of using submersion irrigation regime. The yield of Extra and Fine pods produced under submersion condition was less than the corresponding yield under drip irrigation system. However, the total yield of submerged plants was higher than that of drip irrigated ones because of the increased occurrence of Bobby category that resulted from delaying the harvesting of pods till the soil becomes dry. These results are in agreement with those of several investigators who revealed that application of nitrogen increased yield of ***Phaseolus vulgaris*** plants (Edje et al., 1975; Cyril, 1977; Doss et al., 1977; Santos et al., 1979; Mullins et al., 1980; Feitosa et al., 1980; Cunha et al., 1980; Scarisbrick et al., 1982; Hera et al., 1985; Gligorevic, 1986 and El-Gizy, 1990). On the contrary, there are several conflicting reports concerning the effect of applied inorganic N fertilizer on pod yield of the legume plants. Some investigators declared that nitrogen addition did not increase (Welch et al., 1973), slightly decrease (Sachansky, 1977) and did not affect the yield (Sharma, 1977; Kassem et al., 1977 and Barni et al., 1978).

Irrespective of N application, from the above mentioned results one can notice that drip irrigation regime has a positive effect on pods yield production of both Extra and Fine categories showing an increase of about 24.8 and 21.3% for the 33 N and 13.8 and 26.2% for 66 N treatments, respectively over the plants fertilized with the same doses of ammonium nitrate fertilizer under submersion irrigation condition. Moreover, evaluation of the size distribution of the pods yielded throughout the season as affected by drip irrigation system, revealed that undesirable Bobby category was undiscerned. This findings agreed with those reported by Goldberg and Shmueli (1970) who indicated that trickle irrigation increased yield by 30% or more over furrow or sprinkler irrigation . Willardson et al., (1974) also observed that the yields of many crops and vegetables were more under drip irrigation than conventional methods of irrigation.

**Table (28):** The influence of varying levels of ammonium nitrate under drip and submersion irrigation conditions on yield production (kg/fed) of ***Phaseolus vulgaris*** plants in 1993 season.

| Rate (kgN/fed) | Yielding ability (kg/fed) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Drip irrigation system | | | Submersion irrigation system | | | |
| | Extra pods | Fine pods | Total yield | Extra pods | Fine pods | Bobby pods | Total yield |
| 0 | 250 | 1370 | 1620 | 238 | 1315 | 15 | 1568 |
| 33 | 780 | 1920 | 2700 | 625 | 1583 | 775 | 2983 |
| 66 | 800 | 2650 | 3450 | 703 | 2100 | 1267 | 4070 |

| L.S.D. | 5% | 1% | 5% | 1% |
|---|---|---|---|---|
| Extra pods | 20.69 | 34.32 | 35.51 | 58.90 |
| Fine pods | 15.35 | 25.45 | 38.03 | 63.07 |
| Bobby pods | - | - | 48.76 | 80.87 |

Furthermore, other investigators have reported high yields and high water - use efficiencies for drip irrigation (Shmueli and Goldberg, 1971; Singh, 1978 and Bakr et al., 1979).

The superiority of fertigation might be attributed to the drip irrigation system which helped to maintain a favourable moisture and nutrient level distribution in the soil for plant growth and minimized the leaching losses of applied nitrogen. This interpretation was assured by several investigators who indicated that nutrient concentration remained higher in the root zone of the trickle irrigated plots than it did in those of the plots irrigated by other methods (Phene and Beale, 1976; Bresler, 1977; Keng et al., 1979; Laher and Avnimelech, 1980; Miller et al., 1981; Feigin et al., 1982; Edwards et al., 1982 and Haynes, 1985).

**3. Physical and chemical characteristics of pods:**

**3.1. Physical characteristics of pods:**

**3.1.1. Pod length:**

Regarding the drip irrigation system, application of N fertilizer to ***Phaseolus vulgaris*** plants did not induce any significant effect on average length of Extra pods in all treatments (Table 29). A slight drop in length of Extra pods of about 3-5 %, however, took place with increasing the nitrogen dose up to 66 kg N/fed as compared with the other two doses. However, the pod length was increased with increasing N rate in case of using the submersion irrigation method.

The pod length of the Fine category was increased significantly with increasing N rate under both drip and submersion irrigation conditions. The highest length was recorded with the highest N dose. The highest N rate through drip irrigation system increased pod length by 21% and 3% and 16% and 8.6% under the other system as compared with the control and 33 N treatments, respectively.

Generally, the prementioned results may lead to conclusion that the different responses of the different pod categories toward nitrogen application might be influenced beside the rate of applied N, by maturity stage, planting or harvesting date, genetic and other environmental factors. This interpretation was assured by several investigators, i.e., Anonymous, (1962a,b and 1969); Joubert, (1966) and Stino et al. (1968).

### 3.1.2. Pod diameter:

Data of pod diameter as influenced by N supply, are shown in table (29). Results indicated that application of nitrogen induced a significant positive effect on pod diameter of ***Phaseolus vulgaris*** plants. Under drip irrigation condition, the 33 kg N/fed was the best N dose affecting the length and diameter of Extra pods category , yielding the highest length (10.0 cm) and quite good diameter character (6.5 mm). However, 66 kg N/fed was the most effective dose on diameter and length of Extra pods under submersion irrigation regime as well as Fine pods category under both conditions.

Irrespective of N dose, the pod diameter in the Fine category was higher (7.5 mm) than in the Extra category (5.2 mm) as the nitrogen free treatments. Evidently, this variation could have been due to variations in maturity stage during harvesting date.

**Table (29):** The influence of varying levels of ammonium nitrate under drip and submersion conditions on pod length, diameter and dry weight of ***Phaseolus vulgaris*** in 1993 season.

| Rate (kgN/fed) | Physical characteristics of pods | | | | | |
|---|---|---|---|---|---|---|
| | Drip irrigation system | | | Submersion irrigation system | | |
| | Length (cm) | Diameter (mm) | Dry weight (%) | Length (cm) | Diameter (mm) | Dry weight (%) |
| | **Extra pods** | | | | | |
| 0 | 9.80 | 5.2 | 8.25 | 9.0 | 5.2 | 7.65 |
| 33 | 10.00 | 6.5 | 14.50 | 9.5 | 6.0 | 12.25 |
| 66 | 9.50 | 7.2 | 15.85 | 10.2 | 6.5 | 14.12 |
| | **Fine pods** | | | | | |
| 0 | 14.00 | 7.5 | 12.14 | 14.0 | 7.4 | 10.35 |
| 33 | 16.50 | 7.8 | 13.70 | 15.0 | 7.6 | 11.12 |
| 66 | 17.00 | 8.2 | 14.57 | 16.3 | 7.8 | 12.25 |

| L.S.D. | 5% | 1% | 5% | 1% |
|---|---|---|---|---|
| **Extra pods** | | | | |
| Length | N.S. | N.S. | 0.641 | 1.063 |
| Diameter | 0.641 | 1.063 | 0.817 | N.S. |
| Dry weight | 0.536 | 0.888 | 0.664 | 1.101 |
| **Fine pods** | | | | |
| Length | 1.035 | 1.716 | 1.309 | 2.170 |
| Diameter | 0.346 | 0.574 | 0.321 | N.S. |
| Dry weight | 2.052 | N.S. | 0.495 | 0.820 |

### 3.1.3. Pod dry weight:

The dry matter yield of pods as affected by different N fertilization treatments are shown in table (29). Regardless of nitrogen free treatments, the Extra category was characterized by high dry matter while the Fine grade came in the second order, this was true under the two irrigation systems. In this connection, data revealed highly significant differences on dry matter of Extra category due to different nitrogen rates. Both 33 N and 66 N treatments increased the dry matter of pods produced under drip irrigation system by about 76% and 92% compared with the unfertilized treatment. The same trend was obtained in case of using submersion irrigation system. However, the dry matter of pods of submerged plants was lower than that of drip irrigated ones.

Concerning the dry matter of Fine pods produced under drip irrigation system, the results showed that no significant differences between the 33 N treatment and the other two treatments (O and 66 kg N/fed). However, there is a significant difference in dry matter between these two rates. Dry matter yield of Fine pods produced under the submersion irrigation system tended to increase with increasing N rate from O to 33 kg N/fed, with increasing N rate from 33 to 66 kg N/fed a significant increase in dry matter was obtained.

Irrespective of N rate, the dry matter percentage in the Fine pods grade was higher (12.14% and 10.35%) than in the Extra pods category (8.25% and 7.65%) compared to each other as the unfertilized treatments under both drip and submersion irrigation systems. This could be easily realized by refering to the corresponding fiber values in table (30).

## 3.2. Chemical characteristics of pods:

### 3.2.1. Fibers content:

Data of the fibers content of the green marketable pods are presented in table (30). Fibers content was decreased steady with the rate of N fertilization . Both 33 N and 66 N treatments exhibited a drop in fibers in pods of drip irrigated plants by about 97.55% and 63.73% at the end of the season for Extra and Fine categories, respectively as compared with the control. Similar trend was obtained with submersion irrigation system.

The mean fibers content under drip irrigation system was 3.2, 0.08 and 0.08%, and 12.8, 5.2 and 4.1% for Extra and Fine categories, respectively. Under submersion irrigation system, corresponding values were 3.3, 0.09 and 0.09 for Extra grade and 13.3, 7.0 and 5.1 % for Fine category. It should be noted that Fine grade produces more fiberous pods, while those of Extra grade contained the least amount of fibers. Similar results were also published in C.S.I.R.O., (1977) in which the major factor influencing fiber content was the maturity of pods. This could be attributed to changes in environmental factors involving temperature and light, high temperature prevailing in late harvesting date favours more fibers formation as a result of enhancing cell differentiation. These findings agreed with those reported by Kaldy (1966) who found that fiber content of beans was a varietal characteristic greatly influenced by temperature and humidity.

### 3.2.2. Protein content:

Results of the protein content of the green pods are presented in table (30). Highly significant differences were observed with different nitrogen rates. Pods of ***Phaseolus vulgaris*** plants treated with 66 kg N/fed had the

Table (30): The influence of varying levels of ammonium nitrate under drip and submersion irrigation conditions on som chemical characteristics of pods of ***Phaseolus vulgaris*** in 1993 season.

| Rate (kgN/fed) | Chemical characteristics of pods | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Drip irrigation system | | | | | Submersion irrigation system | | | | |
| | Fiber (%) | Protein (%) | Chlorophyll (mg/g) | | Carbohydrate (%) | Fiber (%) | Protein (%) | Chlorophyll (mg/g) | | Carbohydrate (%) |
| | | | a | b | | | | a | b | |
| **Extra pods** | | | | | | | | | | |
| 0 | 3.207 | 15.286 | 1.98 | 0.78 | 14.25 | 3.285 | 15.850 | 1.33 | 0.78 | 13.75 |
| 33 | 0.080 | 18.725 | 2.21 | 0.97 | 19.85 | 0.085 | 17.250 | 1.85 | 1.06 | 18.30 |
| 66 | 0.077 | 19.574 | 2.46 | 1.08 | 23.00 | 0.085 | 17.525 | 2.03 | 1.06 | 20.50 |
| **Fine pods** | | | | | | | | | | |
| 0 | 12.750 | 15.225 | 1.87 | 0.55 | 12.75 | 13.250 | 14.430 | 1.25 | 0.52 | 13.00 |
| 33 | 5.164 | 17.299 | 2.05 | 0.64 | 15.80 | 7.027 | 15.720 | 1.78 | 0.64 | 17.15 |
| 66 | 4.085 | 18.139 | 2.05 | 0.66 | 16.20 | 5.103 | 16.920 | 1.95 | 0.66 | 19.40 |

| L.S.D. | Drip 5% | Drip 1% | Submersion 5% | Submersion 1% |
|---|---|---|---|---|
| **Extra pods** | | | | |
| Fiber | 0.120 | 0.198 | 0.140 | 0.232 |
| Protein | 0.697 | 1.156 | 1.146 | N.S. |
| Chlorophyll (a) | 0.090 | 1.150 | 0.295 | 0.490 |
| (b) | 0.147 | 0.245 | 0.201 | N.S. |
| Carbohydrate | 1.155 | 1.915 | 0.656 | 1.088 |
| **Fine pods** | | | | |
| Fiber | 0.363 | 0.601 | 0.289 | 0.480 |
| Protein | 0.513 | 0.852 | 0.885 | 1.468 |
| Chlorophyll (a) | 0.109 | 0.182 | 0.507 | N.S. |
| (b) | 0.113 | 0.188 | N.S. | N.S. |
| Carbohydrate | 0.743 | 1.233 | 1.068 | 1.772 |

highest protein content, followed by plants fertilized with 33 kg N/fed, while those grown without nitrogen had the lowest content of protein. This was true under the two irrigation systems. The rate of nitrogen fertilization was also found to affect protein content as previously reported by Hallsworth (1972) and Lawn and William,(1974) who indicated that the application of nitrogen as ammonium nitrate increased considerably the protein contein of pea and beans plants. On the contrary, a negative correlation between protein content of soybean and N application was observed by Kadir (1988):

The protein content differed in different categories. Extra pods was the richest category, the mean protein content was 15.3, 18.7 and 19.6%, and 15.2, 17.3 and 18.1% for Extra and Fine grades in drip irrigated plants, respectively. Similar trend was observed with submersion irrigation system, corresponding values were 15.9, 17.3 and 17.5% for Extra category and 14.4, 15.7 and 16.9% for Fine category. The average value reported by Rutger (1968) and De Moraes and Angelucci (1971) for ***Phaseolus vulgaris*** ranged from 17 to 31%.

### 3.2.3. Chlorophyll content:

Data reported in table (30) revealed that chlorophyll content in pods was affected positively by nitrogen rate. Generally, the Extra pods was the richest category in their chlorophyll content. The mean total chlorophyll contents were 2.76, 3.18 and 3.54 mg/g for the pods of drip irrigated plants and 2.11, 2.91 and 3.09 mg/g for those of the submerged plants. Corresponding values for Fine pods were 2.42, 2.69 and 2.71 mg/g, and 1.77, 2.42 and 2.61 mg/g under drip and submersion irrigation conditions, respectively. Evidently this variation in chlorophyll content of Extra and Fine pods could be due to the degradation of chlorophyll with maturity.

Concerning the effect of N rates on this triat, the results show a striking increase in chlorophyll content in pods as affected by increasing the level of the applied nitrogen. These increases reached to level of significance in both categories under the two irrigation systems. Such a result agreed with what was observed by Brakel and Manil ,(1965); Osawa and Lorenz, (1968) and El-Loboudi et al., (1974), on ***Phaseolus vulgaris*** and Behran et al.,(1979) and Yakout et al., (1981), on soybean, who reported that chlorophyll content was positively correlated with increasing N fertilization. However, Sesay (1979) observed that nitrogen fertilizer had no significant effect on photosynthetic rate and chlorophyll content of soybean plants.

The satisfactory effects of nitrogen application on the content of chlorophyll in pods might be attributed to its prominent role in the chlorophyll pigement synthesis in the plant tissues.

### 3.2.4. Carbohydrate content:

Data presented in table (30) revealed that the total soluble carbohydrate content ranged from 12.75 to 23.0 and from 13.0 to 20.5 g/100 g dry matter in pods produced under drip and submersion irrigation systems, respectively as reported by Tulsiani and Pant (1968) and Aman (1979) who found that soluble carbohydrate content of different ***Phaseolus*** varieties ranged from 12.20 to 22.89 g/100 g dry matter.

Regarding the effect of N rates, the carbohydrate content in different pod categories was increased significantly with increasing N dose under drip and submersion irrigation systems. The highest N rate (66 kg N/fed) under submersion irrigation system increased carbohydrate content in both Extra and Fine categories by 49% as compared with the control. Through the drip irrigation system, however, corresponding increase values for Extra and Fine categories were 61% and 17.8%, respectively.

The possitive effect of N application on the content of carbohydrate in pod might be attributed to its prominent role in the chlorophyll synthesis which in turn encourages the plant to convert light energy to metabolites.

The carbohydrate content in Extra pods of drip irrigated plants were increased over submerged ones by about 3.6, 8.5 and 12.2% for 0,33 and 66 kg N/fed, respectively. The superiority of drip irrigation system might be attributed to the effect of fertigation on plant growth and yielding ability as previously discussed. On the contrary, the carbohydrate content of Fine pods produced under drip irrigation regeim was lower than that of submerged ones by about 1.9, 7.9 and 16.5% for 0,33 and 66 kgN/fed, respectively.

**4. Nutrient content of *Phaseolus vulgaris* plant:**

Concentrations of some essential elements in the different organs of ***Phaseolus vulgaris*** plant at the bloom stage were affected by the rates of nitrogen (Table 31). The N concentration was higher in blades and gradually decreased towards the petioles and stems. Nitrogen applications significantly increased N concentration in the stems and petioles in all treatments except petioles of the plants treated with 33 kg N/fed as compared with unfertilized plants; but in blades the influences were not significant except with the 66 N treatment compared to the control plant.

Blades and petioles contained almost similar amounts of phosphorus which were higher than those in stems. Phosphorus concentration in stems and petioles tended to increase with increasing N rate. Moreover, phosphorus accumulation in blades was increased significantly over the control when N was applied at the rate of 66 kg N/feddan.

Irrespective of N treatments, the concentration of potassium and calcium in the blades was higher as compared with the other tissues. Nitrogen supply did not show any significant effect on potassium concentration in stem. However, nitrogen at the rate of 33 kgN/fed as compared with control increased significantly the concentration of K in petioles and blades . Obviously, further increase of N dose up to 66 kg N/fed resulted in a slight decrease in K concentration in petioles and blades. A positive relationship between nitrogen and potassium in other crop plants has been noticed by Audider (1968).

Nitrogen applications significantly increased the concentration of calcium in the stems and blades over the control except blades of the plants treated with 33 kgN/fed as compared with unfertilized plants. Similar results have been reported by Greig et al., (1968) for spinach and Nathan et al., (1989) for ***Phaseolus vulgaris*** plants.

Following the Mg level in the stems and petioles as affected by the rate of nitrogen, revealed that increasing the N dose did not affect Mg concentration. However, the highest values of Mg concentration in blades were recorded when nitrogen was applied at the rate of 33 and 66 kg N/fed which significantly did not exhibit any difference compared to each other.

**Table (31):** The influence of ammonium nitrate fertilizer applied through the drip irrigation on the concentration of elements in the different organs of ***Phaseolus vulgaris*** plant at the bloom stage in 1993 season.

| Rate (kgN/fed) | Plant organs | Concentration of elements (%) | | | | |
|---|---|---|---|---|---|---|
| | | N | P | K | Ca | Mg |
| 0 | Stems | 1.38 | 0.23 | 1.55 | 0.43 | 0.08 |
| | Petioles | 2.52 | 0.29 | 1.39 | 0.97 | 0.37 |
| | Blades | 3.70 | 0.29 | 1.58 | 1.61 | 0.35 |
| 33 | Stems | 1.47 | 0.25 | 1.62 | 0.88 | 0.11 |
| | Petioles | 2.59 | 0.32 | 1.56 | 0.80 | 0.37 |
| | Blades | 3.86 | 0.32 | 2.50 | 1.73 | 0.46 |
| 66 | Stems | 2.03 | 0.28 | 1.62 | 0.93 | 0.13 |
| | Petioles | 3.02 | 0.34 | 1.45 | 0.80 | 0.34 |
| | Blades | 4.01 | 0.37 | 1.75 | 1.97 | 0.49 |

**L.S.D.**

| | | Stem | Petioles | Blades |
|---|---|---|---|---|
| N | 5% | 0.064 | 0.094 | 0.31 |
| | 1% | 0.106 | 0.157 | N.S. |
| P | 5% | N.S. | N.S. | 0.075 |
| | 1% | N.S. | N.S. | N.S. |
| K | 5% | N.S. | 0.151 | 0.168 |
| | 1% | N.S. | N.S. | 0.279 |
| Ca | 5% | 0.134 | 0.166 | 0.213 |
| | 1% | 0.222 | N.S. | 0.353 |
| Mg | 5% | N.S. | N.S. | 0.086 |
| | 1% | N.S. | N.S. | 0.142 |

Blades analysis showed that the 66 kg N/fed treatment was the best one which increased the concentrations of N, P, Ca and Mg ; but decreased K concentration. The present results corroborate those of Mir and Greig, (1972) and Nathan et al., (1989) who indicated that ***Phaseolus vulgaris*** plants fertilized with the high dose of nitrogen (≈ 12.8 g $N/m^2$) showed higher concentrations of N , P, K, Ca, Mg, S, Fe and Mn in the leaves.