Annals of Agric. Sci., Moshtohor
Vol. 50(2) (2012), 215- 228

ISSN 1110-0419
http://annagricmoshj.com

# Response of some pea cultivars to supplementary irrigation under rainfall conditions

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**Abstract**

The productivity of pea was determined under calcareous soil and rainfall conditions at El-Hammam region in North Western Coastal Zone (NWCZ) of Egypt. Treatments of supplementary irrigation and bacterial inoculation were applied to improve yield for two cultivars (Lincolin and Mastar B) of pea plants.

To achieve the goal of study, the experiment was conducted through two growing seasons i.e. 2005/2006 and 2006/2007. The treatments were the combination between 4 treatments as supplementary irrigation i.e. rainfall, rainfall + 60 mm/fed, rainfall + 90 mm/fed and rainfall +120 mm/fed and 2 inoculation treatments (Rhizobium and Phosphorus dissolving bacteria P.D.B.) or without inoculation, which were applied on two cultivars of pea. Growth characters and yield and its components as well as chemical compositions of pea were determined.

**The results were summarized as follows:-**

1- Rainfall + 120 mm supplementary irrigation treatment led to obtain the maximum significant values for all characteristics under study: plant height, number of leaves and branches per plant, fresh and dry weight per plant, except dry matter percentage which gave the highest value with rainfall treatment. Also, yield and its components (number of pods per plant, pod length, fresh weight of pod, 100 seeds weight, pods yield /plant and per fed.), were increased significantly with increasing the rate of supplementary irrigation. The content of nitrogen, phosphorus, potassium, protein and carbohydrates in pea seeds, showed the same previous trend.

2- Master B cultivar exceeded Lincolin cultivar for all the characteristics under study,

3- Bacterial inoculation, surpassed significantly than uninoculation treatment for all characteristics under study, except the prescription rate of dry matter.

4- Triple interaction treatment indicated that rainfall + 120 mm supplementary irrigation with bacterial inoculation on Master B cultivar led to obtaining the maximum values for all characteristics under study in both growing seasons except dry matter percentage.

**Key words:** pea, cultivars, Rhizobium, Phosphorus dissolving bacteria (P.D.B.), rainfall, supplementary irrigation.

## Introduction

Pea (*Pisum sativm L.*) is one of the widely spread, early maturing legume crop grown during the winter season in Egypt. Pea seeds are rich in protein and vitamins. Also, pea is short durable crop its cultivation is highly profitable and preferable to the farmers. It can be grown in most types of soil. This legume crop is capable of fixing and utilizing atmospheric nitrogen through symbiotic relationship with Rhizobium and improve soil characters. Economizes crop production reducing the requirement of added synthetic nitrogenous fertilizers with legumes cultivation **(Solaiman and Rabbani, 2002)**. Pea was capable of extracting soil water to a depth of about 60 cm at most sites **(McKenzie *et al.* 2004).**

Most lands of Egypt are suffering from the shortage of irrigation water. The important and most agriculture activity in Egypt depend upon the water supplying from River Nile (37.5 mellon $m^3$ /year) beside 12 mellon $m^3$ /year from the other different supplies. Supplemental irrigation increase the production of crops above 50% when compared to rainfall only.

The amounts of rainfall in Egypt were 90 up to 140 mm. It was characterized with irregularity in both distribution and amount. Big project at El-Hammam (NWCZ) area under implementation to cultivate 62,500 hectare by applying two or three supplemental irrigations (according to the available water from River Nile) beside the natural precipitation. **Owies** and **Ryan (1998)** illustrated that the optimum response for rainfall conditions with 50 mm/ha, and addition of only limited irrigation (1/3 full irrigation) significantly increased yield, but near maximum yields were obtained by 2/3 of full irrigation. In another study, also, **Oweis and Hachum (2004)** mentioned that the supplemental irrigation is an option with great potential for increasing water productivity in rainfall areas. In another study, **Schweeers *et al.* (2004)** reported that under Agricultural Stability Zone 2 of Syria (annual precipitation: 300-350 mm) full supplemental irrigation gave more productive and profitable than deficit irrigation (40% deficit). Supplemental irrigation increased pea yield when compared to the rainfall system **(Sherif *et al.*,2010)**

Biological nitrogen fixation is the most important biochemical reaction for plant life. Phosphorus and

Rhizobium inoculation increased N2-fixation by legumes. Legumes in rotation with cereals contribute to the total N in soil and improved cereals yield. Subsequently, the nitrogen deficiency is one of the major factors for yield limiting cereals and legume **(Shah *et al.*, 2003)**. Biological nitrogen fixation occurs mainly through symbiotic association of legumes with certain N2-fixing microorganisms that convert elemental nitrogen into ammonia **(Shiferaw *et al.*, 2004)**.

Low P availability is especially problematic for leguminous crops, since legumes nodules responsible for N2-fixation have a high P requirement **(Vance, 2001)**. Phosphorus is one of the most important elements that significantly affect plant growth and metabolism, thus its deficiency limits legumes production in most agriculture soils **(Shu-Jie *et al.*, 2007)**. In the same line, phosphorus alone with Rhizobium inoculation increased growth, yield and nitrogenase activity as well as improved soil fertility for sustainable agriculture **(Gentili *et al.*, 2006)**. Inoculation with suitable rhizobia along with phosphorus improves symbiotic nitrogen fixation and yield in common bean **(Zaman-Allah *et al.*, 2007)**.

Many researchers showed that there were differences among cultivars in growth characters, yield and chemical composition of vegetative crops. **Pascale and Barbieri 2000, Jagdish *et al.*, 2002 and Hafiz and Damarany (2006)** reported that, the differences among cultivars may be due to the genetic differences between cultivars and their ability for utilizing the environmental sources especially light, CO2, water and nutrients, in addition, to tolerance of stresses. Also, **Ali *et al.* (2008)** studied the differences among 3 varieties of pea with respect to yield and seeds of yield. They reported that BARI Motorshuti-1 cultivar gave significantly the highest values of yield when compared with other cultivars.

The objective of this study was to investigate the effect of supplemental irrigation rates and inoculation pea seeds with Rhizobium + Phosphorus dissolving bacteria (PDB) on growth, production and chemical contents of two pea cultivars under El-Hammam (NWCZ) conditions of Egypt.

## Materials and Methods

Two field experiments were conducted during two growing seasons (2005 – 2006 and 2006 – 2007) under calcareous soil and rainfall conditions at El-Hammam region in NWCZ of Egypt. The experiments concluded 16 treatments which were the combinations between 4 supplemental irrigation treatments i.e. rainfall (106.12 mm), rainfall + 60 mm/fed, rainfall + 90 mm/fed and rainfall +120 mm/fed .Every quantity of supplemental irrigation was divided and added at tillering, booting and yield stages of, 2 pea cultivars i.e. Lincolin and Mastar B. Also, 2 inoculation treatments were used (without inoculation and inoculation with *Rhizobium leguminosarum* which contained two strains of Rhizobium, namely AF165 and AF 214 and Phosphate dissolving bacteria (PDB) consist of two strains of *Bacillus Magaterium* namely Lux. 18 and Ism 7. The bacteria were isolated from soil and produced in the laboratory of Microbiology Department, Desert Research Center, Egypt.

Chemical and mechanical analysis of the experimental soil are shown in Table A according to **Jackson (1967) and Black and Editor (1965)** respectively. Sowing irrigation was carried out in experiment area for one week before sowing. Analysis of irrigation water is given in Table B according to **Richards (1954)**. The meteorological data of El–Hammam area was show in Table C

During soil preparation just month before sowing it had been added 10 $m^3$ compost /feddan plus 100 kg super phosphate (15.5% $P_2O_5$). The experimental plot area was 3.5 m length ×3 m width (1/400 /fadden), with 0.5 m apart between rows, 30 cm distance between hills. Sowing date was on 1st and 15th of December in both growing seasons respectively. Planting irrigation from underground, were 45 mm for all the experimental units (because precipitation rainfall suitable for planting was late). Start of the harvest was 60 days after planting and continued five times for 30 days. Developed surface irrigation system was implemented by using gated pipes system. Water counter was used to calculate the amount of water drawing from underground water.

The experiments were arranged in split split plot design with three replicates .Irrigation treatments were occupied the main plots, while the subplots were assigned to inoculation treatments, while sub-subplots were occupied by the two pea cultivars. The statistical analysis was carried out according to procedure of **Snedecor and Cochran (1980)**.

**Table A.** Chemical and mechanical analysis and soil texture and of the experimental site at El-Hammam (NWCZ).

| Characters | | Depth (cm) | |
|---|---|---|---|
| | | 0-30 | 30-60 |
| | pH | 7.89 | 7.91 |
| | TSS | 2.4 | 1.43 |
| Cations meq/l | $Na^+$ | 15.2 | 6.2 |
| | $K^+$ | 0.08 | 0.03 |
| | $Ca^{+2}$ | 3.15 | 5.51 |
| | $Mg^{+2}$ | - | 2.56 |
| | $CO_3^{--}$ | - | - |
| Anions meq/l | $HCO_3$ | 0.45 | 0.32 |
| | $Cl^-$ | 19.4 | 8.5 |
| | $SO_4^{--}$ | 4.15 | 5.48 |
| Soil texture | | | |
| | Saturation % | 40.0 | 40.0 |
| | Sand % | 54.9 | 56.3 |
| | Silt % | 18.15 | 19.9 |
| | Clay % | 27.0 | 24.8 |

**Table B.** Chemical analysis of the underground irrigation water at El –Hammam (NWCZ),

| Elevation | Depth to water(m) | Water level (m) | Ec (mmo hs/cm) | TDS ppm | pH | $K^+$ (ppm) | $Na^+$ | $Mg^{+2}$ | $Ca^{+2}$ | $Cl^-$ | $SO_4$ | $HCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Meq. /L | | | | | |
| 24 | 9.55 | 11.5 | 2.48 | 1587 | 8.65 | 18 | 299 | 63 | 107 | 590 | 125 | 285 |

**Table C.** Meteorological parameters at El –Hammam experimental (NWCZ),

| Growing season | Month | Relative humidity (%) | Dew Point ($C^O$) | Temperature ($C^O$) | Rainfall (mm) |
|---|---|---|---|---|---|
| 2005- 2006 | Dec. | 74.33 | 10.40 | 15.33 | 25.20 |
| | Jan. | 70.67 | 8.70 | 13.36 | 49.00 |
| | Feb. | 72.00 | 8.86 | 14.10 | 8.61 |
| | Mar. | 64.67 | 9.10 | 16.20 | 8.40 |
| | Apr. | 66.33 | 12.46 | 19.33 | 4.20 |
| | | | | | 106.12* |
| 2006 -2007 | Dec. | 70.495 | 9.83 | 15.795 | 19.35 |
| | Jan. | 67.00 | 8.50 | 14.83 | 6.37 |
| | Feb. | 64.33 | 8.76 | 14.66 | 32.90 |
| | Mar. | 68.00 | 10.26 | 17.60 | 15.40 |
| | Apr. | 63.495 | 12.545 | 19.615 | 0.0 |
| | | | | | 93.27* |

* sum of rainfall amounts during 2005/2006 and 2006/2007 growing seasons.

**Data recorded**:

**A. Vegetative growth characters:** five plants were taken from each plot at the beginning of the flowering stage as a representative sample for recording the following data.

Plant height (cm), number of leaves and branches /plant, fresh and dry weight/plant (g), beside dry matter %.

**B. Yield and its components**

Yield and its components were determined after 60 days from planting as: average of pod length (cm) and weight (g), number of pods/plant, fresh pods yield/plant (g) and /feddan (kg) of five harvesting times, as well as fresh weight of 100 seeds (g). Pod characters: were recorded as average of 10 pods which were taken from each harvest time from each experimental unit.

**C- Chemical composition**

**C-1- Minerals content:** N, P and K (g/100 g dry seed weight) were estimated using wet ashing method according to **Johnson and Ulrich (1959).** The total nitrogen was determined according to the method of **Huphries (1965)** by a modified micro-Kjildahle apparatus. Phosphorus was determined calorimetrically according to the method of **Frie et al. (1964).** While, Potassium was measured by Flame photometer as described by **Brown and Lilliland (1964).**

**C- 2- Total carbohydrates** were estimated by the method described in **A.O.A.C. (1990).** The following equation was used to calculate

**Total protein**: Crude protein percentage = Nitrogen value X 6.25 **(Stewart, 1989).**

**Results and discussions**

**1 - Growth characters:**

Data recorded in Tables 1 and 2 show the effect of supplementary irrigation, two pea cultivars, bacterial inoculation and their interaction on growth parameters expressed as, plant height, number of leaves and branches per plant, fresh and dry weight per plant and dry matter %.

**1-1 - Effect of supplementary irrigation: -**

The results in Tables 1 and 2 referred that there were significant differences in the vegetative growth characteristics of pea plants as a result of transactions supplementary irrigation, on plant height, number of leaves and branches per plant, fresh and dry weight per plant, for two growth seasons. The highest values were obtained with using treatment rainfall +120 mm supplementary irrigation. While the highest values of dry matter percentage was recorded with the treatment of rainfall only. In this respect, the decrease in the percentage of dry matter gradually related with the increase in the amount of irrigation water. The results obtained agree with those reported by **Schweers *et al.* (2004) and Mahajan and Tuteja (2005)** who concluded that the reduction in vegetative growth occurred under water deficit conditions this may be due to reduce nutrients uptake by roots and transport to shoots because of restricted

transpiration rates and impaired active transport and membrane. In Kenya, **Masinde *et al.* (2006)** stated that maintaining soil moisture at 60 % water holding capacity would be sufficient to prevent a decline in stem elongation and transpiration and sustain relatively high dry matter production of two Solanum species.

**1-2- Effect of cultivars: -**

There was a significant effect of cultivars on the growth characters under study as shown in Tables 1 and 2. Master B cultivar showed superiority when compared to Lincolin cultivar for growth characteristics under study, in both growing seasons. The results are in agreements with those obtained by **Hafiz and Damarany (2006)** who found that there was variation among five cowpea cultivars because of differences among genotypes. in Northern Upper Egypt at Assiut governorate. Also, **Ali *et al.* (2008)** found that there were differences of shoot weight among 3 varieties of pea. In another study, **Zaki *et al* . (2009)** studied the effect of irrigation with saline water on three sweet fennel cultivars. They found differences among cultivars in vegetative growth which could be due to differences response to saline stress. **El-Hifny (2010)** studied the effect of two cowpea cultivars. Cream 7 cultivar was significantly superior in plant growth characters when compared to Kafr- ElShekh cultivar. On the other hand, Kafr-ElShekh cultivar was significantly surpassed in fresh and dry weight of plant.

**1- 3 - Effect of bacterial inoculation: -**

Results recorded in Tables 1 and 2 clearly show that there were positive significant differences between inoculation and without inoculation due to the addition of bacteria during the plant growth, which enhanced the growth of plants except the dry matter%, which showed the highest values by using the control treatment (without bacterial inoculation). The results are in agreements with the results of **Khanam *et al.* (1999)** and **Bhuiyan *et al.* (2001)** who worked on lentil, mung bean and garden pea, respectively. The results may be due to that rhizobium inoculation increased $N_2$ fixation by legumes which is most important in biochemical reaction for life and growth **(Shah *et al.*, 2003 and Shiferaw *et al.*, 2004).**

**1-4 - Effect of Interactions:**

The results described in Tables 1 and 2 show the presence of general morale of the bilateral interaction supplemental irrigation× cultivars, supplemental irrigation × bacterial inoculation, cultivars × bacterial inoculation and triple interaction supplemental irrigation× cultivars× bacterial inoculation. The highest values of growth characters was obtained in both growth seasons by using triple interaction rainfall irrigation + 120 mm supplemental irrigation, use Master B cultivar inoculated bacteria. The highest percentage of dry matter was obtained by using the triple treatment interaction rainfall of the variety Lincolin and non-inoculated bacteria. Similar results were found by many workers, like **Khanam *et al.* (1999) and Bhuiyan *et al.* (2001)** who worked on lentil and chickpea

All parameters of vegetative growth were significantly affected by adding the supplemental irrigation with different rates as compared with rainfall treatment. except dry matter%. Also from the previous data it can be concluded that in case of a shortage in supplemental irrigation. 90 mm supplemental irrigation /faddan, only can be applied, whereas in case of water abundance 120 mm supplemental irrigation /faddan is the best.

**2 - Yield and its components:**

**2- 1 - Effect of supplementary irrigation:**

The effect of supplementary irrigation on yield of pea and its components shown in Tables 3 and 4 revealed that rainfall +120 mm supplementary irrigation resulted in the highest values of the number of pods per plant, fresh weight of 100 seeds, pod length, fresh weight /pod, pods yield /plant and per fed, in both growing seasons when compared with other supplementary irrigation treatments. It my be worth to mention that yield of pea plants was doubled 5, 9 and 11 times of rainfall only by adding 60, 90 and 120 mm supplementary irrigation, respectively. The results agree with those obtained by **Anwer *et al.*( 2003) and Guoju *et al.* (2009)** who indicate that supplementary irrigation with 60 mm of water applied over the entire growth stage of the crop can play an important role in improving the pea yield and its component which reached 8.3% –12.8% over the control treatment. This may be due to increase nutrients uptake and transport to shoot and consequently improve growth and yield.

**2- 2 - Effect of cultivars:**

Results recorded in Tables 3 and 4 shows that there were significant differences between cultivars on yield and its components under study. The higher values of yield and its components cleared that Master B cultivar surpassed than the other cultivar Lincolin in both growing seasons.

The results are in agreement with the results of **Ali *et al.* (2008)** who studied the effect of 3 varieties of pea on yield (t/ha) and seed yield (t/ha). They reported that BARI Motorshuti-1 cultivar gave significantly the highest values of yield when compared with the other cultivars. Also, **Hafize and Damarany (2006)** on cowpea and **Zaki *et al.* (2009)** on sweet fennel and **EL-Hifny (2010)** on cowpea showed that the differences among cultivars may be due to the differences among genotypes and tolerance of stresses.

**2- 3 - effect of bacterial inoculation:**

The data listed in Tables 3 and 4 clear significant differences for the pea yield and its components as a result of bacterial inoculation, which gave higher values than uninoclation treatment in the two growing seasons.

**Table 1.** Effect of supplementary irrigation, bacterial inoculations and cultivars and their interaction on pea vegetative growth, throughout 2005 – 2006 and 2006 – 2007 growing seasons

| Characteristics | | Plant height(cm) | | | | | | No. of leaves/plant | | | | | | No. of branches/plant | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seasons | | 1st | | | 2nd | | | 1st | | | 2nd | | | 1st | | | 2nd | | |
| Treatments | | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean |
| Rainfall only | M | 15.31 | 18.35 | 16.83 | 16.08 | 19.27 | 17.67 | 17.31 | 22.45 | 19.88 | 18.18 | 23.57 | 20.87 | 1.00 | 1.00 | 1.00 | 1.05 | 1.050 | 1.050 |
| | L | 13.64 | 16.48 | 15.06 | 14.32 | 17.30 | 15.81 | 15.42 | 18.46 | 16.94 | 16.19 | 19.38 | 17.79 | 1.00 | 1.00 | 1.00 | 1.05 | 1.05 | 1.05 |
| | Mean | 14.48 | 17.42 | 15.95 | 15.20 | 18.29 | 16.74 | 16.37 | 20.46 | 18.41 | 17.18 | 21.48 | 19.33 | 1.00 | 1.00 | 1.00 | 1.05 | 1.05 | 1.05 |
| Rainfall + 60 mm | M | 26.58 | 28.64 | 27.61 | 27.91 | 30.07 | 28.99 | 15.42 | 25.97 | 20.70 | 24.06 | 27.27 | 25.66 | 2.00 | 2.00 | 2.00 | 2.10 | 2.10 | 2.10 |
| | L | 22.53 | 25.94 | 24.24 | 23.66 | 27.24 | 25.45 | 18.76 | 26.99 | 22.88 | 19.70 | 28.34 | 24.02 | 2.00 | 2.00 | 2.00 | 2.10 | 2.10 | 2.10 |
| | Mean | 24.56 | 27.29 | 25.92 | 25.78 | 28.65 | 27.22 | 17.09 | 26.48 | 21.79 | 21.88 | 27.80 | 24.84 | 2.00 | 2.00 | 2.00 | 2.10 | 2.10 | 2.10 |
| Rainfall + 90 mm | M | 36.12 | 46.25 | 41.19 | 37.93 | 48.56 | 43.24 | 31.15 | 37.24 | 34.20 | 32.71 | 39.10 | 35.90 | 3.00 | 4.00 | 3.50 | 3.15 | 4.20 | 3.68 |
| | L | 34.12 | 39.45 | 36.79 | 35.83 | 41.42 | 38.62 | 26.37 | 33.14 | 29.76 | 27.69 | 34.80 | 31.24 | 3.00 | 3.00 | 3.00 | 3.15 | 3.15 | 3.15 |
| | Mean | 35.12 | 42.85 | 38.99 | 36.88 | 44.99 | 40.93 | 28.76 | 35.19 | 31.98 | 30.20 | 36.95 | 33.57 | 3.00 | 3.50 | 3.25 | 3.15 | 3.68 | 3.41 |
| Rainfall + 120 mm | M | 42.61 | 52.55 | 47.58 | 44.74 | 55.18 | 49.96 | 41.69 | 45.97 | 43.83 | 43.77 | 48.27 | 46.02 | 4.00 | 5.00 | 4.50 | 4.20 | 5.25 | 4.73 |
| | L | 41.18 | 48.11 | 44.65 | 43.24 | 50.52 | 46.88 | 29.78 | 39.16 | 34.47 | 31.27 | 41.12 | 36.19 | 4.00 | 4.00 | 4.00 | 4.20 | 4.20 | 4.20 |
| | Mean | 41.90 | 50.33 | 46.11 | 43.99 | 52.85 | 48.42 | 35.74 | 42.57 | 39.15 | 37.52 | 44.69 | 41.11 | 4.00 | 4.50 | 4.25 | 4.20 | 4.73 | 4.46 |
| Mean | M | 30.16 | 36.45 | 33.30 | 31.66 | 38.27 | 34.97 | 26.39 | 32.91 | 29.65 | 29.68 | 34.55 | 32.12 | 2.50 | 3.00 | 2.75 | 2.63 | 3.15 | 2.89 |
| | L | 27.87 | 32.50 | 30.18 | 29.26 | 34.12 | 31.69 | 22.58 | 29.44 | 26.01 | 23.71 | 30.91 | 27.31 | 2.50 | 2.50 | 2.50 | 2.63 | 2.63 | 2.63 |
| | Mean | 29.01 | 34.47 | | 30.46 | 36.19 | | 24.49 | 31.17 | | 26.69 | 32.73 | | 2.50 | 2.75 | | 2.63 | 2.89 | |
| LSD Rainfall | | | | 2.15 | | | 0.15 | | | 1.41 | | | 0.12 | | | 0.43 | | | 0.01 |
| LSD cultivars | | | | 1.22 | | | 0.11 | | | 1.32 | | | 0.10 | | | 0.06 | | | 0.01 |
| LSD Inoculation | | | | 1.82 | | | 0.16 | | | 1.44 | | | 0.11 | | | 0.03 | | | 0.02 |
| LSD Rainfall x cultivars | | | | 0.97 | | | 0.12 | | | 1.42 | | | 0.13 | | | 0.01 | | | 0.01 |
| LSD Rainfall x Inoculation | | | | 0.24 | | | 0.13 | | | 0.14 | | | 0.11 | | | 0.02 | | | 0.01 |
| LSD cultivars x Inoculation | | | | 1.23 | | | 0.11 | | | 1.45 | | | 0.09 | | | 0.08 | | | 0.01 |
| LSD Rainfall x cultivars x Inoculation | | | | 1.64 | | | 0.66 | | | 0.86 | | | 0.45 | | | 0.09 | | | 0.07 |

LSD at 0.05 - W.= without inoculation , In.= Inoculation - M.= Master B , L.= Lincolin - 1st = First season , 2nd = Second season

**Table 2.** Effect of supplementary irrigation, bacterial inoculations and cultivars and their interaction on pea vegetative growth, throughout 2005 – 2006 and 2006 – 2007 growing seasons

| Characteristics | | Fresh weight/plant (g) | | | | | | Dry weight/plant (g) | | | | | | Dry matter (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seasons | | 1st | | | 2nd | | | 1st | | | 2nd | | | 1st | | | 2nd | | |
| Treatments | | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean |
| Rainfall only | M | 12.14 | 13.57 | 12.86 | 12.75 | 14.25 | 13.50 | 2.14 | 2.23 | 2.19 | 2.36 | 2.46 | 2.41 | 17.64 | 16.45 | 17.05 | 18.52 | 17.27 | 17.90 |
| | L | 10.56 | 11.47 | 11.02 | 11.09 | 12.04 | 11.57 | 1.77 | 1.86 | 1.82 | 1.95 | 2.05 | 2.00 | 16.75 | 16.24 | 16.50 | 17.59 | 17.05 | 17.32 |
| | Mean | 11.35 | 12.52 | 11.94 | 11.92 | 13.15 | 12.53 | 1.96 | 2.05 | 2.00 | 2.16 | 2.26 | 2.21 | 17.20 | 16.35 | 16.77 | 18.05 | 17.16 | 17.61 |
| Rainfall + 60 mm | M | 20.36 | 25.43 | 22.90 | 21.38 | 26.70 | 24.04 | 1.77 | 4.12 | 2.95 | 3.81 | 4.55 | 4.18 | 16.97 | 16.22 | 16.60 | 17.82 | 17.03 | 17.42 |
| | L | 15.41 | 19.75 | 17.58 | 16.18 | 20.74 | 18.46 | 2.54 | 3.22 | 2.88 | 2.80 | 3.55 | 3.18 | 16.49 | 16.32 | 16.41 | 17.31 | 17.14 | 17.23 |
| | Mean | 17.89 | 22.59 | 20.24 | 18.78 | 23.72 | 21.25 | 2.15 | 3.67 | 2.91 | 3.31 | 4.05 | 3.68 | 16.73 | 16.27 | 16.50 | 17.57 | 17.08 | 17.33 |
| Rainfall + 90 mm | M | 31.21 | 38.43 | 34.82 | 32.77 | 40.35 | 36.56 | 4.88 | 5.53 | 5.20 | 5.37 | 6.09 | 5.73 | 15.62 | 14.38 | 15.00 | 16.40 | 15.10 | 15.75 |
| | L | 20.64 | 29.43 | 25.04 | 21.67 | 30.90 | 26.29 | 3.23 | 4.45 | 3.84 | 3.56 | 4.90 | 4.23 | 15.64 | 15.11 | 15.38 | 16.42 | 15.87 | 16.14 |
| | Mean | 25.93 | 33.93 | 29.93 | 27.22 | 35.63 | 31.42 | 4.05 | 4.99 | 4.52 | 4.47 | 5.50 | 4.98 | 15.63 | 14.75 | 15.19 | 16.41 | 15.48 | 15.95 |
| Rainfall + 120 mm | M | 35.43 | 42.59 | 39.01 | 37.20 | 44.72 | 40.96 | 5.09 | 5.96 | 5.53 | 5.62 | 6.57 | 6.10 | 14.38 | 14.00 | 14.19 | 15.10 | 14.70 | 14.90 |
| | L | 21.18 | 33.41 | 27.30 | 22.24 | 35.08 | 28.66 | 3.20 | 5.00 | 4.10 | 3.53 | 5.51 | 4.52 | 15.12 | 14.97 | 15.05 | 15.88 | 15.72 | 15.80 |
| | Mean | 28.31 | 38.00 | 33.15 | 29.72 | 39.90 | 34.81 | 4.15 | 5.48 | 4.82 | 4.57 | 6.04 | 5.31 | 14.75 | 14.49 | 14.62 | 15.49 | 15.21 | 15.35 |
| Mean | M | 24.79 | 30.01 | 27.40 | 26.02 | 31.51 | 28.76 | 3.47 | 4.46 | 3.97 | 4.29 | 4.92 | 4.60 | 16.15 | 15.26 | 15.71 | 16.96 | 16.03 | 16.49 |
| | L | 16.95 | 23.52 | 20.23 | 17.79 | 24.69 | 21.24 | 2.69 | 3.63 | 3.16 | 2.96 | 4.01 | 3.48 | 16.00 | 15.66 | 15.83 | 16.80 | 16.44 | 16.62 |
| | Mean | 20.87 | 26.76 | | 21.91 | 28.10 | | 3.08 | 4.05 | | 3.63 | 4.46 | | 16.08 | 15.46 | | 16.88 | 16.23 | |
| LSD Rainfall | | | | 2.17 | | | 0.15 | | | 0.58 | | | 0.02 | | | 0.25 | | | 0.01 |
| LSD cultivars | | | | 1.46 | | | 0.16 | | | 0.44 | | | 0.02 | | | 0.21 | | | 0.01 |
| LSD Inoculation | | | | 1.52 | | | 0.12 | | | 0.49 | | | 0.01 | | | 0.13 | | | 0.01 |
| LSD Rainfall x cultivars | | | | 0.97 | | | 0.11 | | | 1.42 | | | 0.01 | | | 0.36 | | | 0.02 |
| LSD Rainfall x Inoculation | | | | 0.24 | | | 0.10 | | | 0.14 | | | 0.02 | | | 0.40 | | | 0.01 |
| LSD cultivars x Inoculation | | | | 1.23 | | | 0.11 | | | 1.45 | | | 0.09 | | | 0.45 | | | 0.01 |
| LSD Rainfall x cultivars x Inoculation | | | | 1.11 | | | 0.49 | | | 0.67 | | | 0.07 | | | 0.46 | | | 0.05 |

LSD at 0.05 - W.= without inoculation , In.= Inoculation - M.= Master B , L.= Lincolin - 1st = First season , 2nd = Second season

**Table 3.** Effect of supplementary irrigation , bacterial inoculations and cultivars and their interactions on pea yield and its component, throughout 2005 – 2006 and 2006 – 2007 growing seasons.

| Characteristics | | | Number of pods /plant | | | | | | 100 seed fresh weight (g) | | | | | | Pod length (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| seasons | | | 1st | | | 2nd | | | 1st | | | 2nd | | | 1st | | | 2nd | | |
| treatments | | | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean |
| Rainfall only | | M | 5.21 | 6.13 | 5.67 | 5.47 | 6.44 | 5.95 | 15.35 | 20.82 | 18.09 | 16.12 | 21.86 | 18.99 | 2.15 | 3.28 | 2.72 | 2.26 | 3.44 | 2.85 |
| | | L | 3.40 | 4.98 | 4.19 | 3.57 | 5.23 | 4.40 | 17.76 | 19.78 | 18.77 | 18.65 | 20.77 | 19.71 | 2.06 | 2.86 | 2.46 | 2.16 | 3.00 | 2.58 |
| | | Mean | 4.31 | 5.56 | 4.93 | 4.52 | 5.83 | 5.18 | 16.56 | 20.30 | 18.43 | 17.38 | 21.32 | 19.35 | 2.11 | 3.07 | 2.59 | 2.21 | 3.22 | 2.72 |
| Rainfall + 60 mm | | M | 16.12 | 17.23 | 16.68 | 16.93 | 18.09 | 17.51 | 17.76 | 26.21 | 21.99 | 24.84 | 27.52 | 26.18 | 3.54 | 4.12 | 3.83 | 3.72 | 4.33 | 4.02 |
| | | L | 15.24 | 16.14 | 15.69 | 16.00 | 16.95 | 16.47 | 21.22 | 23.14 | 22.18 | 22.28 | 24.30 | 23.29 | 3.74 | 4.65 | 4.20 | 3.93 | 4.88 | 4.40 |
| | | Mean | 15.68 | 16.69 | 16.18 | 16.46 | 17.52 | 16.99 | 19.49 | 24.68 | 22.08 | 23.56 | 25.91 | 24.74 | 3.64 | 4.39 | 4.01 | 3.82 | 4.60 | 4.21 |
| Rainfall + 90 mm | | M | 16.41 | 17.98 | 17.20 | 17.23 | 18.88 | 18.05 | 26.33 | 29.79 | 28.06 | 27.65 | 31.28 | 29.46 | 5.25 | 6.31 | 5.78 | 5.51 | 6.63 | 6.07 |
| | | L | 16.35 | 17.14 | 16.75 | 17.17 | 18.00 | 17.58 | 25.11 | 28.63 | 26.87 | 26.37 | 30.06 | 28.21 | 4.69 | 5.84 | 5.27 | 4.92 | 6.13 | 5.53 |
| | | Mean | 16.38 | 17.56 | 16.97 | 17.20 | 18.44 | 17.82 | 25.72 | 29.21 | 27.47 | 27.01 | 30.67 | 28.84 | 4.97 | 6.08 | 5.52 | 5.22 | 6.38 | 5.80 |
| Rainfall + 120 mm | | M | 17.51 | 19.46 | 18.49 | 18.39 | 20.43 | 19.41 | 31.32 | 36.43 | 33.88 | 32.89 | 38.25 | 35.57 | 6.14 | 7.19 | 6.67 | 6.45 | 7.55 | 7.00 |
| | | L | 16.89 | 18.11 | 17.50 | 17.73 | 19.02 | 18.38 | 28.16 | 31.11 | 29.64 | 29.57 | 32.67 | 31.12 | 5.94 | 6.32 | 6.13 | 6.24 | 6.64 | 6.44 |
| | | Mean | 17.20 | 18.79 | 17.99 | 18.06 | 19.72 | 18.89 | 29.74 | 33.77 | 31.76 | 31.23 | 35.46 | 33.34 | 6.04 | 6.76 | 6.40 | 6.34 | 7.09 | 6.72 |
| Mean | | M | 13.81 | 15.20 | 14.51 | 14.50 | 15.96 | 15.23 | 22.69 | 28.31 | 25.50 | 25.37 | 29.73 | 27.55 | 4.27 | 5.23 | 4.75 | 4.48 | 5.49 | 4.98 |
| | | L | 12.97 | 14.09 | 13.53 | 13.62 | 14.80 | 14.21 | 23.06 | 25.67 | 24.36 | 24.22 | 26.95 | 25.58 | 4.11 | 4.92 | 4.51 | 4.31 | 5.16 | 4.74 |
| | | Mean | 13.39 | 14.65 | | 14.06 | 15.38 | | 22.88 | 26.99 | | 24.79 | 28.34 | | 4.19 | 5.07 | | 4.40 | 5.32 | |
| LSD Rainfall | | | | | 0.35 | | | 0.15 | | | 1.41 | | | 0.06 | | | 0.26 | | | 0.03 |
| LSD cultivars | | | | | 1.22 | | | 0.03 | | | 1.12 | | | 0.07 | | | 0.21 | | | 0.02 |
| LSD Inoculation | | | | | 0.94 | | | 0.07 | | | 1.63 | | | 0.07 | | | 0.45 | | | 0.02 |
| LSD Rainfall x cultivars | | | | | 0.26 | | | 0.02 | | | 0.92 | | | 0.01 | | | 0.86 | | | 0.02 |
| LSD Rainfall x Inoculation | | | | | 0.21 | | | 0.01 | | | 0.56 | | | 0.01 | | | 0.12 | | | 0.02 |
| LSD cultivars x Inoculation | | | | | 0.23 | | | 0.03 | | | 0.98 | | | 0.02 | | | 0.43 | | | 0.03 |
| LSD Rainfall x cultivars x Inoculation | | | | | 1.05 | | | 0.30 | | | 1.21 | | | 0.28 | | | 0.35 | | | 0.08 |

LSD at 0.05 - W.= without inoculation , In.= Inoculation - M.= Master B , L.= Lincolin - 1st = First season , 2nd = Second season

**Table 4.** Effect of supplementary irrigation, bacterial inoculations and cultivars and their interactions on pea yield and its component, throughout 2005 – 2006 and 2006 – 2007 growing seasons.

| Characteristics | | | Pod fresh weight /plant (g) | | | | | | Pod yield /plant (g) | | | | | | Pod yield /fed (kg) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| seasons | | | 1st | | | 2nd | | | 1st | | | 2nd | | | 1st | | | 2nd | | |
| treatments | | | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean |
| Rainfall only | | M | 2.37 | 2.98 | 2.68 | 2.49 | 3.13 | 2.81 | 21.52 | 23.64 | 22.58 | 22.60 | 24.82 | 23.71 | 122.02 | 192.25 | 157.14 | 128.12 | 201.86 | 164.99 |
| | | L | 2.16 | 2.86 | 2.51 | 2.27 | 3.00 | 2.64 | 21.21 | 22.86 | 22.04 | 22.27 | 24.00 | 23.14 | 89.12 | 132.26 | 110.69 | 93.58 | 138.87 | 116.22 |
| | | Mean | 2.27 | 2.92 | 2.59 | 2.38 | 3.07 | 2.72 | 21.37 | 23.25 | 22.31 | 22.43 | 24.41 | 23.42 | 105.57 | 162.26 | 133.91 | 110.85 | 170.37 | 140.61 |
| Rainfall + 60 mm | | M | 3.05 | 4.42 | 3.74 | 3.20 | 4.64 | 3.92 | 21.21 | 40.76 | 30.99 | 31.75 | 42.80 | 37.28 | 505.36 | 1132.26 | 818.81 | 530.63 | 1188.87 | 859.75 |
| | | L | 2.84 | 3.67 | 3.26 | 2.98 | 3.85 | 3.42 | 25.68 | 35.72 | 30.70 | 26.96 | 37.51 | 32.24 | 394.16 | 657.26 | 525.71 | 413.87 | 690.12 | 552.00 |
| | | Mean | 2.95 | 4.05 | 3.50 | 3.09 | 4.25 | 3.67 | 23.45 | 38.24 | 30.84 | 29.36 | 40.15 | 34.76 | 449.76 | 894.76 | 672.26 | 472.25 | 939.50 | 705.87 |
| Rainfall + 90 mm | | M | 4.78 | 5.53 | 5.16 | 5.02 | 5.81 | 5.41 | 42.31 | 56.18 | 49.25 | 44.43 | 58.99 | 51.71 | 1268.61 | 1598.85 | 1433.73 | 1332.04 | 1678.79 | 1505.42 |
| | | L | 3.95 | 4.35 | 4.15 | 4.15 | 4.57 | 4.36 | 28.45 | 43.45 | 35.95 | 29.87 | 45.62 | 37.75 | 870.26 | 1098.65 | 984.46 | 913.77 | 1153.58 | 1033.68 |
| | | Mean | 4.37 | 4.94 | 4.65 | 4.58 | 5.19 | 4.89 | 35.38 | 49.82 | 42.60 | 37.15 | 52.31 | 44.73 | 1069.44 | 1348.75 | 1209.09 | 1122.91 | 1416.19 | 1269.55 |
| Rainfall + 120 mm | | M | 5.25 | 6.18 | 5.72 | 5.51 | 6.49 | 6.00 | 60.88 | 78.22 | 69.55 | 63.92 | 82.13 | 73.03 | 1513.93 | 1733.72 | 1623.83 | 1589.63 | 1820.41 | 1705.02 |
| | | L | 4.35 | 4.76 | 4.56 | 4.57 | 5.00 | 4.78 | 45.36 | 52.91 | 49.14 | 47.63 | 55.56 | 51.59 | 1167.32 | 1496.25 | 1331.79 | 1225.69 | 1571.06 | 1398.37 |
| | | Mean | 4.80 | 5.47 | 5.14 | 5.04 | 5.74 | 5.39 | 53.12 | 65.57 | 59.34 | 55.78 | 68.84 | 62.31 | 1340.63 | 1614.99 | 1477.81 | 1407.66 | 1695.73 | 1551.70 |
| Mean | | M | 3.86 | 4.78 | 4.32 | 4.06 | 5.02 | 4.54 | 36.48 | 49.70 | 43.09 | 40.67 | 52.19 | 46.43 | 852.48 | 1164.27 | 1008.38 | 895.10 | 1222.48 | 1058.79 |
| | | L | 3.33 | 3.91 | 3.62 | 3.49 | 4.11 | 3.80 | 30.18 | 38.74 | 34.46 | 31.68 | 40.67 | 36.18 | 630.22 | 846.11 | 738.16 | 661.73 | 888.41 | 775.07 |
| Mean | | | 3.59 | 4.34 | | 3.77 | 4.56 | | 33.33 | 44.22 | | 36.18 | 46.43 | | 741.35 | 1005.19 | | 778.41 | 1055.45 | |
| LSD Rainfall | | | | | 0.46 | | | 0.15 | | | 5.49 | | | 0.23 | | | 112.35 | | | 7.29 |
| LSD cultivars | | | | | 0.96 | | | 0.01 | | | 6.32 | | | 0.20 | | | 121.36 | | | 7.39 |
| LSD Inoculation | | | | | 0.24 | | | 0.01 | | | 5.64 | | | 0.30 | | | 156.48 | | | 6.58 |
| LSD Rainfall x cultivars | | | | | 0.66 | | | 0.02 | | | 27.16 | | | 0.15 | | | 127.15 | | | 4.02 |
| LSD Rainfall x Inoculation | | | | | 0.29 | | | 0.2 | | | 0.36 | | | 0.11 | | | 106.54 | | | 5.12 |
| LSD cultivars x Inoculation | | | | | 0.46 | | | 0.01 | | | 26.38 | | | 0.10 | | | 168.64 | | | 5.06 |
| LSD Rainfall x cultivars x Inoculat | | | | | 0.67 | | | 0.06 | | | 1.23 | | | 0.81 | | | 58.64 | | | 29.57 |

LSD at 0.05 - W.= without inoculation , In.= Inoculation - M.= Master B , L.= Lincolin - 1st = First season , 2nd = Second season

**Table 5.** Effect of supplementary irrigation , bacterial inoculations and cultivars and their interaction on chemical contents of pea seeds, throughout 2005 – 2006 and 2006 – 2007 growing seasons.

| Characteristics | | | Nitrogen (g/100g) | | | | | | Phosphorus (mg /100g) | | | | | | Potassium (mg /100g) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| seasons | | | 1st | | | 2nd | | | 1st | | | 2nd | | | 1st | | | 2nd | | |
| treatments | | | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean |
| Rainfall only | | M | 1.52 | 1.75 | 1.64 | 1.70 | 1.96 | 1.83 | 278.91 | 296.41 | 287.66 | 312.38 | 331.98 | 322.18 | 718.25 | 776.36 | 747.31 | 804.44 | 869.52 | 836.98 |
| | | L | 1.30 | 1.44 | 1.37 | 1.46 | 1.61 | 1.53 | 257.14 | 277.28 | 267.21 | 288.00 | 310.55 | 299.28 | 708.12 | 726.42 | 717.27 | 793.09 | 813.59 | 803.34 |
| | | Mean | 1.41 | 1.60 | 1.50 | 1.58 | 1.79 | 1.68 | 268.03 | 286.85 | 277.44 | 300.19 | 321.27 | 310.73 | 713.19 | 751.39 | 732.29 | 798.77 | 841.56 | 820.16 |
| Rainfall + 60 mm | | M | 1.58 | 2.12 | 1.85 | 1.77 | 2.37 | 2.07 | 257.14 | 375.11 | 316.13 | 364.35 | 420.12 | 392.24 | 782.11 | 817.00 | 799.56 | 875.96 | 915.04 | 895.50 |
| | | L | 1.69 | 2.17 | 1.93 | 1.89 | 2.43 | 2.16 | 311.21 | 332.41 | 321.81 | 348.56 | 372.30 | 360.43 | 742.24 | 796.21 | 769.23 | 831.31 | 891.76 | 861.53 |
| | | Mean | 1.64 | 2.15 | 1.89 | 1.83 | 2.40 | 2.12 | 284.18 | 353.76 | 318.97 | 356.45 | 396.21 | 376.33 | 762.18 | 806.61 | 784.39 | 853.64 | 903.40 | 878.52 |
| Rainfall + 90 mm | | M | 2.13 | 2.75 | 2.44 | 2.39 | 3.08 | 2.73 | 387.31 | 414.61 | 400.96 | 433.79 | 464.36 | 449.08 | 853.12 | 881.15 | 867.14 | 955.49 | 986.89 | 971.19 |
| | | L | 2.14 | 2.65 | 2.40 | 2.40 | 2.97 | 2.68 | 339.23 | 384.19 | 361.71 | 379.94 | 430.29 | 405.12 | 811.22 | 875.13 | 843.18 | 908.57 | 980.15 | 944.36 |
| | | Mean | 2.14 | 2.70 | 2.42 | 2.39 | 3.02 | 2.71 | 363.27 | 399.40 | 381.34 | 406.86 | 447.33 | 427.10 | 832.17 | 878.14 | 855.16 | 932.03 | 983.52 | 957.77 |
| Rainfall + 120 mm | | M | 2.82 | 3.28 | 3.05 | 3.16 | 3.67 | 3.42 | 412.45 | 496.13 | 454.29 | 461.94 | 555.67 | 508.80 | 890.31 | 956.14 | 923.23 | 997.15 | 1070.88 | 1034.01 |
| | | L | 2.97 | 3.11 | 3.04 | 3.33 | 3.48 | 3.40 | 396.22 | 427.18 | 411.70 | 443.77 | 478.44 | 461.10 | 836.14 | 911.31 | 873.73 | 936.48 | 1020.67 | 978.57 |
| | | Mean | 2.90 | 3.20 | 3.05 | 3.24 | 3.58 | 3.41 | 404.34 | 461.66 | 433.00 | 452.86 | 517.05 | 484.95 | 863.23 | 933.73 | 898.48 | 966.81 | 1045.77 | 1006.29 |
| Mean | | M | 2.01 | 2.48 | 2.24 | 2.25 | 2.77 | 2.51 | 333.95 | 395.57 | 364.76 | 393.11 | 443.03 | 418.07 | 810.95 | 857.66 | 834.31 | 908.26 | 960.58 | 934.42 |
| | | L | 2.03 | 2.34 | 2.18 | 2.27 | 2.62 | 2.45 | 325.95 | 355.27 | 340.61 | 365.06 | 397.90 | 381.48 | 774.43 | 827.27 | 800.85 | 867.36 | 926.54 | 896.95 |
| | | Mean | 2.02 | 2.41 | | 2.26 | 2.70 | | 329.95 | 375.42 | | 379.09 | 420.46 | | 792.69 | 842.47 | | 887.81 | 943.56 | |
| LSD Rainfall | | | | | 0.24 | | | 0.15 | | | 19.31 | | | 22.64 | | | 12.36 | | | 15.67 |
| LSD cultivars | | | | | 0.08 | | | 0.08 | | | 12.35 | | | 18.64 | | | 16.35 | | | 18.24 |
| LSD Inoculation | | | | | 0.09 | | | 0.11 | | | 19.05 | | | 22.34 | | | 48.65 | | | 53.24 |
| LSD Rainfall x cultivars | | | | | 0.15 | | | 0.19 | | | 9.85 | | | 11.37 | | | 28.68 | | | 31.29 |
| LSD Rainfall x Inoculation | | | | | 0.05 | | | 0.08 | | | 39.64 | | | 42.15 | | | 507.34 | | | 525.19 |
| LSD cultivars x Inoculation | | | | | 0.08 | | | 0.11 | | | 15.22 | | | 18.23 | | | 25.31 | | | 25.31 |
| LSD Rainfall x cultivars x Inoculation | | | | | 0.32 | | | 0.35 | | | 21.21 | | | 26.13 | | | 29.46 | | | 29.46 |

LSD at 0.05 - W.= without inoculation , In.= Inoculation - M.= Master B , L.= Lincolin - 1st = First season , 2nd = Second season

**Table 6.** Effect of supplementary irrigation , bacterial inoculations and cultivars and their interaction on chemical contents of pea seeds, throughout 2005 – 2006 and 2006 – 2007 growing seasons.

| Characteristics | | | Protein (%) | | | | | | Carbohydrate (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| seasons | | | 1st | | | 2nd | | | 1st | | | 2nd | | |
| treatments | | | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean | W. | In. | Mean |
| Rainfall only | | M | 9.26 | 10.83 | 10.05 | 10.37 | 12.13 | 11.25 | 40.26 | 41.18 | 40.72 | 45.09 | 46.12 | 45.61 |
| | | L | 7.97 | 9.11 | 8.54 | 8.93 | 10.20 | 9.56 | 36.18 | 40.21 | 38.20 | 40.52 | 45.04 | 42.78 |
| | | Mean | 8.62 | 9.97 | 9.29 | 9.65 | 11.17 | 10.41 | 38.22 | 40.70 | 39.46 | 42.81 | 45.58 | 44.19 |
| Rainfall + 60 mm | | M | 9.82 | 13.11 | 11.47 | 11.00 | 14.68 | 12.84 | 36.18 | 52.26 | 44.22 | 53.88 | 58.53 | 56.21 |
| | | L | 10.32 | 13.43 | 11.88 | 11.56 | 15.04 | 13.30 | 42.25 | 45.31 | 43.78 | 47.32 | 50.75 | 49.03 |
| | | Mean | 10.07 | 13.27 | 11.67 | 11.28 | 14.86 | 13.07 | 39.22 | 48.79 | 44.00 | 50.60 | 54.64 | 52.62 |
| Rainfall + 90 mm | | M | 13.43 | 13.25 | 13.34 | 15.04 | 14.84 | 14.94 | 51.29 | 57.32 | 54.31 | 57.44 | 64.20 | 60.82 |
| | | L | 16.26 | 13.32 | 14.79 | 18.21 | 14.92 | 16.56 | 48.34 | 52.19 | 50.27 | 54.14 | 58.45 | 56.30 |
| | | Mean | 14.85 | 13.29 | 14.07 | 16.63 | 14.88 | 15.75 | 49.82 | 54.76 | 52.29 | 55.79 | 61.33 | 58.56 |
| Rainfall + 120 mm | | M | 14.97 | 16.31 | 15.64 | 16.77 | 18.27 | 17.52 | 56.33 | 61.11 | 58.72 | 63.09 | 68.44 | 65.77 |
| | | L | 18.75 | 15.78 | 17.27 | 21.00 | 17.67 | 19.34 | 51.62 | 59.41 | 55.52 | 57.81 | 66.54 | 62.18 |
| | | Mean | 16.86 | 16.05 | 16.45 | 18.88 | 17.97 | 18.43 | 53.98 | 60.26 | 57.12 | 60.45 | 67.49 | 63.97 |
| Mean | | M | 11.87 | 13.38 | 12.62 | 13.29 | 14.98 | 14.14 | 46.02 | 52.97 | 49.49 | 54.88 | 59.32 | 57.10 |
| | | L | 13.33 | 12.91 | 13.12 | 14.92 | 14.46 | 14.69 | 44.60 | 49.28 | 46.94 | 49.95 | 55.19 | 52.57 |
| | | Mean | 12.60 | 13.14 | | 14.11 | 14.72 | | 45.31 | 51.12 | | 52.41 | 57.26 | |
| LSD Rainfall | | | | | 0.84 | | | 0.15 | | | 0.46 | | | 0.46 |
| LSD cultivars | | | | | 0.15 | | | 0.15 | | | 1.67 | | | 1.67 |
| LSD Inoculation | | | | | 0.21 | | | 0.21 | | | 2.15 | | | 2.15 |
| LSD Rainfall x cultivars | | | | | 0.74 | | | 0.74 | | | 1.26 | | | 1.26 |
| LSD Rainfall x Inoculation | | | | | 0.81 | | | 0.81 | | | 1.16 | | | 1.16 |
| LSD cultivars x Inoculation | | | | | 0.68 | | | 0.68 | | | 0.14 | | | 0.14 |
| LSD Rainfall x cultivars x Inoculation | | | | | 0.44 | | | 0.44 | | | 1.95 | | | 1.95 |

LSD at 0.05 - W.= without inoculation , In.= Inoculation - M.= Master B , L.= Lincolin - 1st = First season , 2nd = Second season

These results are in agreement with those findings by **Feng *et al.* (1997)** and **Solaiman, and Rabbani (2005)** who reported that Rhizobium inoculant significantly increased pods number of pea when compared with uninoculated control. Also, in another study, it was observed that pea var. BARI Motorshuti -1 gave maximum pod yield of 30.78 g/plant (111% increase over uninoculated control) and mature seed yield was 5.10 g/plant (86% increase over uninoculated control) when plants were inoculated with Rhizobium strains (**Solaiman and Khondaker, 2002**). Also, inoculation with suitable rhizobia with Phosphorus improved symbiotic nitrogen fixation and yield in common bean (**Zaman-Allah *et al.*, 2007**).

**2- 4 - Effect of the interaction: -**

The results recorded in Tables 3 , 4 show that the triple interaction treatment rainfall + 120 mm supplemental irrigation for Master B cultivar with inoculated bacteria gave the highest values of yield and its components than the other interaction treatments.

**3- Chemical composition:**

**3- 1 – Effect of supplemental Irrigation: -**

The results presented in Tables 5, 6 showed significant effects of complementary irrigation treatments on the chemical constituents under study. Where the outperforming treatment of irrigation (rainfall +120 mm supplemental irrigation) gave the highest values of the content of nitrogen, phosphorus, potassium, protein and carbohydrates of pea seeds. The results agree with those obtained by **Oweis and Hachum. (2004) and Sherif *et al.* (2010)**. These results may be due to that supplemental irrigation could increase nutrients uptake by roots and transport to shoots (**Mahajan and Tuteja, 2005**)

**3- 2 - Effect of cultivars: -**

The results indicate that there were significant positive effects for Master B cultivar on chemical content of pea seeds (nitrogen, phosphorus, potassium, protein and carbohydrates), when compare to Lincolin cultivar in both growing seasons as shown in Tables 5 , 6. In this respect, such differences may be due to differential in nutrients uptake as regarded by **Bianchini and Eyherabid (1999).** Also, **Zaki *et al.* (2009)** studied the effect of irrigation with saline water on three sweet fennel cultivars. They found differences among cultivars in chemical content; it could be due to differences in cultivars response to saline stress. **EL-Hifny (2010)** studied the effect of two cowpea cultivars, and found that the highest values of chemical content of cowpea seeds were recorded by Kafr El-Shekh cultivar, except Cl content which was increased in Cream 7 cultivar. The differences between cultivars in chemical content could be due to the differences of genotypes cultivars.

**3- 3 – Effect of bacterial inoculation:**

Results presented in Tables 5 , 6 show that bacterial inoculation gave significant positive effect on all chemical components under study, when compared with un-inoculation treatment. The increase in protein content due to biological fertilizers was reported by **Elsheikh (2001).**

**Solaiman and Rabbani (2005)** who found that the performance of Rhizobium inoculated alone was superior to un-inoculated in protein content in green and mature seeds of pea. This could be due to inoculation with bacteria significantly changed the ion balance in plant tissue, regardless of plant part or bacteria type for the element uptake, the metabolic pathway responsible for the increase of ion uptake (**Tahr and Dahdoh, 1997**)

**3- 4 - Effect of Interaction.**

Data presented in Tables 5 and 6 clearly showed that there was a significant effect of the interaction treatments on chemical composition of pea. The highest values of nitrogen, phosphorus, potassium, protein and carbohydrates content were obtained with the interaction treatment rainfall +120 mm supplementary irrigation with Master B cultivar inoculated with bacteria. These results are in the same trend with those of **Osman *et al.* (2010)** and **Rugheim and Abdelgani (2011)** on faba bean.

**Conclusion**

Under NWCZ conditions semi arid region (120 - 150 mm rainfall) we can improve growth, production and chemical compositions of pea plants by using supplementary irrigation with rate of 120 mm beside rainfall and use Master B cultivar inoculated with *Rhizobium Leguminosarum.*

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# استجابة بعض أصناف البسلة للري التكميلي تحت ظروف الزراعة المطرية

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أقيمت تجربتان حقليتان في الحقل المفتوح خلال موسمي الزراعة ٢٠٠٥/٢٠٠٦و ٢٠٠٦ / ٢٠٠٧ تحت ظروف الزراعة المطرية والأراضي الجيرية في منطقة الحمام بالساحل الشمالي الغربي. بجمهورية مصر العربية. وهدف البحث دراسة تأثير أربع معاملات من الري التكميلي ( مطري فقط بدون ري تكميلي ومطري + ٦٠ مم ري تكميلي / فدان. ومطري + ٩٠ مم / فدان ومطري +١٢٠ مم / فدان) وكذلك تلقيح بذور صنفي البسلة (لينكولن وماستر بي) قبل الزراعة بمخلوط بكتيري (الريزوبيم + البكتريا الميسرة للفوسفور) .علي النمو الخضري والمحصول ومكوناته كذلك المحتوي الكيميائي للبذور.

**وقد تم تلخيص النتائج على النحو التالي : –**

أدت معاملة الري المطري + ١٢٠ مم ري تكميلي للحصول على أعلي القيم لجميع صفات النمو الخضري تحت الدراسة ، ارتفاع النبات (سم) ، وعدد الأوراق والفروع للنبات والوزن الطازج والجاف للنبات (جرام) ، باستثناء نسبة المادة الجافة التي كانت عكس هذا الاتجاه حيث انخفضت بزيادة الري التكميلي. علاوة على ذلك ، أدت الزيادة في معدلات الري التكميلي إلي زيادة في قيم المحصول ومكوناته (عدد القرون للنبات و طول القرن (سم) ، و الوزن الطازج لعدد ١٠٠ بذرة (جرام) و متوسط الوزن الطازج للقرن (جرام) ، محصول القرون / نبات (جرام) ومحصول الفدان (كجم)). بالمقارنة مع الري المطري فقط (معاملة المقارنة). كذلك كانت أعلى القيم في كلا الموسمين لمحتوى البذور من النيتروجين والفوسفور والبوتاسيوم و البروتين والكربوهيدرات تحققت مع أعلا معدل إضافة للري التكميلي.

٢ –اظهر صنف ماستر بي تفوقا كبيرا علي صنف لينكولن لجميع صفات النمو الخصري والمحصول ومكوناته وكذلك محتوي البذور من العناصر والكربوهيدرات والبروتين

٣– أعطى التلقيح البكتيري زيادة معنوية في جميع القيم لصفات المحصول تحت الدراسة بالمقارنة مع عدم التلقيح (النمو الخضري والمحصول ومكوناته وكذلك المحتوي الكيماوي) ما عدا نسبة المادة الجافة كانت أعلا القيم للمعاملة بدون تلقيح.

٤ – التفاعل الثلاثي : مطري + ١٢٠ مم ري تكميلي + التلقيح البكتيري مع الصنف ماستر بي أدى إلى الحصول على أعلا القيم لجميع الصفات تحت الدراسة في كلا الموسمين لمحصول البسلة