INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2004/06–1–110–112
http://www.ijab.org

Interactive Effect of Seed Inoculation and Phosphorus Application on Growth and Yield of Chickpea (*Cicer arietinum* L.)

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ABSTRACT

The interactive effect of seed inoculation i.e. un-inoculated and inoculated seed along with various levels of phosphorus (i.e. 0, 60, 90 and 120 kg P_2O_5 ha^{-1}) on chickpea growth was studied at the Agronomic Research Area, University of Agriculture, Faisalabad during 1999-2000. The variety "Bittal-98" was sown on a sandy clay loam soil, having 0.96% organic matter, 0.06% nitrogen, 6.20 ppm phosphorus and 118 ppm potassium. The results revealed that higher 1000-seed weight seed yield and biological yield (256.10 g, 3088.21and 7496.99 kg ha^{-1}, respectively) were obtained with seed inoculation and 90 kg P_2O_5 ha^{-1} application (Inoc.1×P_3). On contrary, the lowest seed yield, biological yield and 1000-seed weight were obtained with un-inoculation and zero applied phosphate (Inoc-0×P_1). This increase in yield occurred due to an increase in growth and development of chickpea crop with inoculation and phosphorus application.

Key Words: Chickpea; Growth; Inoculation; Nodules; Phosphorus; Yield

INTRODUCTION

Chickpea (C*icer arietinum* L) is a grain legume crop grown primarily for its nutritional value. Because of high protein contents, it is considered as an economical source of quality vegetable protein in human diet. Farmers have a wrong notion that chickpea being a legume crop, does not need any nutrition and usually grow it on the marginal land, without applying any fertilizer. The yield gap of chickpea may be attributed to improper agro-technology used by the farmers. Yield gap can be abridged, by adopting the advanced production technology accompanying with the use of inoculums, balanced nutrition, weed management and high yielding varieties. Application of phosphorus to the legumes also improves the seed yield considerably (Hussain, 1983). Further, Raut and Kohire (1991) reported that seed yield of chickpea was increased significantly with *Rhizobium* and phosphorus application. Patel and Patel (1991) also observed that nitrogen application as a starter dose along with phosphorus and seed inoculation has beneficial effect on yield of chickpea crop. Tippannavar and Desai (1992) studied that seed inoculation with *Rhizobium* increased the nodule number, seed yield and plant dry weight. Shah *et al.* (1994) found that increase in number of nodules, and seed yield due to seed inoculation. Roy *et al.* (1995) reported that seed inoculation increased the nodule number per plant and gave highest harvest index and 1000-seed weight. Konde and Deshmukh (1996) and Saraf *et al.* (1997) concluded that plant dry weight and other yield components were generally increased by inoculation. Pawar *et al.* (1998) investigated that seed inoculation increased the number of nodules per plant, nodules dry weight per plant as compared to un-inoculated seed (control) in a trail on chickpea. Takankhar *et al.* (1998) reported similar findings that application of 75 kg P_2O_5 ha^{-1} produced the highest seed yield of 1.25 tons ha^{-1}. El-Hadi and El-Sheik (1999) calculated an increase of 70-72% in seed yield due to inoculation over un-inoculated (control). Keeping in view the above-mentioned importance of seed inoculation and phosphorus application, the present study was designed to select the best-suited combinations of seed inoculation and phosphorus level for chickpea production.

MATERIALS AND METHODS

The experiment regarding the interactive effect of inoculation and phosphorus application on growth and yield of chickpea crop was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad during 1999-2000 on a sandy clay loam, having 0.96% organic matter, 0.06% nitrogen, 6.20 ppm phosphorus and 118 ppm potassium. The treatments were allocated in a randomized complete block design with factorial arrangement with three replicates having a net plot size of 1.6 m×5m. Chickpea variety "Bittal-98" was used as a test crop. The experiment comprised of the treatments viz; un-inoculated seed (control) and inoculated seed and phosphorus levels of 0, 60, 90, and 120 kg P_2O_5 ha^{-1}. All the plots were sown manually with a single row hand drill in the first week of November 1999 using a seed rate of 50 kg ha^{-1}. Row to row distance was 40 cm. All fertilizers were applied as side placement; a basal dose of nitrogen at the rate of 30 kg ha^{-1}

and phosphorus as per treatment in the form of Urea and Triple Super Phosphate, respectively. Plant to plant distance of 15 cm was maintained after 10 days of germination by thinning. The crop was kept free of weeds by hand hoeing at 10 and 20 days after emergence. No irrigation was applied to the crop because a sufficient rainfall (28mm) was occurred during the growth period of crop.

The data were collected by following the standard procedure on leaf area index, number of nodules per plant, 1000-seed weight, biological yield and seed yield. Further, the data collected on yield components were analysed using the computer statistical program MSTAT-C (Freed & Eisen Smith, 1986), and differences among treatment means were compared by least significant differences test (LSD) at 5% probability level (Steel & Torrie, 1984).

RESULTS AND DISCUSSION

Results (Table I) indicate that seed inoculation with *Rhizobium* had significant effect on leaf area index. This increase in leaf area index due to seed inoculation was 16.47% over control. Similar promotive effects of seed inoculation on leaf area have also been reported by Jain *et al*. (1999) and El-Hadi and El-Sheikh (1999). Phosphorus application also significantly influenced the leaf area index and higher phosphorus levels resulted in greater leaf area index while lower levels exhibited minimum. The maximum leaf area index of 3.78 was exhibited by P_3 treatment (90 kg P_2O_5 ha^{-1}), which was on par with P_4 (120 kg P_2O_5 ha^{-1}). The lowest leaf area index (1.94) was observed in treatment where zero phosphorus was applied. Singh *et al*. (1983) and Yahiya *et al.* (1995) have found the similar findings that leaf area index increased with application of phosphorus fertilizer. Interaction of inoculation and different levels of phosphorus was also found to be highly significant. Significantly the highest leaf area index of 4.16 was observed in treatment of Inoc-1 × P_3 that was on a par with Inoc-1 × P_4 (4.08) and significantly the lowest leaf area index of 1.91 was attained by the treatment Inoc-0 × P_1 (control). This increase in leaf area index could be attributed to promotive effect of inoculation and phosphorus application on leaf area of crop plant.

The plants raised from seed inoculated with *Rhizobium* loti produced 21.96% more nodules than control. These results are in line with the findings of other scientists who found that number of nodules per plant was the highest in plants inoculated with *Rhizobium* (Tippannavar & Desai, 1992; Shah *et al*., 1994; Roy *et al*., 1995; Khan *et al*., 1997; Pawar *et al*., 1997; Pawar *et al*., 1998; El-Hadi & El-Sheikh, 1999). The differences in number of nodules among various phosphorus levels were also significant but, the interactions between inoculated seed and phosphorus fertilizer were found to be non significant. Table I shows that inoculation had significant effect on 1000-seed weight and the effect of phosphorus application on seed weight was also found to be significant. Significantly, maximum 1000-seed weight was attained by treatment P_3 where phosphorus was applied at the rate of 90 kg P_2O_5 ha^{-1}. It was followed by P_4 treatment (120 kg P_2O_5 ha^{-1}). Minimum 1000-seed weight was observed in treatment P1 (control). Better growth and development of crop plants due to phosphorus supply and nitrogen uptake might have increased the supply of assimilates to seed, which ultimately gained more weight. Similar achievements on 1000-seed weight with phosphorus are reported by Kar *et al.* (1989), Singh and Hiremath (1990), Chauhan *et al*. (1992) and Anchal *et al*. (1997). The interactive effects between inoculation and phosphorus on 1000-seed weight were observed significant statistically among different treatments. It is evident from the data that the crop raised with inoculation and phosphorus application

Table I. Effect of inoculation and different levels of phosphorus fertilizer on growth and yield of chickpea crop

Treatments	Leaf Area Index	Number of nodules per plant	1000-seed weight (g)	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})
Inoculation (Inoc)					
Uninoculated (0)	2.792 b	18.05 b	240.90 b	5932.52 b	2265.24 b
Inoculated (1)	3.341 a	23.13 a	245.90 a	6507.44 a	2584.77 a
LSD (5%)	**0.678**	**1.028**	**2.467**	**106.2**	**76.27**
Phosphorus P_2O_5					
P_1)- 0 kg ha^{-1}	1.939 c	14.80 c	231.90 d	4481.10 c	1654.82 c
P_2)- 60 kg ha^{-1}	2.855 b	19.85 b	239.20 c	6131.33 b	2331.22 b
P_3)- 90 kg ha^{-1}	3.782 a	23.40 a	253.70 a	7188.83 a	2894.27 a
P_4)- 120 kg ha^{-1}	3.691 a	24.30 a	248.70 b	7078.67 a	2819.72 a
LSD (5%)	**0.135**	**1.454**	**3.489**	**150.20**	**107.90**
Interaction **(Inoc × P_2 O_5)**					
Inoc-0 × P_1	1.905 c	12.50	231.50 c	4344.88 f	1599.54 e
Inoc-0 × P_2	2.560 d	18.30	238.30 b	5746.44 d	2155.33 d
Inoc-0 × P_3	3.403 b	20.30	251.30 a	6880.66 b	2700.32 b
Inoc-0 × P_4	3.301 b	21.10	242.30 b	6758.11 b	2605.77 bc
Inoc-1 × P_1	1.973 e	17.10	232.20 c	4617.33 e	1710.10 e
Inoc-1 × P_2	3.150 c	21.40	240.20 b	6516.22 c	2507.11 c
Inoc-1 × P_3	4.160 a	26.50	256.10 a	7496.99 a	3088.21 a
Inoc-1 × P_4	4.082 a	27.50	255.00 a	7399.22 a	3033.66 a
LSD (5%)	**0.135**	**ns**	**4.935**	**212.40**	**152.50**

produced 4.6% more 1000-seed weight than control.

The maximum biological yield (Table I) was attained by the treatment P_3 (90 kg P_2O_5 ha^{-1}) that was on a par with P_4 (120 kg P_2O_5 ha^{-1}). Significantly, the minimum biological yield was observed in treatment P_1 (control). More plant growth, yield and yield components are the possible reason for more biological yield in inoculated plot (Roy *et al*., 1995). Further, the maximum biological yield was observed in Inoc-1 × P_3 which was on a par with Inoc-1 × P_4. On the contrary, significantly the lowest yield was found in Inoc-0 × P_1 (control). Minimum biological yield in treatments where no phosphorus and inoculation was applied or phosphorus was in low amount was due to low plant height, less yield and yield components.

The seed inoculation had significant effect on seed yield and increase in seed yield due to seed inoculation was 12.4% over control (Table I). This increase in yield was attributed to increase in yield components of the crop in inoculated plots (Konde & Deshmukh, 1996; Pawar *et al*., 1998). Phosphorus showed significant effects on seed yield and the treatments P_3 and P_4 (90 and 120 kg P_2O_5 ha^{-1} respectively) gave significantly higher yield than the treatment P_1 (control). The interactive effect of seed inoculation and phosphorus rates on yield of chickpea was found to be significant. The increase in yield of treatments, treated with inoculation and higher rates of phosphorus application was due to increase in yield components of crop of these plots (Raut & Kohire, 1999; Jain *et al*., 1999).

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(Received 10 November 2003; Accepted 12 December 2003)