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PRODUCTIVITY IMPROVEMENT OF COWPEA UNDER DESERT SOIL CONDITIONS

Ghodia, R. H. A.
Plant Production Dept, Desert Res. Center,

ABSTRACT

Two field experiments were carried out in sandy soil during the summer seasons of 2003 and 2004at Siwa Oasis, Egypt (26.0°N, 29.0°E and 0-22 m under mean sea level). The experiments were irrigated by using drip irrigation system with salinity water of 6000 p.p.m),

Cowpea, *Vigna unguiculata cv.* Cream 7 cultivar was cultivated to study the effect of inoculation by three methods (inoculation of seeds pre-sowing, as soil application by injection of inoculation after germination and with both methods on the growth and yield of cowpea. There were four inoculation treatments represented in new strain of *Rhizobia* (Rh), *Bacillus megatherium* phosphate dissolving bacteria (P. D. B.) and mixed inoculation (Rh + P. D. B.) in addition to control. The data were recorded for vegetative growth characteristics (plant height (cm), No. of branches, fresh and dry weight/ plant (g) and leaf area (cm^2)). Also, dry pods yield and its components (No. of pods/plant, average pod weight (g), seeds number / pod, seeds yield (g)/plant and (kg)/fed.). Chemical constituents of dry seeds (N %, P %, K %, protein % and carbohydrate %) were determined.

Obtained results showed that inoculation of seeds pre-sowing and inoculation of soil after germination together surpassed than other methods in growth characters, yield and its components as well as chemical composition. The same trend was observed for the inoculation with Rh + P. D. B. treatment when compared to other inoculation treatments. The highest values of growth characters, yield and its components and chemical composition of cowpea (Cream 7 cultivar) were obtained with interaction treatment between inoculation of seeds pre-sowing and inoculation of soil after germination and Rh + P. D. B inoculation . The results were true in the two growth seasons.

Keyword: Cowpea, *Vigna unguiculata cv*. Cream 7, methods of inoculation, injection, *Rhizobia* (Rh), *Bacillus megatherium* (PD B), growth, yield and chemical composition.

INTRODUCTION

Cowpea (*Vigna unguiculata* [L.] Walp.) is essential source of dietary protein, calcium and iron for the human and livestock (Murdock *et al.,* 1997). However, the low productivity of this crop is linked to the low technological level used in its production, especially low water availability, using cultivars with low genetic quality, also, low use of inputs such as fertilizers and rhizobial inoculants (Figueiredo *et. al*, 2007). Agarwal and Gupta (1995) reported that salinity suppressed callus growth and caused cellular dehydration, reduction in soluble amino acids and sugars and an increase in proline content in cowpea plants. Kinetin and IAA suppressed, salt induced injuries by lowering osmotic potential and maintaining cellular turgidity. The use of microorganisms to improve nutrients availability to plants is important for improving growth and production (Figueiredo *et al.,* 2008). Currently, there is an emerging demand to decrease chemical fertilizers and increase the sustainability of agriculture plant growth promoting bacteria (PGPB) and the association of rhizobia with leguminous plants which are mutualistic symbioses of great economic importance to increase crop yields (Bonfante and Anca, 2009).

Biological nitrogen fixation (BNF) demands high amounts of ATP energy, so an adequate supply of phosphorous offered by P. D. B. benefits nodule formation (Burity *et al.,* 2000). Rhizobia, is symbiotic association with leguminous plants, convert atmospheric N2 to NH3, which is used by the plants in various ways. This association can be an alternative to chemical nitrogen fertilizers, with the advantage of being more economically (Dakora, 2003). Also, Vessey (2003) reported that bacteria (PGPB) colonize promote plant growth in different organs of plants and exert beneficial effects on them.

Phosphorus (P) is scarce element because it has low mobility in the soil. It is an important nutrient supplied to plants through phosphate dissolving bacteria (Corrêa *et al.* 2006).

The effect of *rhizobium* or phosphate dissolving bacteria single or in combination on plant growth, yield and quality of some crops were studied by many investigators. Ghosh and Poi (1998) found that microbial population in the rhizosphere of some legume crops was increased as a result of combined inoculation with *Rhizobium* and P. D. B..

Liquid inoculation of soybeans at sowing time was equally as successful as soil inoculation of seed production; however, soil inoculation produced earlier nodulation (Brockwell *et al.* 1988). Singh *et al.* (2008) revealed that *Rhizobium* inoculation with seed and soil inoculation methods significantly improved the growth, yield attributes, grain yield, straw yield, nodulation and N and P uptake in lentil.

The objective of this work was to study the effect of bio-fertilizers treatments with *Rhizobium* or phosphate dissolving bacteria either singly or as combination, the inoculation treatments were applied with three different inoculation methods (seeds inoculation, soil inoculation after germination or combination with two methods on plant growth, pod yield and quality of cowpea pods Cream 7 cultivar irrigated with saline water under Siwa Oasis conditions.

MATERIALS AND METHODS

A field trial under sandy soil conditions was conducted in summer seasons of 2003 and 2004 at Swia Oasis south west Matroh Governorate, Egypt (26.0°N, 29.0°E and 0-22 m under mean sea level). Siwa Oasis is one of Egypt's isolated settlements located between the Qattara depression and the Egyptian Sand Sea in the Libyan Desert, nearly 50 km (30 mi) east of the Libyan border, and 300 km west of Marsa Matroh.

Cowpea, *Vigna unguiculata cv.* Cream 7 cultivar, seeds were sown on 25^{th} and 30^{th} of March in the first and second growing seasons , respectively, to study the effect of inoculation by three methods (inoculating the seeds pre-sowing as soil application, injection of inoculation after germination and inoculating the seeds pre-sowing with injection of inoculation after germination). Also, four inoculation treatments represented in new strain of *Rhizobia* (Rh), *Bacillus megatherium* phosphate dissolving bacteria (P. D.

B.) and mixed inoculation (Rh + P. D. B.) in addition to control (without inoculation) were studied to find out their effect on the growth and yield of cowpea. The seeds were divided into four equal parts. The first part was inoculated with different strains of cowpea *Rhizobia*, (D522-1/2 and L1145), while the second part was inoculated with P. D. B. The P. D. B. and Rh were isolated from soil and were produced by the Department of Microbiology, Desert Research Center, Egypt. The inoculated seeds were thoroughly mixed with strains prepared in the soil at the rate of 500 g per 25 kg dry seeds per feddan. The third part of seeds were inoculated with mixed rhizobia and P. D. B. while the fourth part of seeds were un-inoculated. The inoculation injection was done by dissolving 500 grams of inoculation in 200 liters of water per feddan and using spraying machine (20 liters). The three inoculation methods were situated in main plots, while the four inoculation treatments were randomly distributed in sub-plots. The design of the experiment was split plot with three replicates, each replicate included 12 treatments. The plot area was 10.5 m^2 (1/ 400 feddan) included one line of 10.5 m length and one m width. The distance between plants was 30 cm. Each hole on both sides of the line was cultivated with three seeds and then thinned later to two plants.

The N.P.K fertilizers were applied as soil application in a form of 200 kg/fed. calcium superphosphate (15.5 % P_2O_5) during preparing the soil, i.e., before planting. Also, 200 kg/fed. ammonium sulphate(20.5 % N) and potassium sulphate (48.5% K_2O) at the rate of 100 kg/fed. Each N and K. fertilizer level was divided into four equal amounts, which were applied monthly starting at soil preparation as soil application. Regular drip irrigation was carried out . The experiment area received standard amount of 20 m^3 organic manure before planting. Normal agricultural practices were carried as recommend .

Mechanical and chemical analyses of the experimental soil are shown in Tables (A and B). The soil analysis was carried out according to Black and Editor (1965) and Jackson (1967) . Analysis of irrigation water is given in Table (C) according to Richards (1954). The meteorological data of Khamisa location was show in Table (D)

Table (A): Mechanical properties of the experimental soil at Khamisa research station.

Depth (cm)	Particle size distribution (%)				Texture calss
	Coarse sand	Fine sand	Silt	Clay	
0-30	46.8	28.2	15.4	9.6	Medium to fine soil
30-60	50.0	25.9	18.0	6.1	Medium to fine soil

Table (B): Chemical properties of the experimental soil at Khamisa research station.

Depth (cm)	pH	EC (dS/m)	O.M %	Saturation soluble extract							
				Soluble anions (meq / L)				Soluble cations (meq / L)			
				Co_3^{--}	HCO_3^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
0-30	7.4	2,3	-	-	4,3	1,4	3,7	4,4	1,3	2,9	0.3
30-60	7.8	3,7	-	-	4,9	1.5	2,4	4,8	1,8	2,3	0.4

Table (C): Chemical analysis of the irrigation water at Khamisa research station.

pH	EC (dS/m)	Soluble anions (meq/l)				Soluble cations (meq/l)			
		Ca^-_3	Hco^-_3	So^-_4	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
7.8	11,18	-	8,05	41,61	89,29	42,40	12,52	82,01	2,04

Table (D): Meteorological data of Khamisa location.

Months	Average temperature. (°C)	Average relative humidity (%)
	2005	
March	26.44	44.24
April	30.54	37.96
May	35.94	33.32
June	37.66	31.55
July	38.75	30.90
	2006	
March	25.85	42.55
April	29.71	36.18
May	36.23	32.31
June	36.11	30.34
July	37.19	30.77

Date recorded:

Samples of cowpea plants (5 plants) were taken from each sub-plot where the vegetative growth was deter mined at the beginning of flowering stage also, yield and its components of dry pods were estimated after 80 days from sowing seeds to record the vegetative growth characteristics (plant height, number of branches, leaf area , fresh and dry weight/ plant, as well as yield and its components (number of pods/plant, average pod weight , number seeds/ pod, seed yield/plant and seed yield/fed.). Meanwhile, chemical constituents of dry seeds (N , P , K , protein and total carbohydrate %) were recorded . Minerals content N and P content were determined according to the methods of Huphries (1965) and Frie *et al.* (1964), respectively. While K content was measured by method described by Brown and Lilliland (1964) using flame photometer. The protein content in seeds was accounted by multiplying nitrogen percentage by 6.25. While total carbohydrate was determined as descended in AOAC. (1994).

All the obtained data were statistically analyzed according to Gomes and Gomes (1984).

RESULTS AND DISCUSSION

Plant growth characters

Data presented in Table (1) show that inoculation of cowpea with *Rhizobia* or P.D.B significantly increased all vegetative growth characteristics (plant height, number of branches, fresh and dry weight/ plant, leaf area), as compared with un-inoculated control. Inoculation with rhizobia combined with P.D.B gave the highest values of plant growth characters. These results were true in two growth seasons .This may be due to that inoculation of legumes is necessary in absence of compatible rhizobia and when rhizobial populations are low or inefficient in fixing N (Catroux *et al.* 2001). In this concern, EL-Fayoumy and Ramadan (2002) and Abou-Zied *et al.* (2005) found similar results, and stated that inoculation with N fixing microorganisms significantly increased fresh and dry weights of plant over the non inoculated plants. In the same line, Christiansen-weneger (1992), Sivan and Chet (1992) and Xie *et al.* (1996) indicated that bacteria promote growth through the synthesis of phytohormones that increase N2 fixation and reducing membrane potential of the roots. Also, Reynaldo and Reynaldo (1999) showed that the solubilization of inorganic phosphate and mineralization of organic phosphate, increases plant growth. These bacteria act indirectly on decreasing diseases and directly by producing or modifying phytohormone concentration, nitrogen fixation, solubilization of inorganic phosphate or other nutrients from the soil, sulfur oxidation, production of siderophores, and increasing growth permeability (Souchie *et al.,* 2007). It is capable of reducing the costs of nitrogen and phosphate fertilizers. The interaction between Rhizobium and P. D. B. led to greater plant biomass accumulation and plant growth (Byra Reddy *et al.,*1990).

Pre-sowing seed inoculation seed and inoculation injection after germination was superior for the stimulation of all vegetative growth characteristics when compared to other inoculation methods followed by inoculation injection after germination. Similarly, Ahmed *et al.*(2008) applying inoculation to both seeds and soil stimulate all growth parameters of lentil plants.

The interaction between dual inoculation (rhzobia and P. D. B.) and inoculating the seeds pre-sowing with inoculation injection after germination gave the highest values of all growth parameter. Singh *et al.* (2008) recorded that *Rhizobium* inoculation for seed and soil significantly improved the growth parameters in lentil.

Yield and its components

It is clear from data in Table (2) that inoculation of cowpea seeds with rhizobia and (or) P.D.B significantly increased total dry pod yield and its components (number of pods/plant, average pod weight , number of seeds/ pod, seed yield /plant and seed yield /fed.) when compared with those obtained under un-inoculated seeds. The results were true in two growing seasons.

These results are found to be in accordance with those of El-Fayoumy and Ramadan (2002) who found that pod dry weight of cowpea and peanut plants was increased by inoculation. Also, many researchers showed that *Rhizobium* inoculation with and without fertilizers on mungbean crop increased yield and yield components (Malik *et al.,* 2002; Ashraf, 2003; Hayat *et al.,* 2004; Muhammad *et al.,* 2004 ; Nadeem *et al.,* 2004)

The results agree with those obtained by Rudresh *et al,* (2005) who indicated that inoculation application of phosphate solubilizing bacterium, increased fertile pods per plant and emphasized that nutrients availability plays an important role in increasing seed number per pod. Similar reports of increase yield and nutrient uptake of chickpea by combined inoculation of Rhizobium and P.S.B. were reported by Alagawadi and Gaur (1988) and Rudresh *et al. (* 2005) on chickpea also, by Jutur and Reddy (2007) on lentus.

Strains from the genera *Pseudomonas*, *Bacillus* and *Rhizobium* are among the most powerful phosphate solubilizers. The principal mechanism for mineral phosphate solubilization is the production of organic acids, and acid phosphatases play a major role in the mineralization of organic phosphorous in soil. Therefore, genetic manipulation of phosphate-solubilizing bacteria is to improve their ability to improve plant growth. Positive effects of phosphorein (P. D. B.) on plant growth, seed yield and quality were found by El-Kalla *et al.* (1997), Sharma and Nanadeo (1999) on faba bean, Hewedy (1999) on tomato and Anany (2002) on beans.

Inoculation of seeds pre-sowing with injection of inoculation after germination surpassed other inoculation methods and had a significant effect on seed yield and its components, as shown in Table (2). The results agree with those obtained by Singh *et al.* (2008), they found that *Rhizobium* inoculation with seed and soil inoculation methods significantly improved yield and its compensates in lentil. Also, Ahmed *et al.* (2008) applying inoculation to both seed and soil simultaneously improved yield and its components.

The highest values of dry pod yield and its components were obtained from interaction treatment between dual inoculation (pre-sowing inoculation of seeds and injection of inoculation after germination along with combined inoculation of P.D.B.+ R h . The results are in the same line with those obtained by Rudresh *et al. (*2005) and Jutur and Reddy (2007), they found that combined inoculation of P.S.B.+ T. *harzianum* significantly increased grain yield of cowpea. These results may be due to microorganisms' activity to excrete organic acids and phosphates, could be able to release elements from complexes existent in soil and increasing nutrient availability to plants. Consequently improved the plant growth characters (Table 1) which may be reflected on yield.

Chemical contents

Rhizobial inoculation and (or) phosphate dissolving bacteria increased the chemical contents of cowpea seeds (N, P, K, protein and carbohydrate %), when compared to un-inoculated treatment (Table 3). The increases were significant in the two growth seasons. Many researchers studied the effect of *Rhizobium* inoculation with and without fertilizers on mungbean crop (Malik *et al.,* 2002; Ashraf, 2003; Hayat *et al.,* 2004; Muhammad *et al.,* 2004; Nadeem *et al.,* 2004) and found that there was increase in nitrogen content of seeds. The increases in N, P and K content may be due to the interaction effect between rhizobial and P. D. B. which consequently increased the uptake of nutrients (Mohamed, 2001).

Inoculation of seeds pre-sowing combined with injection of inoculation after germination was superior in increasing all chemical contents of cowpea seeds and followed in decreasing order, by injection of inoculation after germination, inoculation of seeds pre-sowing and uninoculation. The results agree with those obtained by Singh *et al.* (2008), they found that *Rhizobium* inoculation with seed and soil significantly improved N and P uptake in lentil. Ahmed *et al.* (2008) indicated that applying inoculum to both seeds and soil was more effective on chemical content of seeds.

1

Table (2): Effect of inoculation and methods of inoculation and their interactions on cowpea yield and its component, throughout 2003 and 2004 growing seasons.

Inoculation Method	Inoculation Treatment	No. pods/plant		Average pod weight (g)		No. seeds /pod		Seed yield (g)/plant		Seed yield (kg)/fed	
		I	II	I	II	I	II	I	II	I	II
with seed	W.	3.69	3.04	0.91	1.21	1.28	1.72	5.94	5.16	247.27	225.61
	Rh.	5.29	4.36	1.01	1.33	3.26	4.37	12.17	15.82	354.58	323.51
	P.D.B	6.29	5.17	1.11	1.47	3.37	4.51	12.62	16.40	421.19	384.29
	Rh+P. D. B.	10.29	8.47	1.37	1.81	5.59	7.49	15.74	20.46	689.45	629.05
Injection after germination	W.	3.75	3.29	0.95	1.25	1.48	1.99	6.75	5.64	267.72	244.27
	Rh.	5.67	4.67	1.11	1.47	4.38	5.86	18.10	23.53	379.90	346.62
	P.D.B	8.01	6.59	1.29	1.70	4.63	6.20	22.86	29.71	536.53	489.53
	Rh+P. D. B.	10.56	8.69	1.54	2.04	6.26	8.38	23.87	31.03	707.11	645.16
with seed + Injection	W.	3.78	3.36	0.97	1.28	1.11	1.49	5.15	5.40	273.10	249.17
	Rh.	9.47	7.79	1.23	1.63	6.74	6.78	33.29	43.27	634.13	578.58
	P.D.B	11.00	9.05	1.55	2.05	8.19	8.23	38.48	47.83	736.56	672.03
	Rh+P. D. B.	12.49	10.28	1.73	2.28	9.14	9.19	41.33	51.12	836.46	763.17
LSD		0.72	0.59	0.05	0.06	0.69	0.87	1.38	1.31	47.86	43.67
with seed		6.39	5.26	1.10	1.45	3.38	4.52	11.62	14.46	428.12	390.61
Injection		7.00	5.81	1.22	1.61	4.19	5.61	17.89	22.48	472.82	431.39
Seed+Injection		9.18	7.62	1.37	1.81	6.30	6.42	29.56	36.91	620.06	565.74
LSD		0.32	0.29	0.03	0.04	0.22	0.29	0.08	0.69	23.92	21.83
W.		2.81	2.42	0.71	0.93	0.97	1.30	4.46	4.05	197.02	179.76
Rh.		5.11	4.20	0.84	1.11	3.60	4.25	15.89	20.66	342.15	312.18
P.D.B		6.32	5.20	0.99	1.30	4.05	4.74	18.49	23.49	423.57	386.46
Rh+P. D. B.		8.33	6.86	1.16	1.53	5.25	6.27	20.23	25.65	558.25	509.35
LSD		0.42	0.34	0.03	0.04	0.40	0.50	0.80	0.76	27.63	25.21

W. = un-inoculation Rh = rhizobia P. D. B. = phosphate dissolving bacteria

Interaction between dual inoculation (rhzobia and P. D. B.) and inoculation of seeds pre-sowing along with injection after germination gave the highest values of chemical content of cowpea under study in two growing seasons.

Similarly, the microbial activity increase biological nitrogen fixation in soil (Chen *et al*, 2003) and nitrogen uptake by plant. Correlation between nitrogen and protein content has been reported by Jutur and Reddy (2007) and Dordas and Sioulas (2008). Chickpea which was inoculated with biofertilizers significantly increased grain protein content. Maximum protein content (%15.06) was observed in the treatment that received a combined inoculation of P.S.B. and T. harzianum (Rudresh *et al*. 2005).

Table (3): Effect of inoculation and methods of inoculation on chemical contents of cowpea seeds, throughout 2003 and 2004 growing seasons.

Inoculation Method	Inoculation treatment	N %		P %		K %		protein %		Carbohydrate%	
		I	II	I	II	I	II	I	II	I	II
with seed	W.	1.51	1.27	0.36	0.37	1.28	1.67	8.70	9.53	30.78	26.99
	Rh.	1.84	1.35	0.44	0.39	1.21	1.57	10.58	10.10	37.43	28.62
	P.D.B	1.73	1.50	0.41	0.44	1.18	1.53	9.95	11.23	35.19	31.80
	Rh+P. D. B.	1.99	1.77	0.47	0.52	1.37	1.79	11.44	13.30	40.48	37.68
Injection after germination	W.	1.44	1.33	0.34	0.39	1.08	1.41	8.28	10.00	29.29	28.33
	Rh.	2.37	1.99	0.56	0.58	1.24	1.61	13.63	14.95	48.21	42.36
	P.D.B	2.21	1.66	0.52	0.48	1.42	1.85	12.71	12.48	44.95	35.35
	Rh+P. D. B.	2.61	2.56	0.62	0.75	1.88	2.44	15.01	19.23	53.09	54.47
with seed + Injection	W.	1.35	1.35	0.32	0.39	1.08	1.40	7.74	10.13	27.39	28.69
	Rh.	2.64	2.35	0.63	0.68	1.62	2.11	15.20	17.63	53.77	49.94
	P.D.B	2.50	2.44	0.59	0.71	1.71	2.23	14.39	18.33	50.92	51.92
	Rh+P. D. B.	3.07	2.95	0.73	0.86	2.37	3.09	17.65	22.13	62.44	63.84
LSD		0.16	0.14	0.04	0.04	0.14	0.18	0.90	1.08	3.17	3.00
with seed		1.77	1.47	0.42	0.43	1.26	1.64	10.17	11.04	35.97	31.27
Injection		2.16	1.89	0.51	0.55	1.40	1.83	12.41	14.16	43.88	40.13
Seed+Injection		2.39	2.27	0.57	0.66	1.70	2.21	13.75	17.05	48.63	48.60
LSD		0.07	0.07	0.02	0.02	0.06	0.08	0.40	0.53	1.41	1.42
W.		1.08	0.99	0.26	0.29	0.86	1.12	6.18	7.41	21.87	21.00
Rh.		1.71	1.42	0.41	0.41	1.02	1.32	9.85	10.67	34.85	30.23
P.D.B		1.61	1.40	0.38	0.41	1.08	1.40	9.26	10.51	32.76	29.77
Rh+P. D. B.		1.92	1.82	0.46	0.53	1.41	1.83	11.03	13.66	39.00	39.00
LSD		0.09	0.08	0.02	0.02	0.08	0.10	0.52	0.62	1.83	1.73

W. = un-inoculation Rh = rhizobia P. D. B. = phosphate dissolving bacteria

4- RECOMMENDATION AND CONCLUSION

Under Siwa oasis conditions and irrigation with saline water, we can ,,improve cowpea productivity and reduce the application of chemical fertilizers by using Cream 7 cultivar and inoculation with rhizobia (Rh) + phosphate dissolving bacteria (P.D.B.) which were added as pre-sowing to seeds and soil application after germination.

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تحسين إنتاجية اللوبيا تخت ظروف الأراضي الصحراوية

رشاد حسن علي غدية
قسم الإنتاج النباتي مركز بحوث الصحراء

أقيمت تجربة حقلية خلال موسمى النمو صيف 2003 و 2004 في الأرض الرملية بمنطقة خميسة بواحة سيوة غرب مطروح. وكان الري بنظام الري بالتنقيط بماء بدرجة ملوحة 6000 جزء في الملون. وقد تم إجراء معاملات بهدف تحسين جودة وإنتاج محصول اللوبيا صنف كريم 7 وتقليل الأثر الضار للري بالماء المالح.

هي ثلاثة طرق للتلقيح: تلقيح البذور قبل الزراعة ، تلقيح التربة أسفل البادرات بعد الإنبات ، الجمع بين الطريقتين وأربعة أنواع من التلقيح: التلقيح ببكتريا الريزوبيا المثبتة للنتروجين الخاصة باللوبيا (Rh) ، التلقيح بالبكتريا الميسرة للفوسفور (P.D.B.) ، الجمع بين النوعين بالإضافة إلي معاملة الكنترول بدون تلقيح والتفاعلات بين طرق التلقيح وأنواع البكتريا المستخدمة.

وقد سجلت النتائج بالنسبة لقياسات النمو الخضري (طول النبات ،عدد الفروع والوزن الطازج والجاف / نبات ، مساحة الورقة، بالنسبة للمحصول تم تقدير محصول القرون الجافة ومكوناته (عدد القرون / نبات، ومتوسط الوزن القرن ، عدد البذور / القرن، ومحصول البذور/ نبات ومحصول البذور/ فدان. بالإضافة إلي تقدير المكونات الكيميائية للبذور الجافة(نسبة النيتروجين والفوسفور والبوتاسيوم) وكذلك نسبة البروتين والكربوهيدرات).

وأوضحت النتائج أن تلقيح البذور قبل الزراعة مع تلقيح التربة بعد الإنبات تفوق علي تلقيح البذور قبل الزراعة و تلقيح التربة بعد الإنبات كل علي حده في النمو والمحصول ومكوناته والتركيب الكيميائي للبذور الجافة.وكذلك تفوق معاملة التلقيح المشترك من Rh + PDB علي معاملة Rh و معاملة PDB كل علي حده وكانت أعلى قيم تم الحصول عليها بالنسبة لصفات النمو والمحصول ومكوناته والمكونات الكيميائية من اللوبيا (كريم 7) معاملة التفاعل الثنائي من تلقيح البذور قبل الزراعة والتربة بعد الإنبات مع بكتريا Rh + PDB. وقد كانت النتائج في نفس الاتجاه خلال موسمي الزراعة.

قام بتحكيم البحث

أ.د / كوثرضوه	**كلية الزراعة – جامعة المنصورة**
أ.د / ابراهيم ابراهيم العكش	**كلية الزراعة – جامعة عين شمس**

Table (1): Effect of inoculation and methods of inoculation on cowpea vegetative growth, throughout 2003 and 2004 growing seasons.

Inoculation Method	Inoculation treatment	Plant height (cm)		No. of branches		Fresh weight/ plant (g)		Dry weight/ plant (g)		Leaf area (cm^2)	
		I	II	I	II	I	II	I	II	I	II
with seed	W.	19.79	18.05	3.09	2.69	6.59	5.01	1.16	0.86	3.12	2.63
	Rh.	28.37	25.88	5.94	5.17	12.67	9.63	2.38	1.76	4.48	3.78
	P.D.B	33.70	30.74	6.16	5.36	13.14	9.98	2.47	1.83	5.32	4.49
	Rh+P. D. B.	55.17	50.32	7.25	6.31	15.46	11.75	3.08	2.28	8.70	7.35
Injection after germination	W.	20.09	19.54	3.51	3.06	7.49	5.69	1.32	0.98	3.38	2.85
	Rh.	30.40	27.72	6.75	5.87	18.84	14.32	3.54	2.62	4.79	4.05
	P.D.B	42.93	39.16	8.04	6.99	22.45	17.06	4.47	3.31	6.77	5.72
	Rh+P. D. B.	56.58	51.60	8.40	7.31	23.45	17.82	4.67	3.45	8.92	7.53
With seed +Injection	W.	20.27	19.93	3.18	3.02	5.72	4.35	1.01	0.75	3.45	2.91
	Rh.	50.74	46.28	7.75	6.74	34.66	26.34	6.51	4.82	8.00	6.76
	P.D.B	58.94	53.75	8.45	7.35	37.80	28.73	7.53	5.57	9.30	7.85
	Rh+P. D. B.	66.93	61.04	9.08	7.90	40.60	30.86	8.09	5.98	10.56	8.91
LSD		3.87	3.49	0.46	0.37	1.41	1.07	0.27	0.20	0.60	0.51
with seed		34.26	31.24	5.61	4.88	11.96	9.09	2.27	1.68	5.40	4.56
Injection		37.50	34.51	6.67	5.81	18.06	13.72	3.50	2.59	5.97	5.04
Seed+ Injection		49.22	45.25	7.12	6.25	29.70	22.57	5.79	4.28	7.83	6.61
LSD		1.71	1.75	0.11	0.04	0.08	0.06	0.02	0.01	0.30	0.25
W.		15.04	14.38	2.45	2.19	4.95	3.76	0.87	0.65	2.49	2.10
Rh.		27.38	24.97	5.11	4.45	16.54	12.57	3.11	2.30	4.32	3.65
P.D.B		33.89	30.91	5.66	4.93	18.35	13.94	3.62	2.68	5.35	4.51
Rh+P. D. B.		44.67	40.74	6.18	5.38	19.88	15.11	3.96	2.93	7.05	5.95
LSD		2.23	2.02	0.26	0.21	0.81	0.62	0.16	0.12	0.35	0.29

W. = un-inoculation Rh = rhizobia P. D. B. = phosphate dissolving bacteria