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RESEARCH ARTICLE

Screening of BARI Rhizobium Biofertilizers against Foot and Root Rot of Lentil

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Abstract

The experiment was conducted at the sick plot, Pulses Research Centre, Ishurdi, Pabna, Bangladesh during two consecutive years of 2011-12 and 2012-13 to screen out the effective BARI *Rhizobium* Biofertilizers against foot and root rot of lentil. Seven BARI *Rhizobium* strains viz. BARI LE 715, BARI Rlc 103, BARI Rlc 140, BARI Rlc 107, BARI Rlc 105, BARI Rlc 138 and BARI Rlc 101 were used as treatments. In 2011-12, foot and root rot incidence ranged from 9.66-29.95%, while the lowest incidence was recorded in BARI LE 715 which was followed by BARI RLC 140, BARI RLC 107 and BARI RLC 138; and the highest incidence was recorded in untreated control. BARI LE 715 gave the highest plant survival (90.34%) and control treatment gave the lowest plant survival (70.05%). BARI LE 715 treated plots reduced maximum foot and root rot incidence (67.75%) over untreated control. Similar trends of the results were observed in 2012-13. The highest yield 2153 and 2016 kg/ha was obtained from BARI LE 715 in 2011-12 and 2012-13, respectively, and the lowest of these parameters were obtained from untreated control for both the years.

Keywords: *BARI Rhizobium, Biofertilizer, Foot and Root Rot, Lentil*

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1. INTRODUCTION

Lentil (*Lens culinaris*) is a popular and widely cultivated crop in Bangladesh and in many other tropical countries. It is cultivated as sole and intercrops. Lentil is the second major pulse crop of Bangladesh in respect of acreage and production. Lentil is also used for human consumption as a protein source in a diverse range of product and is an excellent source of vitamin A and provides fiber, potassium, B vitamins, and iron (Kochhar, 2oo9). The production of lentil is decreasing every year due to cultural and genetic factors, susceptibility to disease, and delay in sowing by the farmers (Anonymous, 1989). Average yield of chickpea is also low due to various diseases. Among the diseases, foot and root rot of chickpea caused by *Fusarium oxysporum* and *Sclerotium rolfsii* (Dey *et al.*, 1993) are common and the most serious disease in Bangladesh. It causes seedling death at early stage resulting very poor plant stand which ultimately produces very low yield. *Fusarium oxysporum* and *Sclerotium rolfsii* are soil-borne pathogens commonly occurs in the tropics and sub-tropics regions of the world causing foot and root rot of many crops (Aycock, 1966). The fungi can attack the crop during any time from seedling to flowering stage and are comparatively more destructive at the seedling stage. Foot and root rot diseases may cause 100% seedling mortality in monoculture under conducive weather conditions for disease development (Begum, 2003). The pathogenic fungi are soil-borne in nature; hence, seed treatment with *Rhizobium* Biofertilizers might be effective in controlling foot and root rot disease and increasing grain yield of lentil. Moreover, by seed treatment, very low quantities of Biofertilizer are required compared to foliar application with fungicides. Again, it reduces the risk of environmental pollution, health hazard and not much costly to the growers. Lentil, a member of the legume family, Leguminosae, can supply a significant part of its nitrogen requirement by fixing nitrogen from the air when inoculated with the appropriate rhizobial inoculant. Nitrogen fixing nitrogen bacteria associated with the roots of crop plants have beneficial effects on their host, and are referred to as plant growth promoting rhizobacteria (PGPR) (Kloepper and Schroth, 1978). The rhizosphere is subjected to dramatic changes and its dynamic nature creates interactions that result in biocontrol of diseases (Rovira, 1965 & 1969). PGPR are free living bacteria that may have beneficial effects on plants, viz. seedling emergence, colonizing roots, stimulating overall plant growth, mineral nutrition, and water utilization as well as disease suppression. The presence of rhizobia in the rhizosphere may also protect host roots from damage caused by pathogens. Integrated use of Vitavax 200 and biocontrol agents was effective in improving seedling emergence and yield as well as in reducing wilt incidence of chickpea (Gupta, 2006). Treatment of seeds with Biofertilizer resulted in 85.2 and

73.1% reduction in death of plants due to infection by *Fusarium oxysporum* in lentil and chickpea, respectively (Hossain, 2000). Treatment of seed with *Rhizobium* strains significantly reduced incidence of damping off and increased seedling height of lentil (Huang and Erickson, 2007). *Rhizobium* strain BINAR P36 largely controlled the foot and root rot and produced higher green pod yield of Bush bean (Khalequzzaman and Hossain, 2008). It has been observed that *Rhizobium* also reduced foot and root rots of leguminous crops. Bangladesh Agricultural Research Institute (BARI) has developed some peat based *Rhizobium* Biofertilizers. Among the BARI *Rhizobium* Biofertilizers, which *Rhizobium* Biofertilizers are effective in controlling foot and root rot of chickpea would be found out. These types of research work are needed in Bangladesh. So, the present study was undertaken to screen out the effective BARI *Rhizobium* Biofertilizers against foot and root rot and yield of lentil.

2. MATERIALS AND METHODS

The experiment was conducted in the sick plot at Pulses Research Centre, Bangladesh Agricultural Research Institute (BARI), Ishurdi, Pabna, Bangladesh during two consecutive years of 2011-12 and 2012-13. The experimental plot was prepared with five ploughings and cross ploughings followed by laddering to break the clods as well as level the soil. The weeds and stubbles of previous crops were collected and removed from the soil. No any chemical fertilizers were applied. The experiment was carried out following Randomized Complete Block Design with three replications. The unit plot size was 1.6 m x 1.5 m and plant spacing was 30 cm with continuous sowing for the experiment. Seven BARI *Rhizobium* Biofertilizers viz. BARI LE 715, BARI Rlc 103, BARI Rlc 140, BARI Rlc 107, BARI Rlc 105, BARI Rlc 138 and BARI Rlc 101 were used as treatments. BARImasur 1 was used in this experiment. Seeds were initially moistened with molasses at the rate of 40 g per kg seed and then the seeds were thoroughly mixed with peat based BARI *Rhizobium* Biofertilizers @ 40 g per kg seed before sowing, where biofertilzer contained 10^8 Rhizobial cells/mg (Somasegaran and Hoben, 1994). The inoculant-coated seeds were sown at the afternoon on November 8, 2011 and November 16, 2012, respectively, and furrow was filled up just after seed sowing. Intercultural operations were done as per needed and to maintain the normal hygienic condition of crop in the field. During the growing period the plots were inspected regularly to record the incidence of foot and root rot disease from seedling to maturity stage of the crop. Dead plants were counted and removed from the field. Disease plant parts were collected and brought into the laboratory for identifying foot and root rot causal pathogens. The crop was harvested on March 4, 2012 and March 12, 2013, respectively. Data were recorded on foot and root rot, plant survival, plant height, number of pods/plant, number of seeds/plant, weight of seeds/plant and yield (kg/ha). The incidence of foot and root rot of lentil was recorded at every alternate day. The incidence of foot and root rot of chickpea was calculated by the following formula:

$$\text{Incidence of foot and root rot (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

The recorded data were analyzed statistically to find out the level of significance and the variations among the respective data were compared following Duncan's New Multiple Range Test (DMRT) according to Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

Results of BARI *Rhizobium* Biofertilizers on foot and root rot and plant height of lentil during 2011-12 are presented in Table 1. BARI *Rhizobium* Biofertilizers showed significant effect on foot and root rot of lentil. Foot and root rot incidence ranged from 9.66-29.95%, while the lowest incidence was recorded in BARI LE 715 which was not statistically similar to all other treatment, but followed by BARI RLC 140, BARI RLC 107 and BARI RLC 138; and the highest incidence was recorded in untreated control. BARI LE 715 gave the highest plant survival (90.34%) and control treatment gave the lowest plant survival (70.05%). BARI LE 715 treated plots reduced maximum foot and root rot incidence (67.75%) over untreated control. Plant height was not significantly influenced by *Rhizobium* Biofertilizers. BARI RLC 107 gave the highest plant height (40.93 cm) and untreated control gave the lowest (37.07 cm).

Table 1. Effect of BARI *Rhizobium* Biofertilizers on foot and root rot and plant height of lentil during 2011-12

***Rhizobium* Biofertilizers**	**Foot and root (%)**	**Plant survival (%)**	**Disease reduction over control (%)**	**Plant height (cm) ^{NS}**
BARI LE 715	9.66 g	90.34	67.75	37.27
BARI RLC 103	20.29 c	79.71	32.25	37.09
BARI RLC 140	11.85 f	88.15	60.44	39.33
BARI RLC 107	11.21 f	88.79	62.57	40.93
BARI RLC 105	17.05 d	82.95	43.07	40.87
BARI RLC 138	13.33 e	86.67	55.49	36.13
BARI RLC 101	25.41 b	74.59	15.15	39.40
Control (Untreated)	29.95 a	70.05	-	37.07

In a column, similar letter does not differ significantly at 5% level of probability. BARI = Bangladesh Agricultural Research Institute. NS=Not significant

Results of BARI *Rhizobium* Biofertilizers on foot and root rot and plant height of lentil during 2012-13 are presented in Table 2. BARI *Rhizobium* strains showed significant effect on foot and root rot of lentil. Foot and root rot incidence ranged from 8.33-33.65%, while the lowest incidence was recorded in BARI LE 715 treated plots which was not statistically similar to all other treatments but the highest incidence was recorded in untreated control. BARI LE 715 gave the highest plant survival (91.57%) and control treatment gave the lowest plant survival (66.35%). BARI LE 715 treated plots reduced maximum foot and root rot incidence (76.25%) over untreated control. BARI RLC 105 gave the tallest plant (38.33 cm) and BARI RLC 103 gave the smallest (34.20 cm) plant.

Table 2. Effect of BARI *Rhizobium* Biofertilizers on foot and root rot and plant height of lentil during 2012-13

***Rhizobium* Biofertilizers**	**Foot and root rot (%)**	**Plant survival (%)**	**Disease reduction over control (%)**	**Plant height (cm) ^{NS}**
BARI LE 715	8.33 e	91.67	75.25	34.47
BARI RLC 103	27.67 b	72.33	17.77	34.20
BARI RLC 140	16.00 d	84.00	52.45	35.73
BARI RLC 107	14.33 d	85.67	57.42	35.07
BARI RLC 105	20.67 c	79.33	38.57	38.33
BARI RLC 138	18.00 cd	82.00	46.51	37.07
BARI RLC 101	29.33 ab	70.67	12.84	35.80
Control (Untreated)	33.65 a	66.35	-	35.07

In a column, similar letter do not differ significantly at 5% level of probability. BARI = Bangladesh Agricultural Research Institute. NS=Not Significant.

Number of pod/plant, number of seeds/plant, weight of seeds/plant and yield of lentil under BARI *Rhizobium* strains varied significantly from one to another during 2011-12 (Table 3). The highest number of pod/plant (74.33), number of seeds/plant (93.27), weight of seeds/plant (2.37 g) and yield (2153 kg/ha) were obtained from BARI LE 715 which was followed by BARI RLC 107 and BARI RLC 138, and the lowest of these parameters were obtained from untreated control.

Table 3. Effect of BARI *Rhizobium* Biofertilizers on yield and yield contributing characters of lentil during 2011-12

***Rhizobium* Biofertilizers**	**No. of pod/ plant**	**No. of seeds/plant**	**Wt. of seeds/plant (g)**	**Yield (kg/ha)**
BARI LE 715	74.33 a	93.27 a	2.37 a	2153 a
BARI RLC 103	58.33 bc	83.47 abc	1.86 b	1799 bcd
BARI RLC 140	59.53 bc	88.67 abc	1.97 ab	1875 a-d
BARI RLC 107	68.47 ab	93.17 a	2.19 ab	2068 ab
BARI RLC 105	60.78 bc	90.13 ab	2.11 ab	1921 a-d
BARI RLC 138	67.80 ab	93.07 a	2.09 ab	1986 abc
BARI RLC 101	56.27 c	82.93 bc	1.78 b	1711 cd
Control (Untreated)	55.23 c	79.20 c	1.71 b	1665 d

In a column, similar letter does not differ significantly at 5% level of probability. BARI = Bangladesh Agricultural Research Institute.

Number of pod/plant, number of seeds/plant, weight of seeds/plant and yield of lentil varied significantly from one to another *Rhizobium* strains during 2012-13 (Table 4). The highest number of pod/plant (65.20), number of seeds/plant (111.67), weight of seeds/plant (2.76 g) and yield (2016 kg/ha) were obtained from BARI LE 715 treated plots which was followed by BARI RLC 107 and BARI RLC 140, and the lowest of these parameters were obtained from untreated control.

Table 4. Effect of BARI *Rhizobium* Biofertilizers on yield and yield contributing characters of lentil during 2012-13

***Rhizobium* Biofertilizers**	**No. of pod/ plant**	**No. of seeds/plant**	**Wt. of seeds/ plant (g)**	**Yield (kg/ha)**
BARI LE 715	65.20 a	111.67 a	2.76 a	2016 a
BARI RLC 103	49.67 bc	75.53 cd	1.87 bcd	1750 cde
BARI RLC 140	56.60 ab	98.53 ab	2.46 ab	1885 abc
BARI RLC 107	62.50 ab	107.07 a	2.67 a	1912 ab
BARI RLC 105	51.40 bc	84.00 bcd	2.10 abc	1797 bcd
BARI RLC 138	55.80 ab	91.33 abc	2.26 abc	1869 abc
BARI RLC 101	40.67 c	64.80 d	1.62 cd	1638 ef
Control (Untreated)	37.93 c	62.20 d	1.35 d	1562 f

In a column, similar letter does not differ significantly at 5% level of probability. BARI = Bangladesh Agricultural Research Institute.

From the above study, it has been observed that BARI *Rhizobium* Biofertilizers showed significant effect on foot and root rot of lentil during 2011-12 and 2012-13. Similar trends of the results were found in both the years. The lowest foot and root rot incidence was recorded in BARI LE 715 which was followed by BARI RLC 140, BARI RLC 107 and BARI RLC 138, but the highest incidence was recorded in untreated control. BARI LE 715 gave the highest plant survival and control treatment gave the lowest plant survival. BARI LE 715 treated plots reduced maximum foot and root rot incidence over untreated control. Plant height was not significantly influenced by *Rhizobium* Biofertilizers. Hossain (2000) found that treatment of seeds with Biofertilizer resulted in 85.2 and 73.1% reduction in death of plants due to infection by *Fusarium oxysporum* in lentil and chickpea, respectively, while Hossain *et al.* (2000) observed that the highest reduction (69.4%) of Fusarial foot and root rot in chickpea over untreated control was with *Rhizobium* inoculation @ 50 g/kg seed (when moistened with molasses). Khalequzzaman *et al.* (2010) found that BARI lentil 5 inoculated with BARI Biofertilizer Rlc 104 showed minimum (11.2%) incidence of foot and root rot, leading to maximum plant survival (88.8%). Hossain (2000) found that treatment of seeds with Biofertilizer also showed 76.7 and 87.0% reduction in death of plants of lentil and

chickpea, respectively, due to infection by *Sclerotium rolfsii*. Arfaoui *et al*. (2005) reported that *Rhizobium* isolates protected chickpea plants from *F. oxysporum*. Hossain *et al*. (1999a) reported that treatment with Bavistin (0.2%) and Biofertilizer (*Rhizobium*) @ 50 g/kg seed resulted in the best control of seed borne fungi *F. oxysporum* of lentil. Huang and Erickson (2007) showed that treatment of seed with *Rhizobium* strains significantly reduced incidence of damping off and increased seedling height of chickpea. Khalequzzaman and Hossain (2008) conducted an experiment on foot and root rot of Bush bean with *Rhizobium* strains and Biofertilizers, and found that *Rhizobium* strain BINAR P36 largely controlled the foot and root rot of Bush bean. Kucuk (2013) showed the effects of 20 *Rhizobium* strains isolated from *Phaseolus vulgaris* L., *Trifolium repens* var. *repens, Cicer arietinum* L., *Lens culinaris* Medik., *Vigna unguiculata* L. and *Phaseolus vulgaris* L. 'Red Kidney' plants on mycelium growth of *Fusarium oxysporum, F. moniliforme, F. solani, F. culmorum, F. oxysporum* F1 strain, *F.oxysporum* F2 strain, *F.oxysporum* F3 strain, *F.oxysporum* F4 strain were observed on solid medium and found that the most *Rhizobium* strains were effective against the *Fusarium* species. Yaqub and Shahzad (2011) found that *Sclerotium rolfsii* showed significant negative effect on plant growth due to severe root colonization, whereas, presence of the microbial antagonists showed significant positive effect on plant growth by reducing the colonization of roots by *S. rolfsii.* Hannan (2012) found that BINA-biofertilizer and BAU-biofungicide (black gram bran-based *Trichoderma harzianum*) were compatible and had combined effects in controlling the pathogenic fungi *Fusarium oxysporum* and *Sclerotium rolfsii*, which cause the root rot of lentil. Post-emergence deaths of plants due to foot rot disease were significantly reduced after combined seed treatment with BINA-biofertilizer and BAU-biofungicide. Hannan *et al.* (2013) applied cowdung in soil and treated seed with BINA-Biofertilizer and BAU-Biofungicide and found that field emergence was higher up to 26.47%, post-emergence deaths of plants due to foot rot disease were also successfully reduced in grasspea. Shaban and El-Bramawy (2011) exhibited that *Rhizobium* spp. and *Trichoderma* sp. fungi showed combined effects in controlling the fungi, which caused the damping off and root rot. Hoque *et al.* (2015) evaluated *Rhizobium leguminosarum* against foot and root rot pathogens *Fusarium oxysporum* and *Sclerotium rolfsii* of lentil. In dual culture method, highest zone of inhibition of *F. oxysporum* (57.37%) was measured against *R. leguminosarum* isolate. In paper towel test, minimum number of deed seeds (9.00), no abnormal and diseased seedlings were counted from *R. leguminosarum* treated seeds. In water agar test tube test, minimum number of dead seed (12.00) and abnormal seedlings (2.00) were counted from *R. leguminosarum* treated seeds.

Number of pod/plant, number of seeds/plant, weight of seeds/plant and yield of lentil under BARI *Rhizobium* strains varied significantly from one to another during 2011-12 and 2012-13. Similar trends of the results were found in both the years. The highest number of pod/plant, number of seeds/plant, weight of seeds/plant and yield were obtained from BARI LE 715 which was followed by BARI RLC 107, BARI RLC 138 and BARI RLC 140, and the lowest of these parameters were obtained from untreated control. Khalequzzaman and Hossain (2008) found that the tallest plant (41.1 cm) was observed in *Rhizobium* strain (BINAR P36) inoculated plots and the shortest plant (33.08 cm) was in untreated control of Bush bean. Use of BINA-Biofertilizer and BAU-Biofungicide as seed treating biocontrol agents and application of cowdung in the soil as an organic source of nutrient resulted higher plant stand, shoot and root length, and dry shoot and root weight of Grass pea (Hannan *et al.*, 2013). Khalequzzaman and Hossain (2008) also found that the highest number of pods/plant (14.6) was recorded in case of using BINAR P36 inoculated plots and the lowest (7.8) in untreated control of Bush bean. Hossain *et al.* (1999b) reported that *Rhizobium* inoculants increased significantly pods/plant of lentil up to 42.1% over the untreated control. Khalequzzaman *et al.* (2010) found that BARI lentil 5 inoculated with BARI Biofertilizer Rlc 104 gave the highest yield (1952.9 kg/ha). Rai and Singh (1979) reported that inoculation with *Rhizobium* bacteria led to a significant increase in seed yield of chickpea compared with the uninoculated control, but Harnadez and Hill (1983) observed that inoculation with *Rhizobium* strain CC 1192 increased seed yield of chickpea by 29% and Sandhu (1984) reported that lentil seed inoculation with *Rhizobium* culture improved yield by 8–22%, but Pal and Ghosh (1986) reported that seed inoculation with *Rhizobium leguminosarum* strain L 25 and L 20 increased seed yield by 59.8% in lentil and up to 38.87% in chickpea. Seed inoculation with *Rhizobium leguminosarum* strain L 25 and L 20 increased seed yield by 59.8% in lentil and up to 38.87% in chickpea (Pal and Ghosh, 1986). Khalequzzaman (2008) found that Biofertilizer increased grain yield which was at par with the fungicides in lentil and chickpea. Khalequzzaman and Hossain (2008) conducted an experiment on foot and root rot of Bush bean with *Rhizobium* strains and Biofertilizers, and found that *Rhizobium* strain BINAR P36 produced higher green pod yield of Bush bean. Seed yield increase with *Rhizobium* Biofertilizer has also been reported by Hossain *et al.* (1999b), Solaiman (1999), Hossain and Mohammed (2002), and Kibria and Hossain (2002). Shaban and El-Bramawy (2011) exhibited that *Rhizobium* spp. and *Trichoderma* sp. fungi showed combined effects on improvement in many plant growth parameters, which are ultimately expressed in increasing the yield components of branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, mean seed weight and then increase seed yield of the legume field crops: broad bean, chickpea and lupine plants.

4. CONCLUSION

From the above study, it may be concluded that seed treatment with BARI LE 715 @ 40 g/kg seeds showed better performance followed by BARI RLC 107, BARI RLC 140 and BARI RLC 138 in respect of foot and root rot control and increase yield of lentil.

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