Indian Journal of Agricultural Sciences **86** (10): 1337–42, October 2016/Article
https://doi.org/10.56093/ijas.v86i10.62134

Response of rhizobium inoculation on growth and productivity of fenugreek (*Trigonella foenum-greacum*) under salt stress condition

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Received: 29 December 2015; Accepted: 12 May 2016

ABSTRACT

Soil salinity is a major restriction to crop production in many areas of the world. Crops growing in salt-affected soils may suffer from many physiological stress and ion toxicity which then lead to reduced growth and productivity. The present study was under taken on the effect of salinity and rhizobium inoculated seeds on plant growth and productivity of fenugreek (*Trigonella foenum-greacum* L.) cultivars (NDM-17 and Pusa Kasauri). The pot experiment was conducted in completely randomized block design with three replicates. Two sets of pot trails were maintained in which one inoculated with effective rhizobium strain (*Rhizobium meliloti)* while other set was uninoculated. Both sets were irrigated with saline water of different electrical conductivities (0, 3, 6, 7, 10, 12 and 14 dS/m). Salinity stress registered the highest detrimental effects on growth and productivity. Present findings revealed that the inoculated seeds with effective rhizobium strain minimized the deleterious effect of salinity at all levels. The maximum growth and productivity was found in NDM-17 in both sets inoculated and uninoculated with rhizobium as compared to Pusa Kasauri.

Key words: Fenugreek, Growth, Rhizobium, Salinity

Salinity is one of the main factors responsible for soil deterioration and poor agricultural productivity. This is mainly due to total concentration of soluble salt or osmotic potential of soil water by Katerji and Oweis (2005). Excess of soluble salt in the soil leads to osmotic stress which results in specific ion toxicity and ionic imbalance and the consequences leads to plant demise (Rout and Show 2001). In semi arid and arid regions, the extended periods of dryness as well as inappropriate intense irrigation engender a concentration of solutes in soil so that 15% of soils in these regions endure problems of salinity and a third of irrigated lands in the world are affected by the salinity (Abdelmoumen *et al.* 2009). Plant scientists have adopted various strategies to overcome the salinity. One of them is to exploit genetic variability of the available germplasm to identify a tolerant genotype that may sustain a reasonable yield on salt affected soil (Asharf *et al*. 2006). The legumes are generally more sensitive to salt stress as compared to other crops and the productivity of all commercially useful legumes is reduced by saline condition (Mass and Hoffman 1977). Legumes provide a nutritious food for man and animal. The special ability of leguminous crops to work symbiotically with rhizobia to fix and produce protein is becoming increasingly important in agriculture.

Fenugreek (*Trigonella foenum-greacum* L.) is an annual herb that belongs to the family *Leguminosae* widely grown in Egypt, Pakistan, India, and Middle Eastern countries. It is an old medicinal plant and has been commonly used as a traditional food and medicine.It is a good soil renovator and widely used as a green manure (Saeed and Elsheikh 1995). Rhizobium are known to be more salt tolerant than their plant partners. Maximal limit of tolerance to salinity is superior in rhizobium as compared to their host plant which frequently constitutes the limiting factor in saline soils. Abdelmoumen *et al.* (2009) and Elsheikh (1992) observed almost complete failure of nodule development in fenugreek at high concentration of salt. Nevertheless, it is not uncommon to expect the presence of many rhizobium species in salt affected soils because legumes like *Sesbania* species were found to nodulate and play important role in reclamation. Poi *et al*. (1991) reported that rhizobium minimized the effect of salinity and increase the biomass of plant and seed production of fenugreek. Although it is well known fact that fenugreek is a good source of atmospheric nitrogen fixation by rhizobium present in its root nodules. It has also been reported that inoculation with effective strain of rhizobium increased the yield of plant under salt stress condition (Ahmad *et al*. 1985). Nitrogen-fixing rhizobium inoculations are promising as sustainable biotechnological treatments in agriculture.

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The present study aims at determining the effect of different salt concentrations on the growth of fenugreek (i) Plant survival and morphology, (ii) The ability of the plant and rhizobium strain to establish an effective symbiosis.

MATERIALS AND METHODS

The pot trail has been designed to study the efficacy of rhizobium strain on plant growth and productivity under saline irrigation on fenugreek. Pure seed of two varieties of fenugreek (Cv. NDM-17 and Pusa Kasauri) were obtained from Vegetable Department, Narender Dev University of Agriculture and Technology, Kumarganj, Faizabad and Indian Agriculture Research Institute (IARI), New Dehli. The variety NDM-17 was salinity tolerant and Pusa Kasauri was salinity sensitive. The effective rhizobium strain was provided by the department of microbiology, GBPUA and T, Pantnagar. Experiment was conducted in earthen pots from 25 November 2010 to 7 April 2011. Earthen pots of 10" diameter were filled with well-mixed garden soil and farmyard manure. The saline solutions of different EC levels were prepared by mixing the salt of NaCl, Na_2SO_4, $NaHCO_3$ and $CaCl_2$ in normal water. The quantity of salts dissolved was followed as mentioned according to U.S. Salinity Laboratory Staff Handbook (1954).The sets of pots were irrigated with different concentrations (3, 6, 7, 10, 12 and 14 dS/m) of 1 litre of saline water while control sets was irrigated with normal water. For each salinity levels two sets of pots trail were conducted, one was containing inoculated seeds with rhizobium and other containing un-inoculated seeds. Each set of salinity was maintained in triplicate and the seeds were sown at 1cm depth at the rate of one gram per pot. Prior to sowing, the seeds were surface sterilized with 0.01% $HgCl_2$ and coated with rhizobium. Rhizobium culture was inoculated to newly germinating plant. All pots were exposed to uniform natural day light and temperature. The electrical conductivity and pH of the soil of each pot were checked from time to time. The average minimum and maximum temperature and relative humidity were recorded during the experimentation. The observations regarding different plant parameters (plant height, shoot dry weight, number of leaves/plant, number of pods/plant, weight of100 seeds/plant, root length, root dry weight and biological yield) have been recorded at 30, 60, 90 and 120 DAS.

RESULTS AND DISSCUSSION

Shoot length and Shoot dry weight

Data revealed that except at 3 and 6 dS/m, which proved to be primitive, saline irrigations inhibited the plant height and this was also consistently true in rhizobium inoculated sets at different stages of growth (Table 1). The depressive effect of saline irrigation was more pronounced

Table 1 Shoot length and shoot dry weight (g/plant) of fenugreek inoculated and uninoculated plants with rhizobium at different salt concentrations and DAS

Fenugreek varieties	Salinity of irrigation water (dS/m)	Days after sowing								Days after sowing							
		30		60		90		120		30		60		90		120	
		NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R
		Shoot length (cm)								*Shoot dry weight (gm/plant)*							
NDM-17	Control	4.30[$]	4.5	25.0	27.0	41.0	44.2	44.0	48.0	0.03*	0.04*	0.49	0.50	0.85	0.85[$]	0.76	0.84
	3	4.2*[$]	4.4*	24.0	26.0	39.0	42.0	41.7	45.5	0.03*	0.04*	0.48*	0.50	0.82	0.84	0.75	0.83
	6	3.9[*$]	4.2*	18.0	23.0	28.0	37.0	28.0	38.0	0.02	0.03	0.40	0.41	0.61	0.68	0.56	0.65
	7	3.5[$]	3.8	15.0	18.0	21.0	28.0	22.0	29.0	0.02	0.03	0.30	0.31	0.47	0.50	0.41	0.47
	10	2.7[$]	3.0	11.6	15.0	16.0	21.0	17.2	22.0	0.01	0.03	0.23	0.25	0.38	0.40	0.35	0.39
	12	2.0	2.4	8.0	13.0	12.0	18.0	13.0	18.5	0.01	0.02	0.20	0.23	0.28	0.35	0.25	0.31
	14	1.4	1.9	5.0	10.0	7.0	14.0	7.3	14.8	0.01	0.01	0.16	0.18	0.20	0.23	0.16	0.21
CD (P=5.00)																	
Salinity	0.54360									0.00661							
Rhizobium	0.26340									0.00684							
S×R	22.2890									0.55157							
Pusa Kasauri	Control	4.0	4.7	24.0	27.0	40.0	44.0	43.0	46.0	0.02	0.03	0.49[$]	0.49	0.74	0.84	0.73	0.80
	3	3.8*	4.5*	22.5	25.5	37.0	41.0	39.8	43.4	0.02	0.03*	0.47	0.48	0.72	0.82	0.71	0.76
	6	3.1	3.8	17.0	20.0	27.0	32.0	28.5	33.0	0.01[$]	0.02	0.38	0.40	0.52	0.61	0.50	0.56
	7	2.4	3.0	12.5	15.0	20.0	23.0	21.6	23.8	0.02	0.01	0.28	0.30	0.36	0.44	0.31	0.39
	10	2.1	2.6	8.0	12.0	14.0	18.0	15.0	18.3	0.01	0.01	0.15	0.18	0.20	0.27	0.19	0.25
	12	1.4	1.9	5.0	9.0	8.0	14.0	8.4	14.5	0.01	0.02	0.12	0.15	0.14	0.23	0.10	0.16
	14	1.1	1.5	3.0	5.0	4.5	6.0	5.0	6.0	0.01	0.01	0.09	0.10	0.10	0.15	0.06	0.12
CD (P=5.00)																	
Salinity	0.50743									0.00800							
Rhizobium	0.39456									0.00204							
S×R	24.2386									0.40331							

NR: Uninoculated with rhizobium; R: Inoculated with rhizobium; $: Non significant for rhizobium; * Non-significant for salinity.

at advanced stage of growth, particularly at 10, 12 and 14 dS/m. Similar observations have also been reported in berseem and finger millet (Agarwal *et al.* 2011); in *Vigna radiata* (Naher and Alam 2010). Inoculation with rhizobium strain enhanced plant height irrespective of salinity and durations. The length progressively and significantly increased in both cultivars with the advancement of plant age irrespective of saline irrigation or rhizobium inoculation. Salinity had differentially affected plant length at different durations e.g. salinity had significantly affected plant length at all saline levels at all sampling dates but had no significant effect at 3 and 6 dS/m in both rhizobium inoculated and uninoculated sets at 30 DAS in cv. NDM-17 while cv. Pusa Kasauri registered no significant effects at 3 dS/m at 30DAS. Rhizobium and salinity induced effects on plant height in cv. Pusa Kasauri. Plant length significantly decreased with increase in salinity levels at different durations but the magnitude of reduction was more pronounced in this cultivar as compared to cv. NDM-17. In general, plant growth in rhizobium inoculated sets was less affected as compared to uninoculated plants. On the basis of data, the percent reduction in rhizobium inoculated pots was lower than uninoculated pots. Cvs. NDM-17 and Pusa Kasauri recorded 3.70-62.96 and 5.56-81.00% reduction at 90 DAS at all salinity levels in treated plants while non treated plants underwent 4.0-80.0 and 6.2-87.00% reduction. Poi *et al.* (1991) and Husain *et al.* (2002) also reported that rhizobium minimized the effect of salinity in fenugreek. Increasing plant height of fenugreek with an increase in rhizobium doses. Similar observations reported by Agarwal and Ahmad (2010) and Abdelmeumen *et al.* (2009).

Shoot dry weight significantly and progressively increased from juvenile stage to maturity in both the cultivars irrespective of salinity or rhizobium treatment. However, the increase was not significant at 120 DAS. Analysis of variance also revealed no significant effect at 3 and 6 dS/m at 30DAS in both cultivars in inoculated as well as uninoculated plants. Considering the effect of rhizobium inoculations, it appears that salinity induced greater decrease in shoot dry weight in uninoculated than inoculated plants with rhizobium. Cv. NDM-17 registered 3.53-76.47 and 1.32-78.95% inhibition in non rhizobium treated sets and 1.18-72.94 and 1.19-75.00% inhibition in rhizobium culture treated sets at 90 and 120 DAS at all saline levels. Similarly, Pusa Kasauri registered 2.70-86.49 and 2.74-91.78% reductions in uninoculated sets and 2.38-82.14 and 4.38-85.00% reductions in inoculated sets with rhizobium. Similar result obtained by Agarwal and Ahmad (2010) on growth and productivity of berseem crop and Abdelmeumen *et al.* (2009) on germination, growth and productivity of fenugreek. The ability of rhizobium to tolerate salt stress also depends on the species and even on the strain of rhizobium studied (Bernard *et al.* 1986).

Root length and root weight

Root growth was differentially affected in the saline irrigation and rhizobium inoculation (Table 2). Length of root had been significantly decreased at different EC levels and at different stages of growth in both rhizobium inoculated and uninoculated sets except at 3 dS/m which had no effect of salinity on root length. These findings are in conformity with the results achieved by earlier researcher Murill-Amader and Troyo-Dieguez (2000) in cowpea. Though the growth pattern of root is almost same at various growth stages but as the crop advanced to maturity, percent inhibition also increased, e.g. uninoculated sets of NDM-17 registered 3.60-68.29 and 4.55-69.32% reductions at 60 and 90 DAS, respectively. Similarly, inoculated sets registered 2.33-61.63 and 3.30-62.64% reductions. In Pusa Kasauri, the % inhibition ranged from 4.55 to 80.30 and 4.55 to 73.86% in uninoculated sets while it varied from 2.86-72.86 and 3.76-73.91% in inoculated sets which is rather higher as compared NDM-17. Rhizobium inoculation promoted root length over non rhizobium inoculated plants invariably. These results clearly indicate that the inhibitory effects of salinity have been somehow minimized by rhizobium inoculation at all salinity levels. Similar findings by Elsheikh and Wood (1990) on soyabeen; Dhanapackiam and Muhammad (2010) on Sesbania grandiflora, Agarwal and Ahmad (2010) on berseem. Root length progressively increased with the advancement of plant age however, maximum elongation was observed between 60 and 90 DAS in both inoculated and non inoculated sets at all salinity levels. Root length of Pusa Kasauri significantly increased at all durations in both uninoculated and inoculated sets at all salinity levels but in NDM-17, this increase was not significant at 3 dS/m in both sets at 30 DAS.

Rhizobium inoculation had expressed positive effects on dry weight of root irrespective of saline irrigation. Kumara *et al.* (1974) found that increase in salinity and alkalinity of Lucerne growth medium resulted in a root system devoid of root hairs and infection thread inspite of optimum growth of rhizobium under such conditions. Agarwal and Ahmad (2010) reported that the dry weight of the root and shoot were generally higher in rhizobium inoculated sets, it may be assumed that plant productivity can be improved in saline condition by proper soil management such as use of salt resistant varieties and biofertilizer as rhizobium. Perusal of the data indicates that saline irrigation had expressed significant reductions in both rhizobium inoculated and uninoculated sets of NDM-17 at all durations and all salinity levels except 3 and 6 dS/m. It is also interesting to note that plants raised from rhizobium inoculated seeds registered lesser reductions, e.g. inoculated sets of NDM-17 registered 1.54-71.54 % while uninoculated sets recorded 2.54-74.58% reductions at 90 DAS at 3-14 dS/m levels of salinity. Percent reductions in Pusa Kasauri were 3.64-83.64 in inoculated sets and 6.02-86.00 in uninoculated sets. Agarwal and Ahmad (2010) and Abdelmeumen *et al.* (2009) were found that rhizobium inoculation expressed positive effects on dry weight of root irrespective of saline irrigation.

Leaf number and dry weight

The data indicates that there was significant decline in

Table 2 Root length and root dry weight (gm/plant) of fenugreek inoculated and uninoculated plants with rhizobium at different salt concentrations and DAS.

Fenugreek varieties	Salinity of irrigation water (dS/m)	Days after sowing								Days after sowing							
		30		60		90		120		30		60		90		120	
		NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R
		Root length (cm)								*Root dry weight (gm/plant)*							
NDM-17	Control	4.00	4.40	8.20	8.60	8.80	9.10	10.00	11.00	0.03	0.03	0.05	0.06	0.59	0.65	0.53	0.61
	3	3.90*	4.30*	7.90	8.40	8.40	8.80	9.50	10.60	0.03*$	0.03*	0.05*	0.06*	0.57	0.64	0.51	0.60
	6	3.50	4.10	7.10	7.90	7.40	8.20	8.20	9.80	0.02	0.02	0.04	0.06*	0.47	0.53	0.43	0.51
	7	3.00	3.80	5.70	7.20	5.90	7.20	6.60	8.30	0.02	0.02	0.03	0.05	0.38	0.44	0.37	0.42
	10	2.30	3.30	4.30	6.20	4.60	6.30	5.10	7.40	0.01	0.02	0.03	0.04	0.28	0.36	0.26	0.35
	12	1.90	2.70	3.70	5.00	3.90	4.90	4.20	5.70	0.01	0.01	0.02	0.03	0.21	0.26	0.19	0.24
	14	1.30	1.80	2.60	3.30	2.70	3.40	2.90	4.00	0.00	0.01	0.01	0.02	0.15	0.18	0.18	0.17
CD (P=5.00)																	
Salinity	0.119485									0.00465							
Rhizobium	0.213552									0.00547							
S×R	13.09047									0.19500							
Pusa Kasauri	Control	3.30	3.60	6.60	7.00	8.80	9.20	9.80	10.90	0.03	0.03	0.04	0.05	0.50	0.55	0.49	0.52
	3	3.10	3.40	6.30	6.80	8.40	8.90	9.40	10.40	0.02*	0.03*	0.04*	0.05*	0.47	0.53	0.47	0.49
	6	2.70	3.10	4.40	5.50	5.70	7.00	7.10	8.10	0.01	0.02*	0.03	0.04*	0.33	0.39	0.33	0.37
	7	2.20	2.60	3.70	4.50	4.30	5.50	5.00	5.80	0.01	0.01	0.02	0.03	0.21	0.26	0.20	0.25
	10	2.00	2.20	3.00	4.00	3.70	5.00	4.00	5.00	0.02	0.01	0.01	0.02	0.16	0.19	0.15	0.18
	12	1.30	1.50	2.00	2.70	2.90	3.20	3.00	3.70	0.01	0.01	0.01	0.01	0.12	0.14	0.11	0.13
	14	1.00	1.20	1.30	1.90	2.30	2.40	2.00	2.40	0.01	0.01	0.01	0.01	0.07	0.09	0.07	0.08
CD (P=5.00)																	
Salinity	0.11548									0.01093							
Rhizobium	0.11434									0.00398							
S×R	6.97153									0.24524							

NR: Uninoculated with rhizobium; R: Inoculated with rhizobium; $: Non significant for rhizobium; * Non significant for salinity.

leaves number in both the cultivars with increase in salinity level (Table 3). Rhizobium application somehow compensated the inhibitory effects of salinity. Similar results has been recorded by several workers Nevespiestum and Bernstein (2001) on maize, Rawson *et al.* (1988) on gas exchange of leaf blades in barley and Agarwal and Ahmad (2010) on berseem.

Similarly, in leaf dry weight, rhizobium inoculated set of cv. NDM-17 and Pusa Kasauri registered 0.57-37.14 and 2.91-40.0% and 1.19-59.94 and 0.44 -63.80% inhibitions at 60 and 90 DAS, respectively, while in uninoculated sets recorded 2.92-40.0 and 3.49-44.67% and 1.83-63.41 and 2.49-67.12% reductions, respectively. Findings revealed that rhizobium inoculated plants minimized salt induced effects. The magnitude of reduction was more pronounced in Pusa Kasauri as compared to cv. NDM-17.

Flowering

Different types of flowers are produced in both cultivars. Cvs. NDM-17 produced small white flowers while Pusa Kasauri produced small yellow flowers in bunches, due to which number of flowers were more in number as compared to NDM-17. The first bud turned into flower at 50 DAS in NDM-17 and at 65 DAS in Pusa Kasauri. Number of flower in both the cultivars had been significantly affected by saline irrigations and rhizobium inoculation. Number of flowers significantly reduced in both rhizobium inoculated and uninoculated sets of both cultivars at different salinity levels however, rhizobium culture treated sets induced earlier and higher. Agarwal and Ahmad (2010) found that rhizobium inoculation improve the flowering in fenugreek under saline area. Although saline irrigation had evoked depressive effect on flowering in both cultivars but the effect was more prominent in cv. Pusa Kasauri. Moreover, rhizobium inoculation had expressed positive effects on flower production. Rhizobium inoculated sets registered 6.67-74.67 and 4.44-81.11% reductions in cv. NDM-17 and Pusa Kasauri respectively. On the other hand rhizobium inoculated set administered 5.26-62.63% and 4.08-79.59% reductions at3 to 14 dS/m, respectively.

Pods and seeds characteristics

In cv. NDM-17 pod number decreased by 5.56-77.78% in uninoculated plants while 3.69-69.83% in inoculated plants with rhizobium at final harvest. In Pusa Kasauri rhizobium inoculated plants exhibited lesser reductions (2.22-80.00%) than uninoculated (7.69-84.62%). Present findings are in good agreement with Taylor *et al*. (2005) on soybean and Agarwal and Ahmad (2010) on berseem.

Seed yield (number of seeds per pod, number of pods per plant, dry weight of seeds and 100 seeds weight) is also an important component of crop productivity in fenugreek.

Table 3 Leaf number per plant and leaf dry weight (gm/plant) of fenugreek inoculated and uninoculated plants with rhizobium at different salt concentrations and DAS

Fenugreek varieties	Salinity of irrigation water (dS/m)	Days after sowing								Days after sowing							
		30		60		90		120		30		60		90		120	
		NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R	NR	R
		Leaf number/plant								*Leaf dry weight (g/plant)*							
NDM-17	Control	8.00	12.00	22.00	28.00	40.00	48.00	31.00	38.00	0.08	0.09	0.34	0.35	0.54	0.55	0.53	0.54
	3	7.90	12.00*	20.00	27.88	36.00	47.00	28.00	37.00	0.07	0.08	0.33	0.34	0.52	0.53	0.51	0.54
	6	6.00	9.66	17.00	22.00	27.00	34.00	25.00	28.00	0.07	0.08	0.20	0.32	0.46	0.48	0.45	0.47
	7	5.80	9.00	15.63	19.88	24.00	31.00	21.00	26.00	0.06	0.07	0.28	0.31	0.43	0.48	0.42	0.46
	10	4.90	8.20	13.00	18.50	21.00	27.00	17.00	22.00	0.06	0.07	0.25	0.27	0.40	0.42	0.39	0.41
	12	3.70	7.00	9.86	14.00	17.00	22.00	13.00	18.00	0.05	0.07	0.21	0.25	0.36	0.38	0.34	0.36
	14	2.80	5.80	7.21	11.00	12.00	17.00	11.00	14.00	0.04	0.06	0.18	0.22	0.30	0.33	0.27	0.31
CD (P=5.00)																	
Salinity	0.70101									0.00745							
Rhizobium	0.08000									0.00538							
S×R	15.5322									1.26101							
Pusa Kasauri	Control	8.00	10.00	21.00	25.00	35.00	40.00	32.00	38.00	0.06$	0.06	0.32	0.33	0.44	0.45	0.43	0.44
	3	8.00*	10.00*	20.00	24.00	33.00	38.00	30.00	36.00	0.05	0.06*	0.32*	0.33*	0.43	0.45*	0.42	0.43
	6	7.00	8.00	17.00	19.00	24.00	27.00	23.00	25.00	0.05	0.05	0.27	0.29	0.35	0.39	0.34	0.37
	7	5.00	6.80	12.80	14.00	20.00	22.00	19.00	20.00	0.04	0.04	0.21	0.25	0.27	0.32	0.26	0.30
	10	3.40	5.90	8.20	12.00	13.50	17.00	13.00	16.70	0.03	0.04	0.19	0.20	0.25	0.26	0.24	0.25
	12	2.60	4.50	6.50	9.30	10.40	13.00	9.00	11.23	0.02	0.03	0.15	0.17	0.21	0.22	0.20	0.20
	14	1.90	3.40	4.40	6.10	6.00	9.00	6.00	7.00	0.02	0.02	0.12	0.13	0.13	0.16	0.13	0.15
CD (P=5.00)																	
Salinity	0.62496									0.00921							
Rhizobium	0.21500									0.00289							
S×R	4.16546									0.56286							

NR: Uninoculated with rhizobium; R: Inoculated with rhizobium; $: Non significant for rhizobium; * Non significant for salinity.

Salinity induced reductions in the number of seeds/pod ranged between 20.0-88.0 and 6.33-62.50% in rhizobium uninoculated plants of cv. Pusa Kasauri and NDM-17, respectively, while rhizobium inoculated plants exhibited lesser reductions (14.16-66.66 and 5.26-50.94%).

Biological yield

Biological yield (total plant dry mass including dry weight of shoot, root, leaves and pods) had been gradually increased with the advancement of plant age but saline irrigations had adversely affected however, 10 to 14 EC exhibited more depressive effect in all accessions. Francois and Conala (1994) and Demiral (2005) were also observed that vegetative growth of different species was unaffected by soil salinity up to 10 dS/m. The plants of cv. Pusa Kasauri invariably registered higher reduction as compared to NDM-17 in both sets at 30, 60, 90 and 120 day after sowing. The plants raised from uninoculated plants of Pusa Kasauri registered 3.57-81.55 and 3.03-84.24% reductions at 90th and 120th day stage respectively. Contrary to this, the deleterious effects of salinity (6 to14 dS/m) were minimized by rhizobium inoculation at both dates (3.11-72.02 and 4.86-74.59%). Cv. NDM-17 also expressed this beneficial effect of rhizobium application at different salinity regimes, e.g. uninoculated plants of cv. NDM-17 registered 3.63-67.00 and 2.75-68.68% reductions while treated set recorded 1.76-63.66 and 1.51-65.33% reductions at 90 and 120 DAS, respectively.

ACKNOWLEDGEMENT

The authors are thankful to the Dr P K Singh, Hindu College, M J P Rohilkhand University, Moradabad for providing the laboratory facilities. We also gratefully acknowledge Dr Manvika Sahgal, G B Pant University of Agriculture and Technology, Pantnagar for providing effective rhizobium strain for this work.

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