# EFFECT OF PHOSPHATE FERTILIZATION, MOLYBDENUM FOLIAR SPRAY AND RHIZOBIUM INOCULATION ON GROWTH AND YIELD OF CHICKPEA

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**ABSTRACT:**

A field experiment was conducted on chickpea plants (Giza 3 var) grown on a sandy soil at Ismailia Agric. Res. Station, Egypt during the winter season of 2005/2006 to study the effect of the separate treatments of phosphorus fertilizer, molybdenum foliar spray and seed inoculation with rhizobium and their combinations on plant growth, root nodulation, seed and straw yields.

The obtained data indicate that the combined application was as good as separate treating and both had significantly increases for root nodulation, vegetative growth, pod, seed and straw yields as well as the plant contents of N, P and K over the untreated control. The individual effects of phosphate fertilization, molybdenum foliar application and rhizobium inoculation on vegetative growth and yield of chickpea arranged in ascending order were molybdenum < seed inoculation < phosphorus. However, the highest values of plant dry weight (70 days after planting) and yield of chickpea existed in the inoculated plants which received 45 kg $P_2O_5$ + 30 g Mo/fed.

**Key words:** Phosphorus, Molybdenum, Rhizobium and Chickpea.

## INTRODUCTION:

Chickpea is an important pulse crop in many regions of the world. However, cereal production has displaced chickpea from many of its traditional area of production, forcing chickpea production to shift to areas of low rainfall and poor soil fertility. Consequently, recent improvements in yield have often been small because plants are grown under drought and poor nutritional management of soil. These factors affect the number of root nodules and consequently the efficiency of nitrogen fixation by plants. While, inoculation with highly effective and exotic strain of rhizobium has been as well-known practice for enhancing nodule formation. The results often are not encouraging due to the predominance of highly competitive but less effective, indigenous strain of bacteria in soil. Therefore, there is a need for enhancing the efficiency of biological nitrogen fixation by nodule bacteria, which can be achieved through improving the technique of inoculation and supplying proper nutrition to the soil **(Chandra and Kothari, 2002)**.

For higher plants the requirements of Mo is lower than for any other essential mineral nutrients. Molybdenum, being a component of nitrate reductase enzyme, plays an essential role in nitrogen fixation by rhizobium in legumes **(Candra and Kathari, 2002 and Kaiser *et al.*, 2005)**. This enzyme controls the reduction of inorganic N and helps in fixing nitrogen as $NH_3$.

An application of molybdenum has been shown to increase nodulation growth, grain and straw yields of various legumes **(Meena *et al.*, 2002; Williams *et al.*, 2004 and Nautiyal and Chatteriee, 2004)**. Beside bacterial inoculation and molybdenum fertilizer, other important factor for stepping up the yield of chickpea is phosphorus. Application of phosphorus significantly increased yield attributes, yield, number of nodules/plant, dry weight of nodules **(Yahiya *et al.*, 1995; Takankhar *et al.*, 1997; Alloush *et al.*, 2000; Kalipada *et al.*, 2003; Gull *et al.*, 2004; Hakoomat *et al.*, 2004 and Shivakumar *et al.*, 2004)**. The former authors reported that phosphorus is the key nutrient for increasing productivity of pulses. It is the most important single factor responsible for improving the production of pulses. They added that protein content of grain increased significantly with the application of phosphorus. One of the best sources to reduce the cost or fertilizer is the inoculation of seed pulses with appropriate strain of rhizobium bacterium.

The present work was conducted to evaluate nodulation, growth yield and yield components of chickpea (Giza 3 var.) as influenced by seed inoculation, molybdenum foliar spray and phosphorus fertilization.

## MATERIALS AND METHODS:

A field experiment was conducted on chickpea plants (Giza 3 var.) grown on a sandy soil at Ismailia Agric. Res. Station, Egypt during the winter season of 2005/2006. The tested treatments consist of phosphate fertilization (45 kg $P_2O_5$/fed), molybdenum foliar spray (30 g Mo with 500 L of water/fed), seed inoculation with rhizobium as well as their interactions and the control. Treatments were replicated 3 times in a randomized blocks design. Phosphorus fertilizer was applied as superphosphate (15 % $P_2O_5$) during the final stage of land preparation, and molybdenum foliar application was performed 25 days after plant emergence as ammonium molybdate (55.2 g dissolved in 500 L of water/fed) and seed inoculation with rhizobium (Rh). The studied treatments were as follows: control, phosphorus fertilizer (P), molybdenum foliar application (Mo), seed inoculation (Rh), (P + Mo), (P + Rh), (Mo + Rh) and (P + Mo + Rh).

Seeds of chickpea (Giza 3 var.) were sown in plots 3.0 X 3.5 m with five ridges per plot. All plots were fertilized with equal amounts of nitrogen at the rate 15 kg N/fed as ammonium sulphate 20.5% N). Potassium sulphate (48% $K_2O$) was also added at the rate 50 kg/fed in two equal doses before planting and 30 days after sowing. Recommended field practices were undertaken.

After 70 days from planting, five plants were carefully uprooted from a section of row beginning 0.5 m from the end of the outer two rows. At each sampling, the roots were washed and plants were separated into their component parts and the following parameters were determined: number & dry weights of nodules/plant and dry weight of shoots. Plant samples were kept for N, P and K determinations.

At maturity, yields of both seed and straw as well as yield attributes were estimated from an area of 6 $m^2$ incorporated to three plot ridges. Protein content of seeds and straw were analyzed according to **Chapman and Pratt (1961)**. Some physical and chemical characteristics of the studied soil were determined according to **Piper (1950) and Jackson (1967)**, as shown in Table (1).

**Table 1. Some physical and chemical properties of the experimental soil.**

| Soil characteristics | Value |
|---|---|
| *Particle size distribution %:* | |
| Coarse sand | 66.8 |
| Fine sand | 22.3 |
| Silt | 6.2 |
| Clay | 4.7 |
| Textural class | Sand |
| *Soil chemical properties*: | |
| Soil pH (1:2.5 soil water suspension) | 7.80 |
| $CaCO_3$ % | 0.50 |
| Organic matter % | 0.20 |
| ECe (dS/m, soil paste extract) | 0.69 |
| *Soluble cations (soil paste, meq/l)*: | |
| $Ca^{2+}$ | 1.96 |
| $Mg^{2+}$ | 1.76 |
| $Na^{+}$ | 2.60 |
| $K^{+}$ | 0.32 |
| *Soluble anions (soil paste, meq/l)*: | |
| $CO_3^{2-}$ | 0.00 |
| $HCO_3^{-}$ | 2.50 |
| $Cl^{-}$ | 2.24 |
| $SO_4^{2-}$ | 1.90 |
| *Available macronutrients (mg/kg soil)*: | |
| N | 14.3 |
| P | 3.5 |
| K | 60.0 |

## RESULTS AND DISCUSSION:

### *I. Effect of phosphorus fertilizer:*

Data presented in Table (2) reveal that plant growth parameters (plant height, shoot dry weight, number of nodules and their weights/plant at 70 days from sowing) and yield attributes (pods/plant, weight of seed/plant and 100 seed weight) significantly increased with phosphorus application at the rate of 45 kg $P_2O_5$/fed of chickpea plants. Increases for plant height, dry matter, number of nodules and dry weight of root nodules were 23.8, 19.7, 44.8 and 34.9% over the control, respectively. The positive effect of phosphorus application at the rate 45 kg $P_2O_5$/fed on root growth promoted the activity of rhizobia on plant roots and induced nodulation **(Meena *et al.*, 2002)**. These results are in close conformity with the findings of **Alloush *et al.*, (2000) and Meena *et al.*, (2002)**.

**Table 2. Effect of phosphorus, molybdenum and bacterial inoculation on growth, root nodulation and nutrient contents in plant tissues of chickpea.**

| Treatments | Plant height (cm) | Shoot dry weight (g/plan) | No. of nodules/ plant | Nodules dry weight (mg/plant) | Nutrient contents in plant tissues % | | |
|---|---|---|---|---|---|---|---|
| | | | | | N | P | K |
| Control | 45.82 | 13.78 | 7.15 | 41.75 | 2.31 | 0.43 | 1.11 |
| P | 56.75 | 16.50 | 10.35 | 56.31 | 3.67 | 0.87 | 2.34 |
| Mo | 48.17 | 14.77 | 9.50 | 50.60 | 3.12 | 0.55 | 1.18 |
| Rh | 50.90 | 15.11 | 10.11 | 54.95 | 3.48 | 0.63 | 1.16 |
| P + Mo | 58.37 | 16.85 | 11.09 | 59.22 | 3.96 | 0.90 | 2.44 |
| P + Rh | 59.63 | 17.05 | 11.92 | 60.71 | 4.01 | 0.96 | 2.51 |
| Mo + Rh | 54.59 | 15.83 | 11.16 | 58.15 | 3.56 | 0.74 | 1.20 |
| P + Mo + Rh | 60.08 | 18.42 | 12.35 | 66.92 | 4.24 | 0.98 | 2.89 |
| L.S.D. at 0.05 | 1.37 | 0.80 | 1.12 | 7.60 | 0.33 | 0.11 | 0.25 |

The relative increases over the control treatment were 53.3% for seed yield (953.8 kg/fed) and 41.9% for straw yield (1157.2 kg/fed) at phosphorus fertilization alone. The increase in yield-attributing characters with phosphorus application might be owing to the low availability of phosphorus in the studied soil (3.5 mg $NaHCO_3$ extractable P/kg soil). Application of phosphorus led to increase in vigour and plant growth and resulted in better development of yield attributes. These results are in good agreement with the findings of **Tiwari *et al.* (1989) and Abidi *et al.* (2001)**. Data in Tables (2 and 3) show that plant contents of N, P, K and protein percentages in seeds and straw were significantly affected by phosphorus application at 45 kg $P_2O_5$/fed. The increase in seed protein content was 17.1 % with phosphorus application alone over the control treatment.

**Table 3. Effect of phosphorus, molybdenum and bacterial inoculation on protein content, yield components and yield of chickpea.**

| Treatments | No. of pods/ plant | Weight of seed/ plant (g) | 100 seed weight (g) | Seed yield (kg/fed) | Straw yield (kg/fed) | Protein content % | |
|---|---|---|---|---|---|---|---|
| | | | | | | Seed | Straw |
| Control | 37.12 | 8.31 | 23.74 | 622.30 | 815.60 | 18.58 | 7.54 |
| P | 43.56 | 11.56 | 29.11 | 953.80 | 1157.20 | 21.76 | 12.93 |
| Mo | 40.85 | 10.05 | 27.85 | 760.10 | 913.80 | 19.47 | 9.44 |
| Rh | 39.44 | 9.88 | 27.01 | 808.50 | 981.10 | 20.29 | 9.98 |
| P + Mo | 44.88 | 12.11 | 29.57 | 970.40 | 1190.20 | 22.17 | 13.30 |
| P + Rh | 43.91 | 11.95 | 29.33 | 989.30 | 1201.8 | 22.83 | 14.65 |
| Mo + Rh | 41.16 | 10.75 | 28.16 | 840.10 | 1112.30 | 23.14 | 12.74 |
| P + Mo + Rh | 46.70 | 13.80 | 30.41 | 1030.50 | 1275.10 | 24.65 | 16.08 |
| L.S.D. at 0.05 | 2.16 | 0.80 | 0.34 | 76.50 | 103.30 | 1.54 | 1.37 |

***II. Effect of seed inoculation:***

Seed inoculation with rhizobium significantly increased plant height, number & dry weight of nodules/plant and dry weights of plants at 70 days from planting. Data presented in Table (2) showed a significant increase in plant dry weight as a result of seed inoculation, which amounted to 9.7% as compared with the control treatment. Shoot N, P and K concentrations for plants grown under the various treatments are illustrated in Table (2). Shoot nutrient contents were significantly affected by rhizobium inoculation and had a similar trend as plant dry weight. The greater nodule number and/or nodule weight led to increase the amount of nitrogen in plant **(Nambiar *et al.*, 1983)**. Chickpea had greater shoot P contents when plants were grown under the combined treatment (P + Rh) than plants received either phosphorus or seed inoculation solely. These results are in line with the findings of **Namdeo *et al.* (1989) and Meena *et al.* (2002)**.

Significant increases in seed yield and its components were observed due to seed inoculation as compared with the control treatment (Table, 2). The increase in seed yield was 29.9% as compared with un-inoculated ones. This increase in yield might have been due to the cumulative effect of increased growth and yield components as well as increased nitrogen and phosphorus contents in plant tissues. These results are in agreement with those of **Namdeo *et al.* (1989); Chandra and Kumar (1995) and Meena *et al.* (2002)**.

Phosphorus and seed inoculation interaction showed significant improvement in seed protein content (Table, 3). These data indicated that phosphorus application increased seed protein content from 18.58% for plots of the control treatment to 22.83% at applied rate of 45 kg $P_2O_5$/fed and rhizobium inoculation. This could be due to the increase of phosphorus availability by rhizobium, which resulted in greater uptake and accumulation of nitrogen in seeds. Similar results observed by **Takankhar *et al.* (1997)**, who found a significant interaction effect between seed inoculation and phosphorus on seed protein content of chickpea. The greatest seed protein content was recorded with bacterial inoculation + 45 kg $P_2O_5$ + 30 g Mo/fed (Table, 3).

***III. Effect of molybdenum foliar application:***

As seen in Table (2) foliar application of molybdenum increased most of the studied characteristics of chickpea plants 70 days old. The increment over the control treatment, at 30 g of molybdenum foliar application/fed, was 7.2% for dry matter, 32.8% for number of root nodules and 21.2% for dry weight of root nodules. Plant roots not only had greater number of nodules but also they were more healthy showing pinkish color in comparison with those of the control. This observation suggests that the increase in nodulation is caused by Mo induced enhancement of nitrogen fixation by rhizobium. Similar observation was reported by **Dubey (1999); Pattanayak *et al.* (2000) and Chandra and Kothari (2002)** who found that both soil application and seed treatment with Mo significantly increased the number of nodules over the control treatment.

Data in Table (2) also showed that foliar application of molybdenum significantly increased N and P contents of plant tissues as compared with the control treatment. Studies of **Jat and Rathore (1994)** indicated that added Mo increases both N and P contents in seed, straw and total biomass production, which lead to greater uptake of these nutrients. Similar observations reported were by **Tiware *et al.* (1989) and Chandra and Kothari (2002)** for cowpea and chickpea, respectively. The same authors also showed that protein content in chickpea seed significantly increased with increasing the levels of Mo through soil application. The increase in protein content by Mo application may be attributed to the increased number of nodules, which ultimately enhanced the symbiotic fixation of nitrogen to the plant and also enhanced the protein content of crop. **Nautiyal and Chatterjee (2004)** found that low concentration of Mo is responsible for low protein.

Foliar application of molybdenum significantly increased the various yield components and seed yield of chickpea (22.15% over the control treatment). These observations are in agreement with the results of **Nautiyal and Chatterjee (2004)** who found that the greatest seed yield was obtained at 0.2 mg Mo/L, whereas the vegetative growth reached its maximum at 0.02 mg/L indicating a higher Mo requirement for chickpea yield. **Yanni (1992)** stated that the seed yield of rhizobia inoculated legume crops increased strikingly by Mo fertilization.

Data in Table (2) show that chickpea plants had greater shoot N and P concentrations when plants were treated with both P and Mo as well as rhizobium inoculation as compared to those of the control treatment. Plants treated with seed inoculation in combination with either P or Mo had higher N and P concentrations than those received individual applications of P, Mo or seed inoculation. Plants treated with P had greater K concentration than those of the control treatment, but plants treated with Mo and seed inoculation had similar K concentration as the control treatment.

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## تأثير التسميد الفوسفاتى والرش بالموليبدنم والتلقيح بالريزوبيوم على نمو نبات ومحصول الحمص

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أجريت تجربة حقلية على نباتات الحمص (صنف جيزة ٣) النامية فى أرض رملية بمحطة البحوث الزراعية بالإسماعلية – مصر خلال الموسم الشتوى ٢٠٠٥-٢٠٠٦، لدراسة التأثير المنفرد لكل من التسميد الفوسفاتى والرش بالموليبدنم والتلقيح بالريزوبيوم، وكذلك التأثير المشترك بينهم على النمو الخضرى ومحصولى الحبوب والقش .

وقد دلت النتائج المتحصل عليها على أن تأثير جميع هذه المعاملات سواء كانت فى صورة منفردة أو مشتركة كان معنويا على كل من النمو الخضرى وتكوين العقد الجذرية وكذلك محصول الحمص وصفاته المحصولية، وكذلك محتواه من النتروجين والفوسفور والبوتاسيوم بالمقارنة بمعاملة الكنترول. وبالنسبة إلى التأثيرات المنفردة لكل من التسميد الفوسفاتى والرش بالموليبدنم والتلقيح بالريزوبيوم على كل من نمو النبات ومحصول الحمص فقد أمكن ترتيبها تصاعديا كما يلى:

المولبيدنم < الريزوبيوم < الفوسفور

وقد تحصل على أعلى القيم لمحصول المادة الجافة عند ٧٠ يوم من الزراعة، وكذلك محصول الحمص من المعاملة (٤٥ كجم فو٢أ٥ + ٣٠ جم موليبدنم مذاب فى ٥٠٠ لتر ماء/فدان للنباتات الملقحة بالريزوبيوم) .