POTENTIAL OF *AZOTOBACTER* FOR PROMOTING POTATO GROWTH AND YIELD UNDER OPTIMUM FERTILIZER APPLICATION

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Field experiment was conducted to study the potential of *Azotobacter* inoculation for enhancing yield and other growth parameters on a sandy loam soil, given NPK @ 250, 125, 125 kg ha^{-1}, respectively. Tubers of CEB-819-17 were inoculated with four strains of *Azotobacter* at the time of sowing. The results showed that shoot, root, single tuber weight, tuber yield $plant^{-1}$ and R/S ratio increased significantly due to inoculation with all the strains and maximum tuber yield (18.13% higher than control) was observed with A_4 inoculation. Single tuber, shoot, root weight $plant^{-1}$ and R/S ratio were maximum with strain A_3 inoculation. This enhancement in the potato growth might be due to the production of plant growth regulators as there was no possibility of N-fixation in the presence of such a high dose of nitrogen.

INTRODUCTION

Azotobacter chroococcum has been widely used to inoculate crop plants and conclusions have been drawn that seed inoculation of non-legume increased the yield of field crops by about 10% and cereals by 15-20% (Mishustin *et al.*, 1963). Effectiveness of inoculation was increased by manuring up to 33.4% and by fertilization up to 12.7% (Fedrov, 1952; Mishustin, 1970; Reddy *et al.*, 1977; Singh *et al.*, 1977). Trials conducted in Pakistan to study the effectiveness of *Azotobacter* inoculation increased the yield of wheat varieties Ch 79 and LU 26 and of maize varieties J_1 and UM 2 by 17.2, 21.3, 19.6 and 15.0%, respectively, compared to unfertilized controls. Trials conducted under fertilized soils (125 kg ha^{-1}) showed that N application without inoculation increased the yields by 29.7, 47.3 and 21.2% of wheat varieties Ch 79, LU 26 and maize variety UM 2 respectively and inoculation increased them further by 8.38, 4.4 and 15.9%, respectively (Hussain and Khan, 1973; Hussain *et al.*, 1985; Hussain *et al.*, 1987). These findings led us to study the possibility of increasing potato yield by inoculating with *Azotobacter* under optimum fertilizer conditions.

MATERIALS AND METHODS

Isolation of *Azotobacter* strains: *Azotobacter* strains were isolated from the potato rhizosphere soil by employing the dilution plate method and modified Jensen's medium (K_2HPO_4 1.5 g, NaCl 0.3 g, $MnSO_4$ traces, Sucrose 15 g, $MgSO_4$ 0.3 g, $FeSO_4$ 0.04 g, $CaCO_3$ 3.0 g, Agar 15 g, Distilled water 1000 ml, pH 8.0). Quick growing colonies were selected and were named as A1, A2 and A3. Mixed strain (A4) was prepared by adding 1 g soil in a flask containing 100 ml of Jensen's liquid medium and incubated at 28 ± 1°C for 7 days.

Seed inoculation: *Azotobacter* strains were grown in 250 ml conical flasks containing 100 ml Jensen's liquid medium for 7 days at 28 ± 1°C. Potato tubers were inoculated with different strains of *Azotobacter* immediately before sowing.

Field trial: Experiment was conducted in the field of the Research Area, Department of Soil Science, University of Agriculture, Faisalabad. The soil was sandy loam (pH 7.8, EC_e 1.46 dS m^{-1}, O.M. 0.70%). Basal dose of NPK @ 250, 125, 125 kg ha^{-1} respectively, were applied as urea, single super phosphate and potassium sulphate. Whole dose of P, K and half dose of N was broadcasted at the time of sowing and remaining half dose of N was applied at the time of first earthing up. Treatments were:

1. Control (without *Azotobacter* inoculation);
2. Inoculation with strain A_1;
3. Inoculation with strain A_2;
4. Inoculation with strain A_3; and
5. Inoculation with strain A_4 (mixed strain).

Uninoculated and inoculated tubers of the variety CEB-819-17 were sown on ridges, keeping row to row and plant to plant distance 60 cm and 20 cm respectively on February 13, 1993.

Treatments were replicated five times using randomized complete block design with plot size of 2.74 x 3.65 m^2. Eighty days old plants were uprooted on May 5, 1993 and data regarding shoot weight, root weight, tuber number and single tuber weight were recorded and calculations were made for root:shoot ratio (R/S ratio). Data collected were subjected to statistical analysis using randomised complete block design (Steel and Torrie, 1980) and means were compared by using Duncan's Multiple Range test (Duncan, 1955).

RESULTS

Effect of *Azotobacter* inoculation on:

Tuber yield: The differences in tubers yield due to inoculation with *Azotobacter* were significant in fertilized soil (Table 1). Maximum effective was mixed strain which increased the tubers yield by 18.13% compared to control NPK @ 250, 125, 125 kg ha^{-1} respectively). This strain differed significantly with control and all other strains except A_3. Strain A_3 and A_1 also increased the tubers yield significantly over control by 16.18 and 10.04%, respectively.

Table 1. Effect of *Azotobacter* inoculation on number of tubers plant^{-1}, single tuber weight and tuber yield

Treatments	Number of tubers	Single tuber weight (g plant^{-1})	Tuber yield (kg ha^{-1})
Control	9.76 ab	18.90 c	14830 d
Strain A_1	8.88 bc	22.62 ab	16320 bc
Strain A_2	8.44 c	23.27 ab	15820 cd
Strain A_3	8.88 bc	23.97 a	17230 ab
Strain A_4	10.44 a	20.63 bc	17520 a

Means sharing the same letter(s) do not differ significantly at P = 0.05.

Tuber number and single tuber weight: Tuber number and single tuber weight (Table 1) as influenced by different *Azotobacter* strains also differed significantly. Strains A_1, A_2 and A_3 decreased the number but strain

A_4 increased them. Single tuber weight obtained due to different strains differed significantly. All the strains increased the single tuber weight and maximum weight was recorded where tubers were inoculated with strain A3 followed by A_2, A_1, A_4 and control (NPK @ 250, 125, 125 kg ha^{-1}, respectively).

Shoot weight: *Azotobacter* inoculation increased the shoot weight significantly (Table 2) under fertilized conditions. Shoot weight was increased by 43.3% compared to control due to inoculation with strain A_3, followed by strain A_1 (16.9%) and A_4 (16.4%). Minimum shoot weight was recorded with strain A_2 but it was still 11.5% higher than control.

and A_4 gave significantly higher R/S ratios compared to control but it was at par with control in case of strain A_2.

DISCUSSION

In this study, it was observed that *Azotobacter* increased the tuber yield in the presence of fertilizers i.e. NPK @ 250, 125, 125 kg ha^{-1}, respectively. Similar results have been reported by Hussain *et al.* (1985), Hussain *et al.* (1987), Singh *et al.* (1977) and Reddy *et al.* (1977) while working on maize and wheat. Also many other workers have reported that N application and manuring

Table 2. Effect of *Azotobacter* inoculation on shoot weight, root weight and R/S ratio of potato

Treatments	Shoot weight (g)	Root weight (g)	R/S ratio
Control	88.9 c	3.88 c	0.044 b
Strain A_1	103.9 b	5.83 bc	0.058 a
Strain A_2	99.1 bc	5.36 bc	0.055 ab
Strain A_3	127.4 a	8.55 a	0.067 a
Strain A_4	103.5 b	6.83 ab	0.066 a

Means sharing the same letter(s) do not differ significantly at P = 0.05.

Root weight and R/S ratio: The results showed that differences in root weight and R/S ratio (Table 2) due to *Azotobacter* inoculation were significant. Strain A_4 was highly effective in promoting root weight in comparison to all other strains. The increase in root weight due to inoculation with strain A_3 was 120.1% followed by A_4, A_1 and A_2 i.e. 75.8, 50.0 and 38.1%, respectively, higher than control. Root:shoot ratio also increased due to *Azotobacter* inoculation and maximum was observed in strain A_3 that was at par with strain A_4, A_1 and A_2. Strains A_1, A_3

increased the effectiveness of inoculation with *Azotobacter* (Fedrov, 1952; Mishustin *et al.*, 1963; Mishustin, 1970). It became evident that tuber inoculation with *Azotobacter* strains increased the yield and other growth parameters. The explanation to this is that it was not due to N-fixation as a very high dose of N was applied to all the uninoculated and inoculated plants but may be due to the production of plant growth regulators, as many workers have reported that *Azotobacter* produced growth regulators (Brown and Burlingham, 1968; Vancura and Macura,

1960; Azcon and Barea, 1975; Barea and Brown, 1974; Brown, 1972; Nieto and Frankenberger, 1989 a) or it may be due to some other mechanisms not yet known.

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