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EFFECT OF INOCULATION WITH *Bradyrhizobium* Sp., *Va-mycorrhizae* AND FERTILIZATION WITH NITROGEN ON COWPEA YIELD AND QUALITY

Abd El-Ati, Y.Y.; M.Y. EL-Maziny; M.M. Farrag and K.A.A. El-Shaikh

Hort. Dept. Fac. Agric., El-Minia University, Egypt.

Agriculture Research Center, Ministry of Agriculture, Egypt.

ABSTRACT

This experiment was carried out during the two successive Summer seasons of 1996 and 1997 on cowpea cv. "Cream 7" plants at Shandaweel Agriculture Research Station, Sohag Governorate, Egypt. The objective of this study was to investigate the effect of inoculation with *Bradyrhizobium sp* and VA-mycorrhizae as well as four rates of nitrogen fertilizer, i.e., the recommended dose (30kg N/fed), three fourth, one half and one fourth of the recommended dose on the fresh yield, dry seed yield and quality of cowpea. Also, the possibility of reducing rate of chemical N fertilizer needed for cowpea plants was an important aim in order to reduce production cost and reducing the environmental pollution.

The obtained results indicated that the inoculation of cowpea plants cv. "Cream 7" with the dual inocula of *Bradyrhizobium* sp., plus VA-mycorrhizae combined with 15.0 kg/N fed. (one half the recommended rate of chemical N fertilizer) gave the highest values for all studied traits i.e. plant height “cm”, number of branches/plant, total fresh pods yield (ton/fed.), pod setting and filling percentage, dry seed yield (ton/fed.), average weight of 100 seeds :g” , shellout percentage, percentage of protein, phosphorus and potassium in plants, and percentage of protein, phosphorus, potassium in the dry seeds. Therefore, the use of combined inocula as biofertilizers may replace the application of 15.0 kg N/fed.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is considered to be one of the most important legume crops grown in Summer season in Egypt for its highly nutritional value. The total cultivated area of cowpea in Egypt was gradually increased during the last several years. The growing area was estimated to be 14170 fed. for the dry seeds production in 1995 with a mean value of 950 kg/fed. Also, the estimated area for the fresh pods production was 10991 fed with a mean value of 3.15 ton/fed* during the same year. The use of biofertilizers is of a great agricultural importance since they can be used as alternatives for chemical fertilizers and hence the production costs of

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* **Data from Agric. Statistics Dept. Agric. Res. Center, Cairo. (1995)**

agricultural crops can be reduced and environmental pollution can be avoided (Abdel-Ati *et al.*, 1996).

Meenakumari and Nair (1992) reported that plants of cowpea cv."C 152" grown in pots in soil inoculated with both *Glomus microcarpum* and *Rhizobium* and given rock phosphate at the rate of 30 kg P_2O_5/ha produced the greatest plant dry weight after 45 days. In addition, several reports have clearly declared that vesicular-arbuscular mycorrhizal fungi caused better absorption of nutrients by plants, specially phosphorus which was found in high concentrations in the endomycorrhizal plants (Khalifa and Badr, 1992). Ibijbijen *et al.* (1996) indicated that inoculation with (AM) fungi significantly increased the production of dry matter by 8-23% and the concentration of P in plants by 160-335%. They also, found a strongly positive correlation between root colonization % with AM fungi and plant P concentration in plants .The observed accumulation suggested that the observed inoculation responses were resulted from improving P acquisition by the mycorrhizal roots. Das *et al.* (1997) in their study on *Vigna radiata* cv. “Nayagrah local”, inoculated seeds with *Rhizobium* and/or vesicular arbuscular mycorrhizae VAM, *Glomus fasciculatum*. Culture was applied at the rate of 15 kg/ha. Shoot and root lengths, number of nodules, number of pods/plant, dry weight of pods and uptake of N and P were increased with using the dual inoculation when compared to the uninoculated control. Seed yield was significantly higher with *Rhizobium* plus VAM treatment when compared to the uninoculation treatment.

The present experiment aimed to study the effect of inoculation with *Bradyrhizobium* sp., VA-mycorrhizae and the addition of nitrogen fertilizer on cowpea yield and quality. This investigation was designed as an attempt to investigate the possible use of the prementioned microorganism as an effective alternative for using the chemical fertilizers in cowpea production.

MATERIALS AND METHODS

The present study was carried out at Shandaweel Agriculture Research Station, Sohag Governorate, Egypt. The experiments were conducted during the 1996 and 1997 Summer seasons. The experimental soil was sandy loam. The physical and chemical characteristics of soil illustrated in Table (1) were determined before sowing according to the methods reported by Wilde *et. al*. (1985). The aim of this study was to investigate the effect of inoculation with *Bradyrhizobium* sp. and/or *VA-mycorrhizae* on the growth, quality and fresh and dry yields of cowpea cv. “Cream 7”. Also, the possibility of reducing amount of chemical N fertilizer as a result of such inoculations was investigated in order to reduce the environmental pollution and production cost.

The preceding crop prior to the present study were Egyptian clover (*Trifolium alexandrinum*), in both seasons. The experimental field were prepared and shaped to ridges 50 cm. wide and 3.5 m long.. Each experimental plot was 3 x 3.5 m and contained six ridges. (two ridges were

used to determine the fresh yield parameters and the other four ridges for the dry yield parameters .

Table 1: Mean of physical and chemical analysis of experimental soil.

Anions	Conc. ml/100g	Cations	Conc. Ml/100g		%
$CO_3^=$	Absent	Ca^{++}	0.98	T.T.S.	0.12%
$HCO_3^=$	1.07	Mg^{++}	0.71	PH	7.7
Cl^-	0.57	Na^+	0.40	$CaCO_3$	1.02%
$SO_4^=$	0.55	K^+	0.98	O.M	0.9%

Soil texture: sandy 1oam

Soil Fertility: Available N = 50 P. P. m Available P = 9.9 P. P. m Available K = 141 P. P. m

Bradyrhizobium sp. was obtained from the Microbiology Dept., Soil and Water Research Institute, Agric. Res. Center, Giza, Egypt.

Seeds of cowpea were inoculated before cultivation. Uninoculated seeds were also involved as a control. Gum Arabic solution 40% was used as an adhesive material at the rate of 3 ml/100 g seeds. Two species of endomycorrhizal fungi vesicular-arbuscular mycorrhizae (*Glomus fasiculatum & Glomus mosseas*) were obtained from the Botany Dept., Fac. Agric., Tanta University, Kafr-El-Sheikh, Egypt. The prepared VAM inoculum was added. Approximately $4x10^5$ spores and mycelia for each plot, when sowing seeds. The spores count was found to be 100 spores/1g soil in VAM inoculum.

Four rates of N fertilizer were tested in the present study i.e., the recommended dose (30 kg N/fed.), three fourth of the recommended dose (22.5 kg N/fed.), one half of the recommended dose (15 kg N/fed.) and one fourth of the recommended dose (7.5 kg N/fed.). Nitrogen fertilizer was applied in the form of ammonium sulphate (20.5%N) and added after 35 days from sowing with the first irrigation.

The experimental design was complete randomized block with three replicates. Each replicate contained one of the following treatments:

1- Control (seeds without inoculation and fertilization).
2- Inoculation of seeds with *Bradyrhizobium* sp.
3- Inoculation with (VAM) fungi.
4- Inoculation with *Bradyrhizobium* sp and (VAM).
5- The recommended nitrogen fertilization (30 kg N/fed).
6- Inoculation with *Bradyrhizobium* sp. and (VAM) and fertilized with 22.5 kg N/fed.
7- Inoculation with of *Bradyrhizobium* sp. and (VAM) and fertilized with 15 kg N/fed.
8- Inoclation with *Bradyrhizobium* sp. and (VAM) and fertilized with 7.5 kg N/fed.
9- Inoculation with *Bradyrizobium* sp. and fertilized with 22.5 kg N/fed.
10- Inoculation with *Bradyrizobium* sp. and fertilized with 15 kg N/fed.
11- Inoculation with *Bradyrizobium* sp. and fertilized with 7.5 kg N/fed.
12- Inoculation with (VAM) and fertilized with 22.5 kg N/fed.
13- Inoculation with (VAM) and fertilized with 15 kg N/fed.
14- Inoculation with (VAM) and fertilized with 7.5 kg N/fed.

Seeds of cowpea cv. "Cream 7" were sown on the first of May in 1996 and 1997 seasons in hills at 10 cm. apart on one side of the ridge. Growing plants were thinned to two plants per hill after two weeks from planting. The normal culture procedures known for commercial cowpea production other than the applied treatments were followed.

After 30, 60 and 90 days from sowing date, ten plants were taken from each plot to determine plant dry weight, number and dry weight of the nodules. The above ground portions of these plant samples were used for chemical analysis to determine the percentages of nitrogen, phosphorus and potassium. Nitrogen was determined by the modified macro Kjeldahl's methods (A.O.A.C, 1980) and percentage of protein was then determined. Phosphorus was determined colorimetrically as described by Jackson (1967) and potassium was determined by flame photometer.

Recorded data:

A- Vegetative growth:

Twenty days before the end of the growing season, ten plants were randomly chosen in each plot to determine the following characters:

1- Plant height (cm.)

2- Number of branches/plant.

B- Fresh pod yield characters:

Seven harvests were done and cowpea pods were picked at six days intervals then the following data were recorded:

1- Total fresh pods yield; ton/fed.

Also, thirty fresh pods were taken at random from each experimental plot at the second harvest to record the fresh pod characters as follows:

2- Pod setting % = No. of seeds / No. of ovules x 100

3- Pod filling % calculated according to Remison (1978) as follows:

Pod filling % = No. of seeds/pod / Fresh pod length (cm) x 100

C- Dry seed yield characters:

Harvesting of dry pods were carried out three times before dropping off their seeds and the following data were recorded:

1- Dry seed yield; ton/fed.

2- Average weight of 100 seeds, g.

3- Shellout percentage (%), where:

Shellout % = Dry seed yield/fed. / Dry pod yield/fed. X 100

Random samples of seeds were taken after harvesting and dried at 70^{o}C.The dried samples were ground and used for the determination of N, P and K

All obtained data were subjected to the statistical analysis and the treatment means were compared using the Duncan's new multiple range test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

VAM-root colonization:

Percentages of mycorrhizal root colonization in cowpea plants as affected by different treatments were assessed microscopically (Table 2).

Table (2):Effect of inoculation with *Bradyrhizobium* sp., vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer on the percentage of (VAM) root colonization after 30, 60 and 90 days from sowing dates in 1996 and 1997 seasons.

Treatments	30 days after sowing		60 days after sowing		90 days after sowing	
	1996	1997	1996	1997	1996	1997
Uninoculated	4.25	5.31	6.16	6.50	9.30	8.20
Bradyrhizobium sp. (B.)	6.82	7.15	8.21	8.45	10.11	9.87
Mycorrhizae (M.)	42.33	43.51	45.70	47.61	51.30	49.93
(B.) + (M.)	46.71	47.00	48.11	49.85	57.31	55.98
30 kg nitrogen (N)	7.30	7.71	8.90	9.64	11.30	11.00
B. + M. + 22.5 kg N	46.9	45.5	49.00	50.1	59.14	60.60
B. + M. + 15 kg N	53.31	55.81	66.14	68.97	71.22	73.42
B. + M. + 7.5 kg N	49.21	48.90	54.62	54.00	64.31	63.90
B. + 22.5 kg N	7.11	8.25	9.25	10.36	12.00	11.95
B. + 15 kg N	10.11	10.84	12.27	12.77	16.31	15.75
B. + 7.5 kg N	7.23	8.82	9.61	10.00	12.09	13.42
M. + 22.5 kg N	44.37	43.49	47.15	48.68	53.11	54.56
M. + 15 kg N	51.43	51.88	63.18	63.62	64.10	65.00
M. + 7.5 kg N	47.12	47.09	52.34	51.93	61.40	61.83

Data in Table (2) indicate that inoculation of plants with VAM fungi separately or combined with *Bradyrhizobium* sp. in presence or absence of different doses of chemical N-fertilizer dramatically increased the percentage of mycorrhizal root infection as compared to the uninoculated plants in both seasons. The low percentages of mycorrhizal infection in the uninoculated plants indicate that the VAM fungi are natively present in the experimental location but in low density.

Inoculation with *Bradyrhizobium* sp. combined with VAM, led to higher percentages of VAM root colonization than in case of inoculation with VAM alone. This can be explained by the postulates of Mosse (1962) who suggested that bacterial compounds act on the cell wall of plants, thereby affecting their plasticity and consequently increase the susceptibility of plant root to fungal infection. Application of chemical N-fertilizer to plants inoculated with VAM plus *Bradyrhizobium* sp. resulted in increasing percentages of VAM root infection. Chemical N-fertilizers may have stimulative effect on VAM fungi. The highest percentages of VAM infection was obtained with the application of ½ the recommended N-dose to plants received dual inocula (*Bradyrhizobium* sp. + VAM) in both seasons, followed by the inoculation treatment with both inocula and received only one fourth of the recommended dose of chemical N. However, data in Table (2) indicated that VAM

colonization were increased with increasing number of days from sowing date (increasing plant age) for all treatments.

Nodulation of cowpea roots:

Number and dry weight percentage of root nodules/plant in the three sampling times in the two seasons (1996 and 1997) are shown in Tables (3, 4) Incoulation of cowpea plants with the effective strain of *Bradyrhizobium* sp. resulted in the formation of higher numbers of root nodules/plant as compared to the uninoculated plants.Further increases in values of these measurements were achieved with the dual inoculation with VAM fungi and *Bradyrhizobium*. Such results may indicate that VAM fungi may have stimulative effect on root nodule bacteria (Khalifa and Badr, 1992).

Under any inoculation treatment (inoculation with *Bradyrhizobium* and/or VAM), application of different doses of chemical nitrogen fertilizer resulted in higher values of number and percentage of dry weight of nodules/ plant as compared to the unfertilized plants. The increase in values of these measurements depended on the amount of applied N-fertilizer. The highest number and dry weight percentage of nodules/plant were recorded in plants received 15 kg N/fed. Whereas, application of more or less than 15 kg N/fed, resulted in lower values of these measurements. This may indicate that the high amount of chemical N-fertilizer may inhibit the nodulation process. However, the medium dose (15 kg N/fed) may have activating effect on nodulation.

Table (3):Effect of inoculation with *Bradyrhizobium* sp. and vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer on number of nodules/plant in the first, second and third sample (after 30, 60 and 90days from sowing date, respectively) in 1996 and 1997 seasons.

Treatments	Number of nodules/plant (first sample)		Number of nodules/plant (second sample)		Number of nodules/plant (third sample)	
	1996	1997	1996	1997	1996	1997
Uninoculated	9.60 K	11.30 M	7.70 I	8.30 J	5.40 J	8.50 K
Bradyrhizobium sp. (B.)	12.70 J	15.30 K	18.30 DEF	19.90 FG	15.90 GH	11.60 H
Mycorrhizae (M.)	12.30 J	13.30 L	18.30 DEF	17.60 H	12.00 I	10.50 I
(B.) + (M.)	16.70 H	18.60 H	18.70 DEF	20.30 F	18.00 EF	16.50 F
30 kg nitrogen (N)	19.70 F	16.10 J	14.30 H	15.50 I	15.90 H	9.80 J
B. + M. + 22.5 kg N	23.00 E	21.60 F	20.00 CDE	21.20 E	17.30 FG	14.90 G
B. + M. + 15 kg N	29.90 A	33.80 A	23.20 B	33.50 A	33.30 A	30.90 A
B. + M. + 7.5 kg N	26.90 B	30.80 C	18.00 EF	19.70 G	20.20 D	23.60 C
B. + 22.5 kg N	14.00 I	18.20 I	18.90 DE	20.10 FG	12.50 I	16.90 F

B. + 15 kg N	25.20 CD	29.90 D	15.30 GH	17.90 H	28.50 C	29.40 B
B. + 7.5 kg N	18.50 G	20.20 G	16.70 FG	17.70 H	18.00 EF	20.70 D
M. + 22.5 kg N	24.50 D	24.10 E	20.30 CD	22.40 D	18.90 DE	20.00 E
M. + 15 kg N	27.70 B	31.30 B	27.90 A	25.20 B	31.70 B	29.60 B
M. + 7.5 kg N	25.80 C	30.10 D	21.60 BC	23.50 C	19.50 D	20.40 DE

Means followed by the same letter or letters are not significantly different at the 5% level.

Table (4):Effect of inoculation with *Bradyrhizobium* sp., vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer on percentage of dry matter of nodules/plant in the first, second and third sample (after 30, 60 and 90 days from sowing date, respectively) in 1996 and 1997 seasons.

Treatments	dry matter % of nodules/plant (first sample)		dry matter % of nodules/plant (second sample)		dry matter % of nodules/plant (third sample)	
	1996	1997	1996	1997	1996	1997
Uninoculated	14.30 F	18.90 H	13.70 H	14.50 I	13.90 G	11.40 I
Bradyrhizobium sp. (B.)	27.10 BC	20.40 G	19.30 G	17.60 H	10.30 H	12.90 H
Mycorrhizae (M.)	24.30 CD	18.90 H	23.40 EF	26.50 E	17.30 F	16.30 F
(B.) + (M.)	27.70 BC	23.70 E	22.70 F	24.40 F	22.20 BCD	20.90 CD
30 kg nitrogen (N)	24.20 CD	21.40 F	26.10 C	27.20 D	14.00 G	10.50 J
B. + M. + 22.5 kg N	28.40 B	24.20 D	26.70 C	28.40 C	23.20 BC	20.40 D
B. + M. + 15 kg N	36.30 A	35.40 A	31.20 A	32.40 A	39.80 A	27.10 A
B. + M. + 7.5 kg N	21.10 DE	24.00 DE	26.20 C	30.20 B	21.40 CDE	21.70 C
B. + 22.5 kg N	22.00 DE	19.00 H	25.50 CD	26.20 E	17.20 F	15.40 G
B. + 15 kg N	27.30 BC	30.10 B	23.90 DEF	22.30 G	18.90 EF	19.20 E
B. + 7.5 kg N	15.10 F	20.30 G	24.90 CDE	26.10 E	19.90 DEF	20.30 D
M. + 22.5 kg N	24.80 BCD	27.00 C	26.00 C	24.50 F	24.90 B	21.10 CD
M. + 15 kg N	24.30 CD	26.80 C	29.60 AB	32.10 A	24.80 B	22.80 B
M. + 7.5 kg N	20.00 E	21.50 F	28.80 B	27.40 D	21.40 CDE	21.70 C

Means followed by the same letter or letters are not significantly different at the 5% level.

Plant height (cm.) and number of branches/plant

Data in Table (5) showed that inoculation of cowpea plants with VA-mycorrhizal fungi separately or combined with *Bradyrhizobium* sp. in the presence or absence of different doses of chemical N-fertilizer dramatically increased plant height (cm.) and number of branches/plant. In addition, inoculation with *Bradyrhizobium* sp. combined with VA-mycorrhizal fungi led to have higher values of the prementioned characters than in case of inoculation with Bradyrhzobium or VA-mycorhiza solely. Moreover, inoculation with either *Bradyrhizobium* or VA-mycorrhiza led to significant increase in

plant height (cm.) and number of branches as compared to the uninoculated treatment.

Application of chemical N-fertilizer to plants inoculated with VAM plus *Bradyrhizobium* sp. resulted in higher values of these characters. The highest values were obtained with the application of ½ recommended N-dose (15 kg N/fed) to the plants received dual inocula (*Bradyrhizobium* sp. + VAM). These results held good in both seasons and in agreement with those obtained by Soddi *et al.* (1994).

Percentage of dry matter of the above ground vegetative portion:

Data in Table (6), showed that dry weight of plants were gradually increased with increasing the age of plants. Also this trait significantly increased by the inoculation with *Bradyrhizobium* sp. when compared to the uninoculated plants in both seasons. These results are in harmony with those obtained by Hassan *et al.* (1990). Data in Table (6) showed that inoculation of cowpea plants with vesicular arbuscular mycorrhizae (VAM) gave almost the same trend of inoculation with *Bradyrhizobium* sp. in both experimental seasons. Moreover, the inoculation with *Bradyrhizobium* in combination with *VA-mycorrhizae* increased the dry matter of plants gradually with increasing the age of plants in both seasons. Also, this interaction led to significant increase in the dry matter of plants as compared to the uninoculated plants or inoculated with either *Bradyrhizobium* sp. or *VA-mycorrhizae* separately in both seasons. Similar results were obtained by Das *et al.* (1997). Application of chemical N-fertilizer to plants inoculated with VAM and *Bradyrhizobium* sp. gave higher percentage of dry matter of cowpea plant. However, the highest values were obtained from the application of ½ the recommended N-dose (15 kg N/fed.) to plants received dual inocula (*Bradyrhizobium* sp. + VAM). On the other hand, the application of 7.5 kg N/fed. to plants received dual inoucla achieved nearly the same results except in the first season and the second sample of both seasons.

Table (5):Effect of inoculation with *Bradyrhizobium* sp., and vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer rate on plant height and number of branches/plant in 1996 and 1997 seasons.

Treatments	Plant height (cm)		Number of branches/ plant	
	1996	1997	1996	1997
Uninoculated	82.10 F	78.80 J	5.30 E	5.00 H
Bradyrhizobium sp. (B.)	87.00 E	85.30 I	6.20 CD	5.90 FG
Mycorrhizae (M.)	87.30 E	89.00 F	5.30 E	5.90 FG
(B.) + (M.)	94.40 C	92.80 D	6.30 CD	6.40 DE
30 kg nitrogen (N)	84.00 F	84.80 I	5.90 CDE	5.90 FG
B. + M. + 22.5 kg N	95.10 BC	98.50 A	6.60 BCD	6.60 D
B. + M. + 15 kg N	99.30 A	98.60 A	7.50 A	8.20 A

B. + M. + 7.5 kg N	87.00 E	86.60 H	6.70 BC	7.80 B
B. + 22.5 kg N	97.20 AB	97.40 B	6.30 CD	6.10 EF
B. + 15 kg N	88.70 E	88.60 F	5.80 DE	6.60 D
B. + 7.5 kg N	86.70 E	87.30 G	5.20 E	5.50 G
M. + 22.5 kg N	88.50 E	95.00 C	6.40 CD	6.70 D
M. + 15 kg N	93.30 CD	92.60 D	7.20 AB	7.90 AB
M. + 7.5 kg N	91.40 D	90.70 E	6.30 CD	7.20 C

Means followed by the same letter or letters are not significantly different at the 5% level.

Table (6): Effect of inoculation with *Bradyrhizobium* sp., and vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer on percentage of dry matter of plants in the first,second and third samples in 1996 and 1997 seasons.

Treatments	Dry matter % of plants (30 days after sowing)		dry matter % of plants (60 days after sowing)		dry matter % of plants (90 days after sowing)	
	1996	1997	1996	1997	1996	1997
Uninoculated	12.60 H	13.00 F	17.30 G	17.50 H	18.00 G	16.60 H
Bradyrhizobium sp. (B.)	13.60 FG	13.50 E	19.00 EF	19.00 EFG	19.90 DE	19.80 E
Mycorrhizae (M.)	13.70 EF	13.10 EF	19.10 EF	19.00 EFG	18.60 F	18.60 F
(B.) + (M.)	14.50 CD	14.20 CD	19.80 CD	19.70 C	20.00 DE	19.90 DE
30 kg nitrogen (N)	13.40 G	13.10 EF	18.70 F	18.70 FG	18.50 F	18.10 F
B. + M. + 22.5 kg N	14.60 C	14.30 CD	19.00 EF	18.90 EFG	20.50 BC	20.00 DE
B. + M. + 15 kg N	15.40 A	15.30 A	21.60 A	21.20 A	22.00 A	22.10 A
B. + M. + 7.5 kg N	15.10 B	15.00 AB	20.40 B	20.50 B	21.90 A	21.50 AB
B. + 22.5 kg N	13.70 EF	13.50 E	19.30 E	19.30 CDE	19.70 E	20.40 CDE
B. + 15 kg N	14.30 D	14.00 D	19.40 DE	18.90 EFG	18.30 FG	16.90 GH
B. + 7.5 kg N	13.90 E	13.40 EF	18.90 EF	18.60 G	18.30 FG	17.40 G
M. + 22.5 kg N	12.60 H	12.50 G	19.10 EF	19.10 DEF	20.80 B	20.90 BC
M. + 15 kg N	15.40 A	15.20 A	19.90 C	19.60 C	20.70 B	20.60 CD
M. + 7.5 kg N	14.90 B	14.60 BC	20.00 BC	19.50 CD	20.20 CD	20.30 CDE

Means followed by the same letter or letters are not significantly different at the 5% level.

Seed setting percentage:

Data in Table (7) showed that inoculation of plants with *Bradyrhizobium* sp. and/or VAM was very effective in increasing seed setting percentage as compared to the uninoculated plants in both experimental seasons. The differences were announced and statistically approved in both seasons. The improving effect of inoculation on seed setting percentage might be due to its effect in enhancing the uptake of nutrients and the nutritional status of the plants in favour of forming more seeds and consequently higher seed setting percentage. These results are in accordance with Hassan *et al.* (1990). Data in Table (7) showed that the inoculation of cowpea plants with *VA-mycorrhizae* positively affected this character in both seasons. These results could be explained in the light of the

fact that hyphae explore a much greater volume of soil. It can be suggested that mycrorrhizal roots can obtain up to 60 times of the soil minerals as the amount that can be taken from the soil by the non-mycorrhizal roots (Bieleski 1973). Regarding the effect of dual inoculation results showed the same general trend in both experimental seasons. In addition, application of chemical N-fertilizer to the plants inoculated with *Bradyrhizobium* sp., VA-mycorrhizae or dual inocula led to significant increases in the prementioned trait as compared to the uninoculated plants. Whereas, the highest values were resulted from plants inoculated with dual inocula and received 15.0 kg N/fed. in both experimental seasons.

Pod filling %:

Data in Table (7) showed that inoculation with *Bradyrhizobium* sp. or VA-mycorrhizae increased pod filling. Moreover, application of dual inocula resulted in higher percentage of pod filling in both seasons. Data in Table (7) showed that pod filling increased with application of nitrogen fertilizer to plants received dual inocula or each inoculum separately in the two experimental seasons. However, the higest values of pod filling percentage were obtained from plants inoculated with VAM and fertilized with 15 kg N/fed., In the first season and those plants inoculated with *Bradyrhizobium* and fertilized with 15 kg N/fed, in the second season. Moreover, most treatments were not significantly different from each other in treir pod filling percentages, in both seasons.

Total fresh pod yield (ton/fed.)

Data in Table (7) indicate that the inoculation of plants with VA-mycorrhizae separately or combined with *Bradyrhizobium* sp. in the presence or absence of different doses of nitrogen chemical fertilizer dramatically increased the total fresh pod yield (ton/fed.), as compared to the uninoculated plants in both seasons. Moreover, data in Table (7) showed that inoculation with VA-mycorrhizae has almost similar effect as that of *Bradyrhizobium* sp. in improving this trait in both seasons. Such results could be attributed to the positive effect of each of the used inoculum (i.e., *Bradyrhizobium* sp. or VA-mycorrhizae) in enhancing some traits such as

Table (7):Effect of inoculation with *Bradyrhizobium* sp., vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer on pod filling percentage, seed setting % and total fresh yield (ton/fed) in 1996 and 1997 seasons.

Treatments	Pod filling %		Seed setting %		Total fresh yield ton/fed	
	1996	1997	1996	1997	1996	1997
Uninoculated	65.00 B	50.60 B	72.20 H	48.80 F	2.86 D	2.30 E
Bradyrhizobium sp. (B.)	65.20 B	55.90 AB	74.60 DEFG	70.20 DE	3.41 D	3.34 BCD
Mycorrhizae (M.)	67.60 B	62.40 AB	73.80 FGH	73.10 BC	3.44 D	3.32 BCD
(B.) + (M.)	68.30 B	65.00 AB	77.60 AB	71.80 CD	3.79 BCD	3.34 BCD
30 kg nitrogen (N)	66.50 B	59.50 AB	74.10 EFGH	70.90 DE	3.40 D	2.90 D
B. + M. + 22.5 kg N	68.90 B	71.00 AB	76.10 BCDE	74.30 AB	4.59 AB	3.87 B
B. + M. + 15 kg N	69.30 B	63.00 AB	78.90 A	75.40 A	5.34 A	4.80 A

B. + M. + 7.5 kg N	71.40 AB	72.50 AB	76.00 BCDE	70.50 DE	4.35 BC	3.76 BC
B. + 22.5 kg N	72.90 AB	68.10 AB	77.10 ABC	75.80 A	4.34 BC	3.28 BCD
B. + 15 kg N	71.60 AB	76.30 A	74.60 EFG	71.00 DE	3.19 D	2.77 D
B. + 7.5 kg N	65.70 B	69.70 AB	73.10 GH	69.50 E	2.97 D	2.68 D
M. + 22.5 kg N	71.10 AB	63.50 AB	70.60 BCD	73.30 BC	3.59 CD	2.74 D
M. + 15 kg N	78.30 A	75.80 AB	75.50 CDEF	69.10 E	5.28 A	3.96 B
M. + 7.5 kg N	68.30 B	58.60 AB	74.60 EFG	74.50 AB	3.56 CD	3.06 CD

Means followed by the same letter or letters are not significantly different at the 5% level.

number and weight of pods per plant ,Hassan *et al.* (1990). In addition, the dual inocula significantly increased the value of this character as compared to the uninoculated plants, in both seasons. Application of different doses of nitrogen to the dual inoculated plants significantly increased total fresh pod yield as compared to the uninoculated ones. However, the highest fresh pod yield was obtained from plants received dual inocula plus 15.0 kg N/fed. This treatment surpassed the uninoculated (control) plants with 46.4% and 52.1% in the first and second seasons, respectively.

Dry seed yield ton/fed.

Data in Table (8) indicated that the inoculation of cowpea plants with *Bradyrhizobium* sp. was very effective in enhancing dry seed yield ton/fed. as compared to the uninouculated plants. The difference between inoculation and uninoculation was highly significant in both seasons. The improving effect of inoculation on dry seeds yield of cowpea plants was reported by Baldeo, *et al* (1992). Moreover, data in Table (8) showed that inoculation with VA-mycorrhiza significantly increased dry seed yield as compared to the uninoculated plants. Whereas there was no significant difference between *Bradyrhizobium* sp. and VA-mycorrhizae when applied solely in this respect. These results are true in both seasons and are in agreement with those found by Ibijbijen *et al.* (1996). In addition, the dual inocula significantly increased the prementioned trait as compared to the uninoculated plants in both seasons. Supplying different doses of nitrogen to plants received any inoculum or dual inocula resulted in an increase in dry seed yield. The differences were statistically approved from the statistical point of view in the two experimental seasons. However, the highest values of this trait were obtained when cowpea plants received the dual inocula plus 15.0 kg N/fed. Also the prementioned treatment surpassed the uninoculated plants by 60.7% and 40.8% in the first and second season, respectively. Similar results were obtained by Soddi *et al.* (1994).

Table (8): Effect of inoculation with *Bradyrhizobium* sp., and vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer on dry seed yield ton/fed., average weight of 100 seeds (g). and shellout percentage in 1996 and 1997 seasons.

Treatments	Dry seed yield ton/fed,		Average weight of 100 seeds, g.		Shellout percentage %	
	1996	1997	1996	1997	1996	1997
Uninoculated	0.42 E	0.58 E	13.20 D	13.90 G	58.30 E	47.30 F

Bradyrhizobium sp. (B.)	0.75 CD	0.81 B	15.20 BC	14.20 FG	63.00 BCD	47.70 F
Mycorrhizae (M.)	0.65 CD	0.73 BC	15.70 B	15.00 CDE	60.80 CDE	47.80 F
(B.) + (M.)	0.76 CD	0.81 B	15.60 B	15.60 B	63.90 B	50.20 E
30 kg nitrogen (N)	0.83 BC	0.92 A	15.40 BC	14.90 DE	62.60 BCD	50.60 E
B. + M. + 22.5 kg N	0.79 CD	0.74 BC	16.40 A	15.30 BCD	62.60 BCD	54.50 C
B. + M. + 15 kg N	1.07 A	0.98 A	16.70 A	16.80 A	72.90 A	63.30 A
B. + M. + 7.5 kg N	0.98 AB	0.94 A	16.40 A	15.60 B	63.50 BC	54.70 C
B. + 22.5 kg N	0.75 CD	0.69 CD	15.00 C	14.60 EF	58.80 EF	49.50 E
B. + 15 kg N	0.64 D	0.72 BC	15.40 BC	15.00 CDE	60.60 DE	52.80 D
B. + 7.5 kg N	0.65 CD	0.60 DE	14.90 C	14.80 DE	62.60 BCD	53.40 CD
M. + 22.5 kg N	0.74 CD	0.65 CDE	15.00 C	14.90 DE	64.50 B	50.40 E
M. + 15 kg N	1.01 A	0.95 A	16.60 A	15.80 B	65.30 B	56.40 B
M. + 7.5 kg N	0.72 CD	0.72 BC	15.40 BC	15.50 BC	63.70 B	54.70 C

Means followed by the same letter or letters are not significantly different at the 5% level.

Average weight of 100 seeds, g.:

Data in Table (8) indicated that the inoculation of plants with *Bradyrhizobium*, VAM or the dual inocula increased average weight of 100 seeds, as compared to the uninoculated ones in both seasons. However, the differences were more announced and statistically approved in the first season. The effect of *Bradyrhizobium* sp. on improving of the nutritional status of the cowpea plants was reflected on increasing the availability and the movement of organic and mineral nutrients to plants and consequently increased average weight of 100 seeds .

Inoculation of cowpea plants with *VA-mycorrhizae* significantly increased the average of 100 seeds, as compared to the uninoculated plants in both seasons. These results may be due to the highly nutritional status of cowpea plants caused by mycorrhizal roots which can obtain up to 60 times of soil minerals as the amount that can be taken from the soil by non-mycorrhizal roots (Bieleski 1973). Furthermore, dual inocula significantly increased the average of 100 seeds weight as compared to the uninoculated plants in both experimental seasons. Supplying different doses of nitrogen in addition the dual inocula significantly increased average weight of 100 seeds, in both seasons. Whereas the highest values were recorded form plants received dual inocula plus 15.0 kg N/fed. Application of 22.5, 15.0 or 7.5 kg N/fed. to the dual inoculated plants resulted in no significantly differences in average weight of 100 seeds, in the first season.

Shellout percentage:

Data in Table (8) indicated that inoculation of plants with VA-mycorrhizae fungi separately or combined with *Bradyrhizobium* sp. in the presence or absence of different doses of nitrogen fertilizer increased the shellout percentage as compared to the uninoculated plants. Inoculation with *Bradyrhizobium* sp. or VA-mycorrhizae increased shellout percentage as compared to the uninoculated plants (control). Whereas, the differences were more announced and statistically approved from the statistical point of view in the first season only. In addition, dual inocula significantly increased shellout percentage as compared to the uninoculated plants. These results are true in

both experimental seasons. In both seasons, application of different nitrogen doses to plants inoculated with *Bradyrhizobium* sp., *VA-mycorrhizae* or dual inocula significantly increased shellout percentage as compared to the uninoculated plants.

Percentage of protein in plants:

Data in Table (9) indicated that the inoculation with *Bradyrhizobium* sp. significantly increased protein percentage in the three sampling times (30, 60 and 90 days from sowing) as compared to the uninoculated plants. The beneficial effect of inoculation in fixing atmospheric N could give an explanation for the detected increase in plant proteins. These findings are in agreement with those reported by Baldeo *et al* (1992). Inoculation of cowpea plants with *VA-mycorrhizae* significantly increased protein percentage as compared to the uninoculated plant in each sample. Data also showed that inoculation with *Bradyrhizobium* sp. plus VA-mycorrhizae resulted in significant increase in protein percentage as compared to the uninoculated plants. These results are true in any sampling time of both experimental seasons. These results are in agreement with those found by Das *et al.* (1997). Application of nitrogen fertilizer to the plants inoculated with dual inocula (i.e., *Bradyrhizobium* sp. plus *VA-mycorrhizae*) significantly increased protein percentage in the three samples in both seasons as compared to the uninoculated plants. However, the highest values of this character in the three samples were obtained when cowpea plants received the dual inocula plus 15.0 kg N/fed. in both seasons. These results are in accordance with those reported by Soddi *et al.* (1994).

Table (9):Effect of inoculation with *Bradyrhizobium* sp., and vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer on protein percentage in the vegetative portions of plants in the first, second and third sample in 1996 and 1997 seasons.

Treatments	protein % in the first sample		protein % in the second sample		protein % in the third sample	
	1996	1997	1996	1997	1996	1997
Uninoculated	15.12 G	15.17 G	13.32 G	13.66 F	12.03 G	12.05 G
Bradyrhizobium sp. (B.)	17.23 CD	17.35 C	16.49 D	16.50 BCD	12.55 F	12.66 FG
Mycorrhizae (M.)	17.59 C	17.36 C	16.61 CD	15.93 D	13.42 E	13.23 EF
(B.) + (M.)	17.26 CD	16.64 CDE	15.36 F	14.51 E	13.84 CDE	13.47 EF
30 kg nitrogen (N)	17.4 D	16.93 C	17.12 B	17.21 B	12.86 F	12.81 FG
B. + M. + 22.5 kg N	16.47 E	15.93 DEFG	16.99 BC	16.65 BCD	15.56 B	15.32 BC
B. + M. + 15 kg N	20.39 A	19.98 A	18.86 A	18.17 A	17.21 A	17.11 A
B. + M. + 7.5 kg N	15.72 F	15.65 FG	15.86 E	15.95 D	13.62 E	13.23 EF
B. + 22.5 kg N	17.27 CD	17.32 C	16.62 CD	16.50 BCD	15.36 B	15.65 B
B. + 15 kg N	15.97 F	15.74 EFG	17.10 B	16.93 BC	13.67 DE	13.40 EF
B. + 7.5 kg N	16.89 DE	16.64 CDE	15.93 E	15.89 D	14.08 CD	14.66 CD
M. + 22.5 kg N	18.31 B	18.25 B	17.07 BC	16.98 BC	13.42 E	13.38 EF
M. + 15 kg N	17.03 D	16.78 CD	16.40 D	16.22 CD	13.86 CDE	13.95 DE
M. + 7.5 kg N	16.88 DE	16.50 CDEF	16.21 DE	16.17 CD	14.14 C	14.09 DE

Means followed by the same letter or letters are not significantly different at the 5% level.

Percentage of phosphorus in plants:

Data in Table (10) showed that inoculated plants with *Bradyrhizobium* sp. had high values of P % in the vegetative portions as compared to the uninoculated ones. The differences between inoculation with *Bradyrhizobium* sp. and uninoculation were statistically approved from the statistical point of view in both seasons. The effect of *VA-mycorrhizae* on phosphorus percentage data in Table (10) showed that significant increase in phosphorus percentage due to the inoculation of cowpea plants with *VA-mycorrhizae* was recorded as compared to the uninoculated plants. The highest values for this trait was achieved in plants inoculated with *Bradyrhizobium* sp. plus *VA-mycorrhizae* and received 15.0 kg N/fed. This positive effect of *VA-mycorrhizae* on the phosphorus percentage may be due to the mycorrhizal endophytes that may alter the plant root morphology, by inducing the growth of an enlarged root system and thus causing a greater surface area for P absorption. Similar results were found by Marschner (1995); Ibijbijen *et al.* (1996) and Das *et al.* (1997). Moreover, dual inocula significantly increased phosphorus percentage as compared to the uninoculated plants. Also, the

Table (10): Effect of inoculation with *Bradyrhizobium* sp. and vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer on phosphorus percentage in the vegetative portions of plants in the first, second and third sample in 1996 and 1997 seasons.

Treatments	Phosphorus % in the first sample		Phosphorus % in the second sample		Phosphorus % in the third sample	
	1996	1997	1996	1997	1996	1997
Uninoculated	0.46 F	0.46 FG	0.39 I	0.39 D	0.39 H	0.42 F
Bradyrhizobium sp. (B.)	0.56 D	0.44 BCDE	0.45 EF	0.44 BCD	0.44 G	0.45 E
Mycorrhizae (M.)	0.64 B	0.60 B	0.50 B	0.48 B	0.51 B	0.52 B
(B.) + (M.)	0.60 C	0.57 BCD	0.47 CD	0.48 B	0.51 BC	0.50 BC
30 kg nitrogen (N)	0.59 C	0.59 BC	0.45 DE	0.45 BCD	0.50 BC	0.50 BC
B. + M. + 22.5 kg N	0.60 C	0.60 BC	0.46 CDE	0.46 BC	0.49 CD	0.49 CD
B. + M. + 15 kg N	0.69 A	0.68 A	0.56 A	0.55 A	0.54 A	0.54 A
B. + M. + 7.5 kg N	0.55 D	0.52 DE	0.45 DE	0.45 BCD	0.46 EF	0.45 E
B. + 22.5 kg N	0.46 FG	0.45 G	0.43 FG	0.42 BCD	0.51 B	0.52 B
B. + 15 kg N	0.44 G	0.43 G	0.41 GH	0.41 CD	0.45 FG	0.44 E
B. + 7.5 kg N	0.46 FG	0.44 G	0.41 H	0.41 CD	0.38 H	0.39 G
M. + 22.5 kg N	0.55 D	0.54 CDE	0.47 C	0.48 B	0.48 DE	0.48 D
M. + 15 kg N	0.51 E	0.50 EF	0.45 DE	0.44 BCD	0.38 H	0.36 H
M. + 7.5 kg N	0.55 D	0.54 CDE	0.48 BC	0.47 BC	0.39 H	0.40 G

Means followed by the same letter or letters are not significantly different at the 5% level.

dual inocula significantly surpassed the effect of inoculation with *Bradyrhizobium* solely, except in the case of the first sample in the second season, where there were no significant differences from the statistical point of view. These results are in accordance with those obtained by Das *et al.* (1997). Application of nitrogen chemical fertilizer to the plants inoculated with *VA-mycorrhizae* plus *Bradyrhizobium* sp. led to higher values as compared to the uninoculated plants. However, the highest values

were recorded for plants received 15.0 kg N/fed plus dual inocula in both seasons in the three sampling times. Similar results were obtained by Soddi *et al.* (1994).

Percentage of potassium in plants:

Results in Table (11) show that, in both seasons, inoculation with *Bradyrhizobium* sp. significantly increased the percentage of potassium in the vegetative portions of cowpea plants as compared to the uninoculated plants. Data in Table (11) showed that the inoculation of cowpea plants with *VA-mycorrhizae* significantly increased percentage of potassium in the vegetative portions of plants as compared to the uninoculated ones. On the other hand, the increase in percentage of potassium due to inoculation with *VA-mycorrhizae* surpassed the increase, which recorded in case of inoculation with *Bardyrhizobium* sp., in the first sample, and the second sample of first season. These results are in line with those found by Marschner (1995). In addition, the dual inocula significantly increased percentage of potassium in the above ground portions of cowpea plant in both experimental seasons as compared to the uninoculated plants.

Table (11): Effect of inoculation with *Bradyrhizobium* sp., and vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer on potassium percentage in the vegetative portion of plants in the first, second and third sample in 1996 and 1997 seasons.

Treatments	Potassium % in the first sample		Potassium % in the second sample		Potassium % in the third sample	
	1996	1997	1996	1997	1996	1997
Uninoculated	2.75 H	2.78 G	1.78 H	1.72 G	1.77 G	1.83 E
Bradyrhizobium sp. (B.)	3.33 EFG	3.30 CDEF	2.53 CD	2.50 BC	2.32 DE	2.23 CD
Mycorrhizae (M.)	3.777 B	3.70 B	2.68 B	2.63 B	2.37 CDE	2.30 C
(B.) + (M.)	3.35 DEFG	3.33 CDEF	2.60 BC	2.58 B	2.33 DE	2.32 C
30 kg nitrogen (N)	3.52 CDE	3.53 BC	2.67 B	2.62 B	2.43 BCD	2.47 B
B. + M. + 22.5 kg N	3.57 BCD	3.22 DEF	2.45 DE	2.38 CD	2.27 EF	2.13 D
B. + M. + 15 kg N	4.10 A	4.03 A	2.85 A	2.83 A	2.78 A	2.78 A
B. + M. + 7.5 kg N	3.43 DEF	3.37 CDEF	2.15 G	2.04 F	2.33 DE	2.32 C
B. + 22.5 kg N	3.68 BC	3.57 BC	2.35 EF	2.23 DEF	2.32 DE	2.28 C
B. + 15 kg N	3.53 CDE	3.52 BC	2.15 G	2.12 EF	2.55 B	2.53 B
B. + 7.5 kg N	3.22 G	3.20 EF	2.18 G	2.20 DEF	2.47 BC	2.50 B
M. + 22.5 kg N	3.53 CDE	3.48 BCD	2.45 DE	2.47 BC	2.30 DE	2.20 CD
M. + 15 kg N	3.50 CDE	3.47 BCDE	2.27 FG	2.27 DE	2.23 EF	2.25 CD
M. + 7.5 kg N	3.28 FG	3.18 F	2.23 FG	2.20 DEF	2.15 F	2.11 D

Means followed by the same letter or letters are not significantly different at the 5% level.

The highest percentage of potassium was obtained from plants inoculated with dual inocula and received 15.0 kg N/fed. These results are true in both seasons.

Percentage of protein, phosphorus and potassium in the dry seeds:

Inoculation of cowpea plants with *Bradyrhizobium* sp. significantly increased the percentage of protein in the dry seeds as compared to the uninoculated ones in both seasons. The increase in the protein percentage in

dry seeds of cowpea inoculated with *Bradyrhizobium* sp. might be attributed to the promoting effect of inoculation on the fixation of atmospheric nitrogen, consequently the improvement in the N uptake (Mengel 1984). These results are in harmony with those obtained by Baldeo, *et al* (1992). Data in Table (12) also showed that percentage of phosphorus and potassium in dry seeds significantly increased in both seasons as a result of inoculation with *Bradyrhizobium*. Moreover, inoculation with *VA-mycorrhizae* significantly increased percentage of protein, phosphorus and potassium in dry seeds as compared to uninoculated plants. The increase of nutrient uptake (phosphorus and potassium) by *VA-mycorrhizae* may be attributed to the effect of endophyte mycellium in the soil on increasing the absorptive area of the root by exploring a larger volume of soil than the root alone.

Regarding the effect of dual inocula (i.e., *Bradyrhizobium* sp. plus *VA-mycorrhizae*) on the prementioned traits, data showed that dual inocula significantly increased percentage of protein, phoshporus and potassium in dry seeds as compared to the uninoculated plants. These results held good in both seasons. Data in Table (12) showed that the application of nitrogen chemical fertilizer to plants inoculated with both *Bradyrhizobium* sp. and VA-mycorrhizae increased the previously mentioned characters.

Table (12):Effect of inoculation with *Bradyrhizobium* sp., and vesicular arbuscular mycorrhizae (VAM) and nitrogen fertilizer on percentage of protein, phosphorus and potassium in the dry seeds in 1996 and 1997 seasons.

Treatments	Protein % in the dry seeds		Phosphorus % in the dry seeds		Potassium % in the dry seeds	
	1996	1997	1996	1997	1996	1997
Uninoculated	24.18 H	24.45 G	0.46 F	0.47 I	1.05 F	1.08 F
Bradyrhizobium sp. (B.)	28.62 C	29.02 BC	0.65 D	0.65 F	1.45 B	1.43 ABC
Mycorrhizae (M.)	28.15 CD	28.27 CD	0.70 C	0.70 E	1.47 AB	1.33 BCDE
(B.) + (M.)	27.98 CDE	27.36 DE	0.57 E	0.57 H	1.35 BCD	1.28 DE
30 kg nitrogen (N)	26.26 FG	26.32 EF	0.57 E	0.56 H	1.28 CDE	1.25 E
B. + M. + 22.5 kg N	27.74 DE	27.64 CDE	0.69 C	0.70 E	1.45 B	1.45 AB
B. + M. + 15 kg N	33.04 A	32.97 A	0.78 A	0.78 A	1.57 A	1.56 A
B. + M. + 7.5 kg N	27.78 DE	27.88 CD	0.65 D	0.62 G	1.25 DE	1.20 EF
B. + 22.5 kg N	28.06 CDE	28.04 CD	0.71 C	0.70 DE	1.27 CDE	1.30 CDE
B. + 15 kg N	26.70 F	26.32 EF	0.69 C	0.70 DE	1.17 E	1.27 E
B. + 7.5 kg N	29.83 B	29.82 B	0.71 C	0.71 CDE	1.23 DE	1.32 BCDE
M. + 22.5 kg N	27.35 E	27.46 DE	0.73 B	0.72 CD	1.38 BC	1.42 ABCD
M. + 15 kg N	25.83 G	24.88 FG	0.73 B	0.74 B	1.32 CD	1.27 E
M. + 7.5 kg N	26.60 F	26.15 EF	0.73 B	0.73 BC	1.27 CDE	1.22 EF

Means followed by the same letter or letters are not significantly different at the 5% level.

The differences were announced and statistically approved in the two seasons. However, the highest values of protein, phosphorus and potassium were recorded for plants received dual inocula plus 15.0 kg N/fed. in both seasons.

In general, the obtained results indicated that the importance of using the dual inocula of *Bradyrhizobinm* and VAM on increasing the

productivity of fresh and dry seed yield as well as improving their quality. Also, the present study showed that using only one half of the recommended chemical N fertilizer (using only 15 kg N/fed) to plants inoculated with the dual incula was the most effective treatment on increasing productivity and quality of cowpea. Moreover, the possibility of reducing the chemical N fertilizer as was found in the present study would help in reducing the production cost as well as reducing the environmental pollution and the harmful effect of using chemical fertilizers on the human health. Therefore, it may be recommended to inoculate cowpea seeds with the *Bradyrhizobium* and inoculate soil with VAM fungi just after sowing and fertilize the growing plants with the first irrigation by only 15 kg N/fed under similar conditions to that of the present study.

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تـأثير التلقـيح بـالبرادى ريـزوبيم ؛ فطـر الميكـورهيزا والتسـميد النيتروجينـى علـى محصول وجودة اللوبيا

يوسف يوسف عبد العاطى ، محمد يسن المـازنى ، محمد محمود فراج ، خالد أحمد أمين الشيخ*

قسم البساتين – كليـة الزراعـة – جامعة المنيـا – مصر.* مركز البحوث الزراعيـة – شندويل – وزارة الزراعة – مصر.

- أجريت هذه الدراسة خلال موسمي 1996 ؛ 1997 على نباتات اللوبيا صنف "كريم 7" في مزرعة البحوث الزراعية بشندويل / محافظة سوهاج ؛ مصر.
- تم تصميم هذه الدراسة لمعرفة تأثير التلقيح البكتيربالبرادي ريزوبيم وفطر الميكورهيزا على النمو والمحصول الاخضر والجاف والجودة ومدى امكانية تقليل الكمية المستخدمة من التسميد الكيماوي للنيتروجين لتقليل تلوث البيئة و خفض تكاليف الانتاج.

طبقا للنتائج التي أمكن الحصول عليها يمكن أن نستخلص الآتي:-

- وجد أن نباتات اللوبيا صنف "كريم 7" التي لقحت باللقاح الثنائي (البرادي ريزوبيم + الميكورهيزا) وسمدت بـ 15 كجم نيتروجين / فدان (نصف كمية التسميد النيتروجيني الموصى بها فى الانتاج التجارى) أعطت أعلى القيم لمحصول اللوبيا ومعظم الصفات موضع الدراسة.
- وجد أن استخدام اللقاح الثنائي كسماد حيوي لنباتات اللوبيا يمكن أن يقلل من كمية السماد النيتروجينى الكيماوى الموصى به لانتاج اللوبيا الى النصف حيث يمكن استخدام السماد النيتروجيني بمعدل 15 كجم نيتروجين /فدان وهذا يؤدى الى تقليل تكاليف الانتاج وتقليل تلوث البيئة وكذلك تقليل مخاطر السماد الكيماوى على صحة الانسان.