

SUMMARY

String bean, *Phaseolus vulgaris*, L. is a new cultivar has a good potential to be exported and there is a great demand on it especially from the European community. These new variety alone produce a high percentage of straight pods in the Extra and Fine categories which enjoy the best market prices. Thus export of this variety becomes very important to increase the national revenue.

The aim of this investigation was to study:

- 1) The response of *Phaseolus vulgaris* plants to inoculation under sterilized condition as well as the effect of N application to inoculated and uninoculated plants on nodulation and plant growth.
- 2) The ability of *Phaseolus vulgaris* plants to form nodules under natural soil condition and their ability to utilize the atmospheric nitrogen.
- 3) The effect of N source, rate and method of application on the commercial exportable yield of the Extra and Fine categories.
- 4) The efficacy of ammonium nitrate fertilizer when applied through drip or as surface continuous band under submersion irrigation conditions.

To accomplish the first and second objectives, laboratory and greenhouse experiments were conducted.

I. LABORATORY EXPERIMENT

Seeds of *Phaseolus vulgaris* were planted in sterilized sand culture (Leonard Jar system), inoculated or uninoculated with the appropriate

Rhizobium culture (strain No. 3612). Nitrogen was applied at the rate of 0, 16.5 and 33 mg N/kg sand to the inoculated and uninoculated treatments.

The results obtained from this experiment can be briefly summarized as follows:

1. The plants failed to form any nodules when planted in sterilized soil free from *Rhizobium* bacteria, but the nodules were formed after inoculation with effective strain of *Rhizobium phaseoli*.
2. Inoculated treatments without N 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 number of nodules/plant but also the total and individual weight of nodules. The number of nodules/plant was reduced from 136 in absence of nitrogen to 38 with the rate of 16.5 mgN/kg and to 6 with the highest rate of nitrogen (33 mgN/kg).
3. The root dry weight was increased significantly with increasing N rate. However, the effect of inoculation on dry weight of root was negative.
4. The shoot dry weight was increased significantly with increasing N application to inoculated and uninoculated plants. At the rate of 0 and 16.5 mg N/kg, the inoculated plants produced high shoot dry weight comparing with uninoculated ones.
5. Total N and NO₃-N in blade were increased significantly as a result of increasing the applied nitrogen and the increase was higher in the inoculated plants provided that the rate of nitrogen did not exceed 16.5 mgN/kg.

II. GREENHOUSE EXPERIMENT

Natural and fumigated sandy soil was used in this experiment. Nitrogen was applied to the pots before sowing at the rate of 0, 16.5 and 33 mgN/kg. *Phaseolus vulgaris* seeds were planted in soil inoculated or uninoculated with the appropriate *Rhizobium* culture (strain No. 3612).

The following is a brief summary of the results obtained:

1. *Phaseolus vulgaris* plants in all investigated treatments failed to form any nodules.
2. Soil organisms and antagonistic factors had no inhibitive effect on the *Rhizobium phaseoli* indicating that such a failure could be undoubtedly attributed to the high content of available native soil-N, or pH effects.
3. 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 any nodules under common natural soil condition. Thus the addition of N to *Phaseolus vulgaris* plants is very important to increase the productivity than other leguminous crops.

To achieve the third and fourth objectives two field experiments were executed.

III. FIELD EXPERIMENTS

A) Submersion irrigation experiment:

The aim of this study was to determine the most effective N source, rate and method of application on plant growth, yielding ability and physical and

chemical characteristics of pods. The N sources (ammonium nitrate, ammonium sulphate and urea) were applied at rates of 33 and 66 kg N/fed through the two application methods namely surface continuous band (SCB) and surface localized band (SLB).

The results obtained from this experiment can be summarized in the following:

a) Plant growth:

1. Plant height was not affected significantly by N source, rate and method of application in the two growing seasons.
2. Plants fertilized with ammonium nitrate had the highest number of leaves/plant, followed by those received ammonium sulphate, while the other treated with urea had the lowest number of leaves, in both seasons. Furthermore, increasing N rate resulted in significant increase in number of leaves/plant in both seasons with all N treatments.
3. The effect of N source on leaf area was followed this order: urea > ammonium sulphate > ammonium nitrate. Nitrogen rate showed a significant effect on leaf area only in the second season.
4. The highest dry weight of plant was obtained with ammonium nitrate and ammonium sulphate which significantly did not exhibit any difference compared each other in the first season. The lowest dry weight of plant was recorded when N was applied as urea fertilizer with significant difference in both seasons compared to the other two sources. Increasing N fertilization dose resulted in a significant increase in dry matter production with all N sources during the two seasons.

5. Application of N through surface continuous band method significantly increased the dry weight of plant comparing with surface localized band method.

b) Yielding ability:

1. The yield of Extra pods was affected positively and significantly by N source. Ammonium nitrate was the superior and urea was the inferior. The yield was increased as the rate of N application increased except with urea, whereas the yield was decreased by increasing the rate. This was true in both growing seasons.
2. The effect of N source on Fine pods yield was followed the following order: ammonium nitrate>urea> ammonium sulphate with significant difference compared to each other, in both growing seasons. The highest values of Fine pods yield, in both seasons, were concomitant with the highest level of applied nitrogen except with urea the high dose of nitrogen significantly retarded the pods production.
3. The highest yield of Bobby pods was concomitant with ammonium sulphate source, while the lowest was recorded with ammonium nitrate. Concerning the effect of rate, there is a significant decrease in the yield of Bobby pods as a result of increasing the rate of ammonium nitrate and ammonium sulphate. However, the yield was increased sharply with increasing the rate of urea. Similar effects of ammonium nitrate and urea on the yield were obtained in the second season, but increasing the rate of ammonium sulphate increased the production of Bobby pods.

c) Physical and chemical characteristics of pods:

*** Physical characteristics of pods:**

1. The lowest average length of pods was recorded when N was applied as ammonium nitrate with significant difference compared to the other two sources (ammonium sulphate and urea) which significantly did not exhibit any difference compared to each other, in both seasons. The pods length of Extra category was not affected significantly by N rate in the two growing seasons.
2. The least values of length trait were obtained after ammonium sulphate application with significant difference compared to the other two sources. Nitrogen rates did not induce any significant effect on length of Fine pods, in both seasons.
3. The effect of N source on Extra pod diameter was followed this order: ammonium nitrate > ammonium sulphate > urea.
4. The most effective N source on Fine pod diameter was ammonium nitrate followed by urea and the least effective was ammonium sulphate.
5. In both growing seasons, the higher values of Extra and Fine pods diameter were significantly concomitant with the highest level of the applied nitrogen.
6. The effect of N source on Extra pod dry weight was followed this order: ammonium nitrate > ammonium sulphate > urea. Increasing the dose of applied nitrogen was accompanied by significant increase of about 7.4% in dry weight of Extra category.

7. The following order describes the effect of N source on Fine pod dry weight: ammonium nitrate > urea > ammonium sulphate. Increasing N fertilization dose resulted in a significant increase in dry matter production during the two seasons.

**** Chemical characteristics of pods:**

1. The fibers content in Extra pods was ranged from 0.01 to 0.04%. Neither N source and rate nor method of application had a marked effect on fibers content in Extra pods, in both growing seasons, indicating that this category is free from fibers.
2. The fibers content in Fine pods was ranged from 3.9 to 5.8%. The effect of N source on fibers content of Fine category was followed this order: ammonium sulphate > urea > ammonium nitrate with significant difference compared to each other during the two growing seasons. Concerning the effect of N rate, there is a significant decrease in the fibers content of Fine pods as a result of increasing the rate of N in both seasons. Moreover, the surface localized band method gave a relatively high effect on fibers trait, in the two growing seasons.
3. The fibers content in Bobby pods ranged from 29.9 to 60%. Therefore this category is practically unexportable because the fibers content was too high .
4. The effect of N source on fibers content of Bobby category was followed this order: ammonium sulphate > urea > ammonium nitrate. Increasing the nitrogen rate resulted in a significant decrease in the fibers bontent of this category in both seasons.

5. The effect of N source on protein content of Extra pods was followed this order: ammonium nitrate > ammonium sulphate > urea. Nitrogen rates did not induce any significant effect on protein content of Extra pods, in both seasons.
6. The surface continuous band method gave the superior results with significant effect compared with the other method of application in both seasons.
7. The effect of N source on protein content of Fine pods was followed this order: ammonium nitrate > urea > ammonium sulphate with significant effect in both seasons.
8. The protein content in Fine pods was decreased significantly with increasing N rate, in the first season. However, a poor relationship between protein content and N rate was found in the second one.
9. The protein content was affected significantly by the methods of application, only in the first season. Furthermore, the surface continuous band method gave a relatively high effect on protein content of Fine category, in both growing seasons.

Generally, application of ammonium nitrate fertilizer at a rate of 66 kg N/ha through surface continuous band method was commercially the best of all fertilization treatments. Such a treatment gave the highest commercial exportable yield with quite excellent pod characteristics during the two growing seasons.

B) Drip irrigation experiment:

This investigation aimed at studying the efficacy of ammonium nitrate fertilizer when applied through drip irrigation or as surface continuous band

under submersion irrigation systems. The ammonium nitrate was applied at the rate of 0, 33 and 66 kgN/feddan.

The results of this experiment could be summarized as follows:

a) Plant growth:

1. Plant height was increased significantly as the rate of N increased from 0 to 33 kgN/fed under the two irrigation methods. Increasing N rate from 33 to 66 kgN/fed resulted in a slight decrease in plant height when the N was applied through the drip irrigation system.
2. The plant heights in the drip irrigated plots were increased over the submerged ones by about 7.5, 15.6 and 6.4% for the 0,33 and 66 kg N/fed, respectively.
3. The leaf area was increased significantly with increasing N rate and the highest leaf area was obtained with the highest N rate (66 kg N/fed) under the two irrigation regimes.
4. The dry weight of plant exhibited a positive response towards drip irrigation system of about 7.5 and 10.0% for the 33 and 66 N dose, respectively, as compared with those irrigated by the other one.
5. The number of leaves/plant was increased significantly with increasing the application rate and the highest number was obtained with the highest N rate (66 kgN/fed) with the two irrigation systems.

b) Yielding ability:

The drip irrigation system exhibited a positive effect on the yield of Extra and Fine categories showing an increase of about 24.8 and 21.3% for the 33 kgN/fed and 13.8 and 26.2% for 66 kgN/fed over the plants fertilized

with the same doses of N fertilizer under submersion irrigation regime. However, the total yield of submerged plants was higher than that of drip irrigated ones because of the occurrence of undesirable Bobby category.

c) Physical and chemical characteristics of pods:

*** Physical characteristics of pods:**

1. Regarding the drip irrigation system, application of N fertilizer to plants did not induce any significant effect on the average length of Extra pods in all treatments. However, significant increase was observed with increasing N rate in case of using the submersion irrigation regime.
2. The pod length of the Fine category was increased significantly with increasing N rate under drip and submersion irrigation conditions.
3. The 33 kg N/fed was the best N dose affecting the length and diameter of Extra pods through drip irrigation system which accompanied with the highest length (10.0 cm) and quite good diameter character (6.5 mm). However, 66 kgN/fed was the most effective dose on diameter and length of Extra pods under submersion irrigation system as well as on the same character of the Fine pods under both regimes.
4. There were a continuous increments in dry matter of Extra and Fine pods with increasing N rate from 0 to 66 kgN/fed under both irrigation conditions. However, pod dry weight of drip irrigated plants was higher than that of submerged ones.

**** Chemical characteristics of pods:**

1. There is a gradual decrease in fibers content of Extra and Fine with increasing N rate under both irrigation systems. Fine category produced more fibrous pods, while those of Extra grade contained the least amount

of fibers. This was true under the two irrigation systems.

2. Extra pods was the richest category in their protein content. The protein content in pods was increased significantly with increasing N dose and the highest value was obtained with the highest N rate (66 kgN/fed) with the two irrigation systems. Moreover, the superiority was recorded for the drip irrigation regime.
3. Extra pods was the richest category in the chlorophyll content. There were a significant increase in chlorophyll content in Extra and Fine pods with increasing the level of the applied nitrogen under both irrigation systems.
4. 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 kgN/fed, respectively. However, Fine pods produced under drip irrigation regime was lower in their carbohydrate content than that of submerged ones by about 1.9, 7.9 and 16.5% for 0,33 and 66 kgN/fed, respectively.

d) Nutrient content of *Phaseolus vulgaris* plant:

The results indicated that blades were the best representative organ for the nutritional status in plants. Blades analysis showed that the 66 kgN/fed treatment was the best one which increased the concentration of N,P, Ca and Mg; but decreased K concentration.