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EVALUATION OF SELECTED CHICKPEA NODULATION VARIANTS IN BANGLADESH

D. Khanam, M. A. H. Bhuiyan, A. K. M. Hossain and O. P. Rupela[1]

Soil Science Division, BARI, Gazipur, Bangladesh &
[1]Agronomy Division, ICRISAT Asia Center, Patanchru, 502 324, Andhra Pradesh, India

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Abstract

A field experiment on high nodulating selection of chickpea cultivars was carried out at Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during the rabi seasons of 1994-95 and 1995-96. Eight genotypes of chickpea namely ICC 4948 HN, ICC 4948 LN, ICC 4948 UB, ICC 5003 HN, ICC 5003 LN, ICC 5003 UB, ICC 4993 NN and ICC 4918 NN were included in the study. Peat-based inoculants RCa-220 and IC-59 were used. Different cultivars of chickpea showed considerable variations in nodule number, nodule mass, shoot mass, stover yield and grain yield. The high nodulating cultivars ICC 4948 and ICC 5003 gave higher nodulation, dry matter yield and also grain yield than their respective low nodulating selections in both the years.

Introduction

Chickpea (*Cicer arietinum*) is an important pulse crop in Bangladesh. It can fix atmospheric nitrogen through symbiotic association with *Rhizobium*. From the studies at Bangladesh Agricultural Research Institute (BARI) it was observed that inoculation with efficient strains of *Rhizobium* increased yield of chickpea (Khanam *et al.*, 1994; Bhuiyan *et al.*, 1998; Bhuiyan *et al.*, 1999). Several other authors (Khurana and Dudeja, 1981; Raut and Ghonsikar, 1982 and Namdeo *et al.*, 1989) also reported significant improvement in yield and biological nitrogen fixation due to *Rhizobium* inoculation in chickpea. Recent studies at ICRISAT Asia Center have established wide intracultivaral differences in nodulation capacity in chickpea plants (Rupela, 1992; Rupela and Johansen, 1992). Studies have also indicated that high nodulating selections fix significantly more N_2 than low nodulating selections of the same cultivar. Also, high-nodulating selections tend to yield more than the low-nodulating selections at low soil N levels (Rupela, 1994). However, at N levels higher than 15 mg kg^{-1} soil, there was no such consistent trend in nodulation, biological nitrogen fixation, or yield. The present study was undertaken to assess the performances of nodulation variants of two chickpea cultivars in Bangladesh that could be used for the improvement of biological nitrogen fixation (BNF).

Materials and Methods

The field experiment was carried out at Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh (24°-23'N latitude, 90°-08' E longitude, 8.40 m elevation) during the rabi seasons of 1994-95 and 1995-96. Eight ICRISAT supplied chickpea genotypes namely, ICC 4948 HN, ICC4948LN, ICC4998UB, ICC5003HN, ICC5003LN, ICC5003UB, ICC4993NN and ICC 4918 NN were tested in this experiment. The peat based rhizobial inoculant was prepared in the Soil Microbiology Laboratory of Bangladesh Agricultural Research Institute using *Rhizobium* strain RCa-220 for first year and IC-59 for second year. The *Rhizobium* strains used were obtained from the stock culture of the Laboratory, which were originally collected from NifTAL and ICRISAT.

The experiment was conducted in split-plot design having 2 main plots and 8 sub-plots along with 4 replications. Nitrogen levels (N_0 and N_{100} kg ha^{-1}) were considered as main plot and genotypes as sub-plot. The size of each sub-plot was 4 × 3 m. Hundred kg N ha^{-1} as urea was applied only in the previous cereal crop, maize in 1994-95 and rice in 1995-96. Phosphorus (50 kg P_2O_5 ha^{-1}) as triple superphosphate and potash (50 kg K_2O ha^{-1}) as muriate of potash were applied at the sowing time of chickpea. Peat based rhizobial inoculants were applied in the field in liquid method (ICRISAT, 1992) and the population in the peat inoculant was about 10^7 cells g^{-1} in both the years. Chickpea seeds were sown on 5 Nov. 1994 and 20 Nov. 1995. Row to row distance was 30 cm and plant to plant distance was 10 cm. A light irrigation was given in the field on 6 Nov. 1994 and 21 Nov. 1995 for germination of seeds. Second irrigation was applied on 17 Dec, 1994 and 15 Jan. 1996. Weeding and mulching were done as and when necessary. Before application of fertilizers, soils from main plots were collected at 0-15 cm depth for chemical analysis. Total N, mineral N, pH, Olsen P, electric conductivity and soil moisture were determined in the standard methods (Table 1). Monthly maximum and minimum temperature and rainfall were collected from Meteorological Department (Table 2). Plant samples from m^{-2} in each sub-plot were uprooted on 7 Jan. 1995 and 22 Jan. 1996 for nodule number, nodule mass and shoot mass. The crop was harvested at maturity on 2 April 1995 and 1 Apr. 1996. One row on each side of a plot and 30 cm at row ends were left as borders at the time of harvest. Infestation of pod borers (*Helicoverpa armigera*) in both years, which were controlled by spraying insecticide.

Table 1. Soil characteristics of experimental site during 1994-95 and 1995-96

Sample	Year	pH	Total-N %	EC ds m^{-1}	Mineral-N µg ml^{-1}	Olsen P %	Soil moisture at sowing %	Soil type
N_0	1994-	5.60	0.185	0.160	22.00	0.01		Red Brown
N_{100}	95	5.70	0.193	0.167	18.50	0.01	8.17	Terrace Soil
N-Mean		5.65	0.189	0.163	20.75	0.01	-	-
CV %		5.30	6.30	11.3	7.20	0.0	-	-
N_0	1995-	5.68	0.063	0.165	20.00	0.24	20.20	-
N_{100}	96	5.58	0.093	0.168	23.25	0.24		
N-Mean		5.63	0.078	0.167	21.63	0.24	-	-

N in kg ha^{-1}

Table 2. Temperature and rainfall of the cropping period

Year	Month	Temperature (° C)		Rainfall (mm)
		Maximum	Minimum	
1994	November	29.45	18.51	0.90
1994	December	27.22	12.70	0.00
1995	January	24.55	10.96	7.50
1995	February	26.73	14.40	26.40
1995	March	32.04	17.43	3.40
1995	April	35.56	23.16	49.40
1995	November	30.05	19.75	109.00
1995	December	25.74	13.07	2.00
1996	January	25.13	11.92	0.00
1996	February	28.42	14.78	21.00
1996	March	33.22	21.19	49.00

Source: Meteorological Department, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh.

Results and Discussion

The experiment was initiated with maize crop from kharif season of 1994 and rice in 1995. The chickpea crop was tested during the rabi seasons of 1994-95 and 1995-96. Noudule number and nodule mass were higher in low N level among all selections of two cultivars in both the seasons of 1995 and 1996 (Table 3). Higher dose of nitrogenous fertilizer (100 kg N ha^{-1}) resulted lower number of nodules and nodule mass in both the years (Table 3). Different cultivars of chickpea showed considerable variations in nodule number, nodule mass, shoot mass, stover yield and grain yield (Tables 3 and 4). The cultivar ICC 4948 HN produced significantly higher nodule number compared to ICC 4948 LN at N_0 and N_{100} levels in 1995 (Table 3). Similarly, the cultivar ICC 4948 HN recorded higher nodule number compared to 4948 LN and ICC 4948 UB in 1996 and the differences were significant. The cultivar ICC 5003 HN gave markedly higher nodule number over ICC 5003 LN at low and high N levels in 1995. The same cultivar also produced significantly higher nodule number in comparison to 5003 LN at both N levels in 1996. The highest nodule number were obtained from the cultivar ICC 5003 UB at both N levels in both the years. The non-nodulating selections of ICC 4993 and ICC 4918 did not produce any nodule (Table 3). The high-nodulating selections of cultivar ICC 4948 and ICC 5003 recorded significantly higher nodule number in comparison to their respective low-nodulating selections, which indicates that high-nodulating selections produced higher number of nodules than low-nodulating ones from the same cultivar.

Table 3. Effect of different cultivars and nitrogen level on chickpea nodule number, nodule mass and shoot mass during 1994-95 and 1995-96

Cultivar[1]	Year	Nodule[2] Plant^{-1}		C-mean	Nodule mass[2] mg plant^{-1}		C-mean	Shoot mass[2] g plant^{-1}		C-mean
		N_0	N_{100}		N_0	N_{100}		N_0	N_{100}	
ICC4948HN		84.2c	44.6b	64.4	233.3c	99.0c	166.2	9.30bcd	12.17ab	10.73bc
ICC4948LN		44.5de	13.6cd	29.1	109.2d	30.0cd	69.6	5.43e	8.23cd	6.83d
ICC4948UB		62.5d		48.4	166.4cd	72.1c	119.2	9.63bc	10.47bc	10.05c
ICC5003HN		147.0b	34.4bc	123.	370.9b	210.9b	290.9	9.86bc	14.00a	11.93ab
ICC5003LN	1995	39.6e	100.4a	7	174.2cd	57.3cd	115.8	10.03ab	12.60ab	11.32abc
ICC5003UB		186.5a	23.5bc	31.8	485.9a	321.8a	403.8	12.24a	13.34a	12.78a
ICC4993NN		0.0f	119.5a	153.	0.0e	0.0d	0.0		8.93cd	8.25d
ICC4918NN		0.0f	0.0d	0	0.0e	0.0d	0.0	7.57cde	7.67d	7.33d
			0.0d	0.0				7.00de		
				0.0						
N-Mean		70.5	42.0	56.4	192.1	98.9	145.7	8.88	10.93	9.90
CV %		-	-	17.1	-	-	21.0	-	-	10.5
ICC4948HN		59.2ab	52.5a	55.9a	87.7c	69.4c	78.5	3.21d	3.80c	3.51c
ICC4948LN		15.2d	12.4c	13.8d	41.6d	31.9d	36.8	2.71d	3.67c	3.18c
ICC4948UB		11.9d	11.7c	11.8d	34.1d	26.4d	30.3	3.82bcd	4.20bc	4.01c
ICC5003HN	1996	52.9b	47.8a	50.3b	117.7b	109.1b	113.4	4.84ab	7.26a	6.05a
ICC5003LN		43.0c	27.6b	35.3c	110.7b	72.2c	91.4	4.57abc	5.25b	4.91b
ICC5003UB		60.6a	52.9a	56.8a	151.8a	127.9a	139.9	5.12 a	6.39a	5.76a
ICC4993NN		0.0e	0.0d	0.0e	0.0e	0.0e	0.0	3.46 cd	3.94c	3.70c
ICC4918NN		0.0e	0.0d	0.0e	0.0e	0.0e	0.0	3.52 cd	3.72c	3.62c
N-Mean		30.3	25.6	28.0	68.0	54.6	61.3	3.90	4.78	4.34
CV %		-	-	17.9	-	-	14.6	-	-	18.40

1. HN = High nodulating, LN = Low nodulating, UB = Unselected bulk, NN = Non nodulating
2. Data obtained as m^{-2}. It was transformed to plant^{-1} assuming population of 30 plants m^{-2}

Highest nodule mass were obtained from the cultivar ICC 4948 HN over ICC 4948 LN at low and high N levels in 1995 (Table 3). Similarly, highest nodule mass were observed with the same cultivar over ICC 4948 LN in 1996. The highest nodule mass were found in the bulk of ICC 5003 at both N levels in both the years. The high-nodulating selection of ICC 5003 produced higher nodule mass than the low nodulating selection of the same cultivar in 1st year. The above high-nodulating selection also recorded higher nodule mass over its low-nodulating selection at two N levels in the 2nd year. Similar results for nodule number and mass were recorded at Akola, Hisar, and Sehore, India (AWGBNFL Notes, 1995). Nodulation variants within cultivars of chickpea were selected in order to identify high nodulating lines that could be used for the improvement of biological nitrogen fixation (BNF). High nodule number and mass fix higher amount of atmospheric nitrogen and also produce high pod yields (Venkateswarlu, 1997).

The cultivar ICC 4948 HN recorded significantly higher shoot mass over ICC 4948 LN (Table 3). Higher shoot mass was also obtained from the cultivar ICC 5003 HN over ICC 5003 LN at both N levels and years.

High-nodulating selection of ICC 4948 and ICC 5003 gave significantly higher stover yield compared to low-nodulating selection at both N levels in 1995 (Table 4). But in 1996, all the selections of cultivar 4948 and 5003 yielded statistically same at both N levels.

Table 4. Effect of different cultivars and nitrogen level on chickpea stover yield and grain yield during 1994-95 and 1995-96

Cultivar	Year	Stover yield[1] (t ha^{-1})		C-mean	Grain yield[1] (t ha^{-1})		C-mean
		N_0	N_{100}		N_0	N_{100}	
ICC 4948 HN		8.83a	10.58ab	9.71a	2.28b	2.83bc	2.55bc
ICC 4948 LN		6.50bcd	8.58cd	7.54cd	2.21b	2.71bc	2.46c
ICC 4948 UB		7.33abc	9.08bcd	8.21bc	2.19b	2.46c	2.32c
ICC 5003 HN	1995	7.75ab	10.92a	9.33ab	3.08a	4.25a	3.67a
ICC 5003 LN		5.67cd	8.75cd	7.21cd	2.58ab	3.46b	3.02b
ICC 5003 UB		8.33a	10.25abc	9.29ab	1.92bc	3.13bc	2.52bc
ICC 4993 NN		5.67cd	8.25d	6.96cd	1.38cd	2.96bc	2.17c
ICC 4918 NN		5.33d	7.75d	6.54d	0.75d	1.50d	1.13d
N-Mean		6.93	9.27	8.10	2.05	2.91	2.48
CV %		-	-	9.80	-	-	13.90
ICC 4948 HN		3.13ab	4.11a	3.62a	1.31ab	1.60abc	1.45
ICC 4948 LN		3.26ab	3.68ab	3.47a	1.10b	1.24ef	1.17
ICC 4948 UB		3.31ab	3.99a	3.65a	1.22ab	1.55bcd	1.39
ICC 5003 HN	1996	3.63a	3.81ab	3.72a	1.37a	1.80a	1.58
ICC 5003 LN		3.23ab	3.99a	3.61a	1.07b	1.67ab	1.37
ICC 5003 UB		3.20ab	3.40ab	3.30b	1.21ab	1.41cde	1.31
ICC 4993 NN		2.66b	3.14b	2.90b	1.20ab	1.33de	1.26
ICC 4918 NN		3.73a	3.90ab	3.82a	0.65c	1.08f	0.86
N-Mean		3.27	3.75	3.51	1.14	1.46	1.30
CV %		-	-	14.80	-	-	11.80

1. Data obtained as kg plot^{-1} excluding one row on each side of a plot and 30 cm at row ends and transformed to t ha^{-1}

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

In 1995, the high-nodulating selection of cultivar ICC 4948 produced 3 and 4% more grain yield over its low-nodulating selections at N_0 and N_{100} levels respectively (Table 4). In 1996, ICC 4948 HN produced 19 and 29% more grain yield over its low-nodulating selection and only 7 and 3% more than the unselected bulk of ICC 4948 at low and high N levels. The high-nodulating selection of ICC 5003 recorded 28 and 8% higher grain yield over low-nodulating selection of the same cultivar at N_0 and N_{100} levels, respectively. At low N level ICC 5003 HN recorded significant yield compared to ICC 5003 LN but at high N level the yield of ICC 5003 HN and LN was statistically similar. Rupela (1994) also reported that the high and low-nodulating selections at cultivar ICC 5003 yielded similarly when tested in 1991-92. In both the years, ICC 4993 NN yielded better than ICC 4918 NN.

From two years results it may be concluded that the high- nodulating selection of cultivars ICC 4948 and ICC 5003 recorded higher nodulation, dry matter yield and also grain yield than their low-nodulating selections. The overall nodulation and yield performance of 1st year is better than that of 2nd year. Probable causes of low yield in 2nd year may be: i) chickpea was sown on 8 Nov. but due to heavy continuous rainfall for three days just after sowing, the crop was completely damaged. Then resowing was done on 20 Nov. ii) heavy rainfall in second year at flowering stage; flowers were dropped due to heavy rainfall during flowering stage and pod formation reduced and seed size was smaller than that of previous year. As a result, reduced yield was obtained.

The nitrogen of stover for the selection of cultivar ICC 4948 HN was higher compared to ICC 4948 LN at both nitrogen levels in 1995. Similar observations were also recorded for cultivar ICC 5003 (Table 5). Higher stover yield of different selections of cultivar ICC 4948 and ICC 5003 produced higher nitrogen yield at both levels. The cultivar ICC 4948 HN produced lower nitrogen yield than ICC 4948 LN and ICC 4948 UB but the cultivar ICC 5003 HN recorded higher nitrogen yield than ICC 5003 LN and ICC 5003 UB at both N levels (Table 5). In case of total N yield, high-nodulating selections of cultivar ICC 4948 and ICC 5003 produced higher N yield than the low-nodulating selections of the same cultivars. Field studies of high nodulating selections of chickpea for nodulation, nitrogen fixation and yield show that the high nodulating selection of ICC 4948 and ICC 5003 nodulated consistently higher than the low nodulating selections from their respective cultivars. Chickpea having high nodulating capacity to produce higher yield is a desirable character for maximum biological nitrogen fixation. The high nodulating selections are also high N_2-fixing plants including higher yield. These studies thus suggest a greater scope for enhancing BNF in legumes through host-plant selection. Further research to this area needs attention.

Table 5. Effect of different cultivars and nitrogen level on N-content of stover and grain of chickpea during 1994-95

Cultivar	Year	N-content of stover[1] (kg ha^{-1})		C-mean	N-content of stover[1] (kg ha^{-1})		C-mean	Total N-content[1] (kg ha^{-1})		C-mean
		N_0	N_{100}		N_0	N_{100}		N_0	N_{100}	
ICC4948HN	1995	46.7a	64.3a	55.5a	74.0bc	55.0bc	64.5b	120.7ab	119.3b	120.0b
ICC4948LN		24.3bc	41.1bcd	32.7cd	74.6bc	63.3bc	69.0b	98.9b	104.3bc	101.6bc
ICC4948UB		32.2abc	46.4bc	39.3bc	77.7ab	60.7bc	69.2b	109.9ab	107.1bc	108.5bc
ICC5003HN		30.3bc	64.4a	47.3ab	113.7a	121.8a	117.8a	144.0a	186.36a	165.1a
ICC5003LN		18.2c	40.3bcd	29.3cd	86.2ab	85.3ab	85.8b	104.4ab	125.6b	115.0bc
ICC5003UB		37.0ab	55.0ab	46.0ab	73.3bc	78.5bc	75.9b	110.3ab	133.4b	121.9b
ICC4993NN		18.8c	35.1cd	26.9d	36.6cd	89.1ab	62.8b	55.4c	124.1b	89.8c
ICC4918NN		17.0c	30.3d	23.6d	13.8d	39.7c	26.7c	30.8c	69.9c	50.3d
N-Mean		28.1	47.1	37.6	68.8	74.2	71.5	96.8	121.3	109.0
				18.0	-	-	23.3	-	-	15.9

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