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Original Article

Field Performance of Rhizobial Inoculants on Lentil

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A field experiment was conducted at Regional Agricultural Research Station (RARS), Jamalpur during rabi season of 2005-2006 and 2006-2007 to find out the effectiveness of *Rhizobium* strains on lentil. BARI Masur–4 and *Rhizobium* inoculum (strains BARI RLc-104, BARI RLc-105, BARI RLc-106 and BARI RLc-107) were used in this experiment. Unit plot size was 4 m x 3 m. The experiment was designed in randomized complete block having 4 replications for each treatment. There were six treatments, T_1: *Rhizobium* strain BARI RLc-104, T_2: *Rhizobium* strain BARI RLc-105, T_3: *Rhizobium* strain BARI RLc-106, T_4: *Rhizobium* strain BARI RLc–107, T_5: mixed culture of the above four strains and T_6: control. The strains were used to prepare peat based rhizobial inocula which were used @ 1.5 kg ha^{-1}. A basal dose of P, K, S, Zn @ 22, 42, 20, 5 kg ha^{-1}, respectively for all treatments were used in the experiment. Plant receiving peat based rhizobial inocula (strain BARI RLc-104, BARI RLc-105, BARI RLc-106, BARI RLc-107 and mixed culture) produced significantly higher nodule number, nodule weight, stover yield and seed yield over non-inoculated control. The highest nodule number (12.84 plant^{-1} in 2006 and 12.30 plant^{-1} in 2007) and nodule weight (10.51 mg plant^{-1} in 2006 and 13.53 mg plant^{-1} in 2007) were found with strain BARI RLc-104. This strain also recorded the highest seed yield (1.23 t ha^{-1}, 55.7% higher over non-inoculated control) in 2006 but BARI RLc-107 produced the highest seed yield (1.20 t ha^{-1}, 50.0% higher over non-inoculated control) in 2007 though all the strains including mixed culture recorded identical yields.

Key words: *Rhizobium*, lentil, nodulation, yield

Introduction

Lentil (*Lens culinaris* L.) occupies the top position in terms of popularity and has been placed second in respect of area and production in Bangladesh[1]. It is cultivated during rabi season under rainfed condition. About 80% of total lentil in the country is grown in Faridpur, Kustia, Jessore, Rajshahi and Pabna. The yield of lentil is very poor. There is a great possibility to increase its production by exploiting better colonization of their root and rhizosphere through *Rhizobium* bacteria, which can reduce nitrogenous fertilizer use and protect environment. But Bangladesh soils have lack of sufficient and effective *Rhizobium* strains in most of the cases[2]. Moreover, degradation of *Rhizobium* occurs regularly. So, collection and screening of new *Rhizobium* strains and their sub-culturing and testing are necessary for quality inoculant production. For this reason, indigenous *Rhizobium* strains were collected from different AEZs of Bangladesh for lentil and were screened. Their efficiency in lentil production needs to be tested. The present study was, therefore under taken to find out the effectiveness of some *Rhizobium* strain/(s) on lentil at Regional Agricultural Research Station (RARS), Jamalpur (Agro-ecological Zone, AEZ-9) of Bangladesh.

Materials and Methods

A field experiment was conducted at Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Jamalpur under Old Brahmaputra Floodplain Soils and in Agro-ecological Zone 09 during rabi season of 2005-2006 and 2006-2007 to find out the effectiveness of *Rhizobium* strains on lentil. The initial soil sample of the experimental field was collected and analyzed following standard procedures in the laboratory and are presented in Table 1.

The soil was neutral (pH 7.00) having low organic matter (0.47%). The content of total-N and exchangeable K was very low. The available phosphorus, sulphur and boron content were medium while zinc was low. The initial rhizobial population of the soil was below 10^3. The experiment was laid out in randomized complete block design considering four replications. The unit plot size was 4 m × 3 m. The variety BARI Masur–4 of lentil and peat based rhizobial inocula BARI RLc-104, BARI RLc-105, BARI RLc-106 and BARI RLc-107 were used for the experiment. There were six treatments, T_1: *Rhizobium* strain BARI RLc-104, T_2: *Rhizobium* strain BARI RLc-105, T_3: *Rhizobium* strain BARI RLc-106, T_4: *Rhizobium* strain BARI RLc–107, T_5: mixed culture of the above

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Table 1. Fertility status of the initial soil of the experimental field

Station	pH	OM (%)	Ca	Mg	K	Total	P	S	B	Cu	Fe	Mn	Zn
			meq/100g		µg g^{-1}	N (%)							
Jamalpur	7.00	0.47	3.1	1.0	0.12	0.025	16	17	0.3	3.5	26	14.0	1.50
Critical level	2.0	0.8	0.2	0.12	14	14	0.2	1	10	5	2		

four strains and T_6: control. The above peat based rhizobial inocula containing 10^8 cells g^{-1} inoculum were used @ 1.5 kg ha^{-1}. Chemical fertilizers i.e. P, K, S and Zn were applied in all treatments as basal dose at 22 kg P ha^{-1} from triple superphosphate, 42 kg K ha^{-1} from muriate of potash, 20 kg S ha^{-1} from gypsum and 5 kg Zn ha^{-1} from zinc oxide.

Lentil was sown on 21 November 2005 and 16 November 2006 with a spacing of 30 cm x 10 cm. During the course of the experiment, growth and development of plants in the field were carefully observed. Ten randomly selected plants along with roots were collected at 50% flowering stage from each unit plot and dry weight of roots, shoots and nodules including nodule numbers were recorded. The plants were harvested on 02 March 2006 and 09 March 2007. Data on plant height, 1000-seed weight, stover yield and seed yield were also taken plot wise and expressed on hectare basis. All data were analyzed statistically.

Results and Discussion

Effects of rhizobial inoculants on nodule number plant^{-1}, nodule weight (mg plant^{-1}), root weight (g plant^{-1}), shoot weight (g plant^{-1}), plant height (cm), 1000-seed weight (g), stover yield (t ha^{-1}), seed yield (t ha^{-1}) and percent yield increase over control are presented in Table 2. Inoculated plants produced significantly higher nodule number, nodule weight, root weight, shoot weight, stover yield and seed yield compared to non-inoculated treatments. Plant heights and 1000-seed weight in all treatments were insignificant. Plant height and 1000-seed weight did not find any definite trend due to application of rhizobial inoculants.

Plants inoculated with *Rhizobium* strain BARI RLc-104 produced the highest number of nodules (12.84 plant^{-1} in 2006 and 12.30 plant^{-1} in 2007) (Table 2). All the *Rhizobium* strains including mixed culture recorded identical nodule number but significantly higher over non-inoculated control. It indicated that all the strains individually or in combination had the ability to produce higher number of nodules. The lowest nodule formation (7.54 plant^{-1} in 2006 and 6.05 plant^{-1} in 2007) was noted in the treatment where no *Rhizobium* strain was used. These results were supported by many other workers that the *Rhizobium* was responsible for higher nodulation[3-5]. Significant differences among strains in number of nodules plant^{-1} were also found for lentils[6]. Awan[7], Rahman *et al*.[8] also reported that seed inoculation improved nodulation compared with the non-inoculated control.

Table 2. Effect of *Rhizobium* strains on nodulation, dry matter production and yield of lentil

Treatment	Nodule number plant^{-1}	Nodule weight (mg plant^{-1})	Root weight (g plant^{-1})	Shoot weight (g plant^{-1})	Plant height (cm)	Stover yield (t ha^{-1})	1000-seed weight (g)	Seed yield (t ha^{-1})	Yield increase over control (%)
2006									
BARI RLc-104	12.84a	10.51a	0.10a	1.12a	31.5	1.45a	18.7	1.23a	55.7
BARI RLc-105	11.54a	9.01b	0.09ab	0.88bc	30.4	1.24b	18.0	1.03a	24.0
BARI RLc-106	11.71a	9.13ab	0.09ab	0.88bc	30.3	1.31ab	17.6	1.07a	35.4
BARI RLc-107	12.21a	9.25ab	0.08ab	1.00ab	34.8	1.24b	17.9	1.13a	43.0
Mixed culture	11.97a	9.02b	0.09ab	1.08a	29.5	1.30ab	17.1	1.08a	36.7
Control	7.54b	6.21c	0.08b	0.80c	29.0	1.03c	18.1	0.79b	-
CV (%)	8.6	10.2	10.0	12.6	5.0	10.0	6.8	13.2	-
2007									
BARI RLc-104	12.30a	13.53a	0.09a	0.98ab	39.1	1.58a	20.4	1.13a	41.3
BARI RLc-105	9.32a	9.59ab	0.08a	0.79ab	37.5	1.35b	20.4	1.05ab	31.3
BARI RLc-106	12.11a	12.00a	0.09a	0.83ab	36.7	1.55ab	20.0	1.10ab	37.5
BARI RLc-107	12.18a	13.01a	0.09a	0.91ab	35.5	1.45ab	20.4	1.20a	50.0
Mixed culture	11.08a	11.21a	0.08a	0.99a	33.7	1.46ab	19.8	0.91ab	13.8
Control	6.05b	7.00b	0.07b	0.71b	32.3	1.13c	20.6	0.80b	-
CV (%)	14.6	20.7	7.5	19.1	8.4	9.1	6.8	13.2	-

Means followed by common letter are not significantly different at 5% level by DMRT

The highest nodule weight (10.51 mg plant^{-1} in 2006 and 13.53 mg plant^{-1} in 2007) was observed in BARI RLc-104 strain which was significantly higher over BARI RLc-105, mixed culture and non-inoculated control in 2006, and identical to all other strains including mixed culture but different from non-inoculated control in 2007 (Table 2). All the strains recorded significantly higher nodule weight over non-inoculated control. BARI RLc-105 failed to produce higher nodule weight over non-inoculated control in 2007 and non-inoculated plants showed poor performance like nodule number. These results shows similarity with previous findings[4-5, 9]. Significant differences among strains in nodule weight plant^{-1} were also found for lentils[6, 8].

Plants inoculated with BARI RLc-104 strain also gave the highest root weight (0.10 g plant^{-1} in 2006 and 0.09 g plant^{-1} in 2007) (Table 2). Strain BARI RLc-105, BARI RLc-106, BARI RLc-107 and mixed culture did not show significant effect on root weight over non-inoculated control in 2006 but all the strains showed significantly higher root weight in 2007. All the strains recorded identical root weight. This was supported by the findings of other groups[5, 10].

Strain BARI RLc-104, BARI RLc-107 and mixed culture recorded significant effect on shoot weight over non-inoculated control in 2006 and only mixed culture had significant effect in 2007. Bhuiyan *et al*.[9] observed that strains resulted higher shoot weight in groundnut. Rahman *et al*.[8] also noted that rhizobial strains gave higher shoot weight in lentil.

Strains had also significant effect on stover yields in both the years. Among the four strains and mixed culture, BARI RLc-104 gave the highest stover yield (1.45 t ha^{-1} in 2006 and 1.58 t ha^{-1} in 2007). This result was supported by Kumar and Agarwal[10] and Bhuiyan *et al*.[4, 12].

Plant height and 1000-seed weight in all the strains were found non-significant and this two parameters did not find any definite trend like others. These results were supported by Bhuiyan *et al*.[13] that *Rhizobium* strain did not show significant effect on plant height and 1000-seed weight in soybean. Strains had no effect on plant height in lentil which was also observed by Rahman *et al.*[8].

Significant positive effect of *Rhizobium* inoculation on seed yield of lentil over non-inoculated control both in 2006 and 2007 was observed (Table 2). Strain BARI RLc-104 recorded the highest seed yield of 1.23 t ha^{-1} (55.7% higher over non-inoculated control) in 2006 and BARI RLc-107 recorded the highest seed yield of 1.20 t ha^{-1} (50.0% higher over non-inoculated control) in 2007. All the strains gave identical yield in both the years but different from non-inoculated control in 2006. In 2007, only BARI RLc-104 and BARI RLc-107 gave significantly higher seed yield over non-inoculated control. Higher nodulation, dry matter production and seed yields might be due to the effect of *Rhizobium* inoculation on lentil. Bremer *et al*.[6] reported that inoculation increased lentil yields by up to 135%. Namdeo *et al*.[14] also observed that inoculation increased lentil seed yield by 17.5-23.2% compared with no inoculation. In the present study, *Rhizobium* strains increased 14 to 56% higher yield. The results were in agreement with the findings of other researchers who worked on lentil where *Rhizobium* inoculation gave higher yield[11, 15 -17]. These results were also supported by others[9, 12, 18 -20].

Table 3. Correlation matrix among different parameters of lentil

Characters	Year	Correlation coefficient (r value)					
		Nodulenumber	Nodule weight	Root weight	Shoot weight	Plant height	Stover yield
Nodule weight	2006	0.880**					
	2007	0.768**					
Root weight	2006	0.623**	0.720**				
	2007	0.691**	0.603**				
Shoot weight	2006	0.684**	0.752**	0.739**			
	2007	0.661**	0.292^{NS}	0.268^{NS}			
Plant height	2006	0.567**	0.622**	0.476*	0.416*		
	2007	0.261^{NS}	0.524**	0.308^{NS}	-0.150^{NS}		
Stover yield	2006	0.585**	0.620**	0.366^{NS}	0.366^{NS}	0.230^{NS}	
	2007	0.902**	0.787**	0.636**	0.646**	0.360^{NS}	
Seed yield	2006	0.534**	0.486*	0.425*	0.483*	0.049^{NS}	0.322^{NS}
	2007	0.719**	0.576**	0.435*	0.516**	0.265^{NS}	0.675**

r values with 22 d.f., 1% level= 404, 5% level= 515

*Significant at 5% level, **Significant at 1% level, NS: Non-significant

Correlation

Correlation matrix among the plant characters of lentil has been shown in Table 3. Some plant characters were strongly correlated among themselves. A significant and positive correlation was observed between nodule number and nodule weight, root weight, shoot weight, stover yield and seed yield; nodule weight and root weight, stover yield, seed yield; root weight and seed yield; shoot weight and seed yield in both the years. These results confirmed the findings of Bhuiyan *et al*.[13, 20]. They observed positive and significant correlation of nodule number with nodule weight, root weight, and shoot weight of inoculated chickpea and soybean. Solaiman[21] and Bhuiyan[22] found positive correlation among mungbean growth and yield parameters.

References

1. Bangladesh Bureau of Statistics. 2006. Statistical Yearbook of Bangladesh. 26th Edition. Bangladesh Bureau of Statistics. Planning Division, Ministry of Planning, Govt. People's Republic of Bangladesh, Dhaka, Bangladesh. pp. 143.
2. Khanam DK, Bhuiyan MAH, Rahman MHH and Hossain AKM. 1999. On-farm experience of the application and adoption of biological nitrogen fixation technology in Bangladesh. *Bangladesh J. Agril. Res.* **24**(2): 375-382.
3. Podder AK. 1994. Performance of single and mixed rhizobial inocula for nodulation and growth of lentil. *LENS Newsletter* 21(1): 39-40.
4. Bhuiyan MAH, Rahman MM, Khanam D and Khaleque MA. 1998a. Nodulation and yield of groundnut in relation to strains of *Bradyrhizobium*. *Bangladesh J. Sci. Ind. Res.* **33**(3): 323-326.
5. Eusuf Zai AK, Khanam D, Ullah MH, Bhuiyan MAH and Quamruzzaman AKM. 2004. Effect of *Rhizobium* inoculation on gardenpea (*Pisum sativum*) in Noncalcareous Grey Flood plain Soil of Bangladesh. *Thai J. Agric. Sci.* **37**(4): 299-304.
6. Bremer E, Kessel C, Nelson L, Rennie RJ, Rennie DA and Van-Kessel C. 1990. Selection of *Rhizobium leguminosarum* strains for lentil (*Lens culinaris*) under growth room and field conditions. *Plant Soil*. **121**(1): 47-56.
7. Awan MFM. 1994. Ontogenetic variation of nodulation, nitrogen fixation and nitrogen accumulation in lentil (*Lens culinaris* Medic) I. Soil characteristics, nodulation and plant yield. *Acta Physiologiae Plantarum*. **16**(3): 163-169.
8. Rahman AKMH., Bhuiyan MAH, Khanam D, Ali ME and Alam F. 2009. Effect of *Rhizobium* strains on nodulation, dry matter production and yield of lentil. *Bangladesh J. Agriculturists*. **2**(2): 133-136.
9. Bhuiyan MAH, Rahman MM, Khanam D and Basak NC. 2000. Effects of different *Bradyrhizobium* strains on nodulation, dry matter production and yield of groundnut. *Bangladesh J. Microbiol.* **17**(1): 41-44.
10. Dravid MS. 1991. Effect of salinization, *Rhizobium* inoculation, genotypic variation and P-application on dry matter yield and utilization of P by pea (*Pisum satimun* L.) and lentil (*Lens culinaris* Medic). *J. Nuclear Agric. Biol*. **19**(4): 227-231.
11. Kumar P and Agarwal JP. 1993. Response of lentil to *Rhizobium* inoculation, nitrogen and phosphorus fertilization. *Indian J. Agron.* **38**(2): 318-320.
12. Bhuiyan MAH, Khanam D, Rahman MM and Ali MM. 1998b. Variation in the symbiotic effectiveness of *Bradyrhizobium* strains on soybean. *Bangladesh J. Microbiol.* **15**(1): 25-30.
13. Bhuiyan MAH, Khanam D, Rahman MM and Talukder MZI. 2001a. Response of soybean to inoculation with different strains of *Bradyrhizobium*. *Bangladesh J. Agril. Res.* **26**(4): 529-534.
14. Namdeo SL. Gupta SC. and Joshi RK. 1996. Influence of rhizobial inoculation on nodulation and yield of lentil genotypes under rain fed conditions. *LENS Newsletter*. **23**(1& 2): 24-26.
15. Bhuiyan MAH, Kabir MS and Khanam D. 1998c. Effects of boron, molybdenum and rhizobial inoculation on nodulation and yield of lentil. *Bangladesh J. Seed Sci. Tech.* **21**(1&2): 39-44.
16. Khanam D, Rahman MHH, Bhuiyan MAH, Islam MZ, Rahman AFM and Hossain AKM. 1996. Varietal screening of lentil (*Lens culinaris* L.) in presence and absence of *Rhizobium* inoculation. *Progress. Agric.* **7**(2): 143-146.
17. Khanam D, Bhuiyan MAH, Rahman MHH and Hossain AKM. 1999. On-farm experience of the application and adoption of biological nitrogen fixation technology in Bangladesh. *Bangladesh J. Agril. Res.* **24**(2): 375-382.
18 Yanni YG. 1992. Performance of chickpea, lentil and lupin nodulated with indigenous or inoculated rhizobia micropartners under nitrogen, boron, cobalt and molybdenum fertilization schedules. *World J. Microbiol. Biotech.* **8**(6): 607-613.
19 Kantar F, Kiziloglu T, Caglar O and Akien S. 1995. Lentil yield in relation *to Rhizobium leguminosarum* inoculation in eastern Anatolia. *LENS Newsletter*. **21**(2): 36-40.
20 Bhuiyan MAH, Khanam D, Khatun A, Hossain AKM and Islam MS. 2001b. Nodulation, dry matter weight and grain yield of chickpea as influenced by *Rhizobium* inoculation. *Bangladesh. J. Agril. Res.* **26**(3): 463-466.
21 Solaiman ARM. 1999. Response of mungbean to *Bradyrhizobium* sp. (*Vigna*) inoculation with and without phosphorus and potassium fertilization. *Bangladesh J. Sci. Res.* **17**(2): 125-132.
22 Bhuiyan MAH 2004. Evaluation of introducing mungbean into cereal based cropping pattern for sustainable soil fertility and productivity. Ph.D Thesis, Dept. of Soil Science, Bangladesh Agricultural University, Mymensingh.