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Impact of bio-fertilizers and weed management practices on growth and quality characters of chickpea (*Cicer arietinum* L.) under eastern U.P. conditions

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Abstract
A field experiment was conducted to study the effect of bio-fertilizer and weed management practices on growth and quality characters of chickpea during two consecutive Rabi seasons of years 2019-20 and 2020-21, respectively. The experiment was laid out in split plot design with four bio-fertilizer treatments for seed inoculation *viz*., RDF (20 kg N, 50 kg P and 20 kg ha^{-1}), RDF + *Rhizobium* culture, RDF + PSB (Phosphorus Solubilizing Bacteria) and RDF + *Rhizobium* culture + PSB in main plot. Each main plot was further divided into four sub plots to accommodate sub plot treatments *i.e.* weed management practices comprising application of Pendimethalin @ 1.0 kg a.i. ha^{-1} as pre emergence, Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb* Imazethapyr 0.060 kg a.i. ha^{-1} as post emergence, Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb* clodinafop 0.060 kg a.i. ha^{-1} as post emergence, two hand weeding (25 and 50 DAS) and weedy check. The results reported that the higher growth parameters *viz.* plant height, number of branches (mainand lateral), number of nodules $plant^{-1}$ and dry matter accumulation were recorded under application of RDF + *Rhizobium* culture + PSB during both the experimental years. In case of weed management practices, two hand weeding (25 and 50 DAS) exerted significant effect on growth of chickpea at harvest stage. However, in herbicidal treatments, application of Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb* clodinafop 0.060 kg a.i. ha^{-1} as post emergence noted higher values of above parameters. Protein content was failed to show any significant effect due to above treatments during both the years.

Keywords: Bio-fertilizers, pendimethalin, clodinafop, imazethapyr, *rhizobium* and psb (phosphorus solubilizing bacteria) weed management

Introduction
Pulses are integral part of Indian dietary system due to richness in protein and other important nutrients such as Calcium, Iron and Vitamins *viz*., carotene, thiamine, riboflavin and niacin. Indian population is predominantly vegetarian and protein requirement for the growth and development of the human being is mostly met with pulses. They are said to be poor man's meat and rich man's vegetables. The availability of pulses per capita per day has proportionately declines from 71 g (1995) to 56 g (2018) against the minimum requirement of 70 g per capita per day (Anonymous, 2018) [1].

Among the legumes, chickpea (*Cicer arietinum* L.) commonly known as Bengal gram and locally Chana is an important and unique food legume because of its use in the variety of food products like snacks, sweets etc. Condiments and vegetables are prepared from it world-wide. It is also consumed in the form of processed whole seed (boiled, roasted, parched, fried, steamed sprouted etc.) or as dal flour (besan). Gram is a good source of protein (18-22 per cent), carbohydrate (52-70 per cent), fat (4-10 per cent), minerals and vitamins. It is an excellent animal feed. Its stover has good forage value.

In spite of the importance of this crop in our daily diet and in agricultural production, productivity of this crop is very low in India as well as in the Uttar Pradesh. The low production of this crop is due to improper use of fertilizers, weed competition, improper time of sowing and seed rate, pest and disease management and no use of bio-fertilizers such as *Rhizobium*, PSB and VAM fungi (Singh *et al.*, 2019).

The role of bio-fertilizers is also well recognized which supplies macro and micro nutrients necessary for the plant growth. Among bio-fertilizers *rhizobium* inoculation is cheapest, easiest and safest method of supplying nitrogen to legumes through well-known symbiotic nitrogen fixation process. *Rhizobium* inoculation can increase the seed yield of pulse crops to the tune of 10 to 15 per cent (Fatima, *et al.*, 2008) [4].

Inoculation of appropriate strain enhances nodule formation resulting better nitrogen fixation. Phosphate solubilizing bacteria (PSB) have the consistent capacity to increase the availability of phosphates to plants by mineralizing organic phosphorus compounds. It solubilizes insoluble inorganic phosphorus compounds by exerting organic acids, which is the primary mechanism of solubilizing of insoluble inorganic phosphates. Besides organic acids, production of chelating substances, mineral acids, siderophores and proton extrusion mechanism are also involved (Gaur, 1990) [6].

Weed infestation is one of the major constraints in chickpea cultivation. Uncontrolled weeds may reduce chickpea yield by 50-90 per cent depending upon cultivars, soil type, soil moisture level and other environmental conditions (Verma *et al*., 2015) [21]. Therefore weed management is an important factor for enhancing the productivity of chickpea, as weeds compete for nutrients, water, light and space with the crop plant during the early growth period. Due to unavailability of labour and hike in labour cost, chemical weed management is possible to control a wide spectrum of weeds in pulses effectively at a remunerative cost.

In the present time, some of the very effective high potency herbicide molecules have been developed which may be useful to control the wide spectrum of weeds in chickpea further, if there molecules are used in a combination may be more effective to control the wide spectrum weeds.

However, information regarding effect of bio-fertilizer and weed management in chickpea production in Uttar Pradesh is lacking. Keeping in view the above discussed facts of sufficient information and sparce related research, the present investigation was undertaken to find out the effect of bio-fertilizer and weed management practices on growth of chickpea in Ayodhya conditions.

Material and Methods

The experiment was conducted during two consecutive *rabi* seasons of years 2019-20 and 2020-21, respectively at Agronomy Research Farm of the Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), situated at latitude of 26º47' North and longitude of 82º 12' East, with altitude of 113 meters above the mean sea level. The total rainfall of 189.4 and 0.0 mm were received during crop growing season of year, 2019-20 and 2020-21, respectively. The soil of the experimental field was silty loam in texture having slightly alkaline in reaction (pH 8.32& 8.36), low in organic carbon (0.31& 0.32%) and available nitrogen (189.5&185.0 kg ha^{-1}), but medium in available phosphorus (16.2& 16.0 kg ha^{-1}) and potassium (282.0& 284.0 kg ha^{-1}) during first and second year, respectively. Pusa-362 variety of chickpea was used for sowing of the experiment. Inoculation of bio-fertilizer and weed management were done as per treatment.

The experiment was laid out in split plot design with four bio-fertilizer treatments for seed inoculation *viz*., RDF (20 kg N, 50 kg P and 20 kg ha^{-1}), RDF + *Rhizobium* culture, RDF + PSB (Phosphorus Solubilizing Bacteria) and RDF + *Rhizobium* culture + PSB in main plot. Each main plot was further divided into four sub plots to accommodate sub plot treatments *i.e*. weed management practices comprising application of Pendimethalin @ 1.0 kg a.i. ha^{-1} as pre emergence, Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb* Imazethapyr 0.060 kg a.i. ha^{-1} as post emergence, Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb* clodinafop 0.060 kg a.i. ha^{-1} as post emergence, two hand weeding (25 and 50 DAS) and weedy check. Each main plot as well as sub plot were surrounded by a buffer of 1.0 m. All growth and quality characters were recorded with standard procedures. The data relating to each character were analyzed as per the procedure of analysis of variance and significance was tested by "F" test (Gomez and Gomez 1984) [8].

Results and Discussions

Effect of bio-fertilizers

Inoculation with bio-fertilizers influenced significantly almost all the growth parameters *viz*, plant height, number of main branches (plant^{-1}), number of lateral branches (plant^{-1}), number of nodules plant^{-1} and dry matter accumulation at harvest (Table 1 & 2). Application of RDF + *Rhizobium* culture + PSB recorded significantly higher values during both the experimental years for plant height (45.78 and 46.12 cm), number of main branches (7.51 and 7.54plant^{-1}), number of lateral branches (8.78 and 8.72 plant^{-1}), number of nodule (29.60 and 30.73 plant^{-1}) and dry matter accumulation (575.42 and 577.64g m^{-2}). Protein content was failed to reach the level of significance under inoculation with bio-fertilizers during both the years (Table 3). However, maximum protein content recorded with RDF + *Rhizobium* culture + PSB during both the years.

Increase in plant height and number of branches might be due to the inoculation of bio-fertilizers benefited the plant by providing atmospheric nitrogen and rendering the insoluble phosphorus into available form. The enhanced availability of phosphorus favored nitrogen fixation and rate of photosynthesis and consequently led to better plant height and number of branches. The results are in agreement with those reported Shiva Kumar *et al.* (2004) [17]; Rabieyan *et al.* (2011) [14]; Thenua and Sharma (2011) [20] and Gangwar and Dubey (2012) [5].

Increase in number of nodules could be ascribed to nitrogenase activity in the nodules reaches its maximum at 30 to 90 DAS. Almost similar findings were also reported by Meena *et al.* (2002) [11]; Giri and Joshi (2010) [7]; Mohammadi *et al.* (2010) [12]; Gangwar and Dubey (2012) [5]; Maya *et al.* (2012) [10] and Tagore *et al.* (2013) [19].

Dry matter accumulation was increased might be due to better growth of plants in terms of plant height and number of branches plant^{-1}, ultimately resulted in higher dry matter accumulation. Almost similar findings were reported by Mukherjee and Rai (2000) [13]; Shivakumar *et al.* (2004) [17]; Singh and Prasad (2008) [18]; Mohammadi *et al.* (2010) [12]; Thenua and Sharma (2011) [20]; Gangwar and Dubey (2012) [5] and Tagore *et al.* (2013) [19].

Effect of weed management

Two hand weeding (25 and 50 DAS) showed significantly higher values of growth characters *viz*., plant height, number of main branches (plant^{-1}), number of lateral branches (plant^{-1}), number of nodules plant^{-1} and dry matter accumulation at harvest (Table 1 & 2). In case of herbicidal treatments, application of Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb* clodinafop 0.060 kg a.i. ha^{-1} as post emergence noted significantly higher plant height (47.64 and 49.62 cm), number of main branches (6.93 and 7.10 plant^{-1}), number of lateral branches (7.95 and 7.95 plant^{-1}), number of nodule (26.65 and 26.74 plant^{-1}) and dry matter accumulation (528.58 and 531.63 g m^{-2}) during both the experimental years (Table 1-2). However, protein content was failed to reach the level of significance under weed management practices during both the years (Table 3). However, maximum protein content recorded under tow hand weeding during both the years.

Table 1: Effect of bio-fertilizer and weed management practices on plant height and number of branches plant^{-1} at harvest

Treatments	Plant height (cm)		Number of main branches plant^{-1}		Number of lateral branches plant^{-1}	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Bio-fertilizers (Main plot)						
RDF (20 kg N, 50 kg P and 20 kg K ha^{-1})	43.07	42.73	5.27	5.14	6.53	6.03
RDF + *Rhizobium* culture	44.25	44.38	6.85	6.97	7.96	7.68
RDF + PSB (Phosphorus Solubilizing Bacteria)	43.33	43.66	5.94	6.11	6.96	7.16
RDF + *Rhizobium* culture + PSB	45.78	46.12	7.51	7.84	8.78	8.72
SEm±	0.68	0.84	0.26	0.28	0.22	0.23
CD at 5%	2.12	2.57	0.79	0.81	0.68	0.71
Weed management (Sub-plot)						
Pendimethalin @ 1.0 kg a.i. ha^{-1} PE	40.04	41.13	6.41	6.51	7.55	7.41
Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb*Imazethapyr 0.060 kg a.i. ha^{-1} (POE)	41.74	43.05	6.67	6.78	7.77	7.69
Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb*clodinafop 0.060 kg a.i. ha^{-1} (POE)	47.64	49.62	6.93	7.10	7.95	7.95
Two hand weeding (25 and 50 DAS)	51.33	52.26	7.16	7.43	8.17	8.35
Weedy check	37.01	37.83	4.80	4.76	5.80	5.58
SEm±	0.66	0.66	0.12	0.13	0.11	0.11
CD at 5%	1.90	1.91	0.41	0.42	0.32	0.33

Table 2: Effect of bio-fertilizer and weed management practices on number of nodules plant^{-1}at 90 DASand dry matter accumulation at harvest

Treatments	Number of nodules plant^{-1}		Dry matter accumulation (g m^{-2})	
	2019-20	2020-21	2019-20	2020-21
Bio-fertilizers (Main plot)				
RDF (20 kg N, 50 kg P and 20 kg K ha^{-1})	15.04	14.93	373.58	375.34
RDF + *Rhizobium* culture	26.54	27.45	465.00	466.72
RDF + PSB (Phosphorus Solubilizing Bacteria)	24.78	25.22	496.75	509.96
RDF + *Rhizobium* culture + PSB	29.60	30.73	575.42	577.64
SEm±	1.03	1.17	15.26	15.86
CD at 5%	3.12	3.54	46.65	47.84
Weed management (Sub-plot)				
Pendimethalin @ 1.0 kg a.i. ha^{-1} PE	24.05	25.91	495.78	499.00
Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb*Imazethapyr 0.060 kg a.i. ha^{-1} (POE)	25.42	26.33	510.40	526.07
Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb*clodinafop 0.060 kg a.i. ha^{-1} (POE)	26.65	26.74	528.58	531.63
Two hand weeding (25 and 50 DAS)	27.05	27.19	541.28	541.30
Weedy check	16.77	16.74	312.40	314.08
SEm±	0.80	0.84	10.97	11.23
CD at 5%	2.45	2.52	33.17	34.12

Table 3: Effect of bio-fertilizer and weed management practices on protein content of chickpea

Treatments	Protein content (%)	
	2019-20	2020-21
Bio-fertilizers (Main plot)		
RDF (20 kg N, 50 kg P and 20 kg K ha^{-1})	20.43	20.44
RDF + *Rhizobium* culture	20.65	20.66
RDF + PSB (Phosphorus Solubilizing Bacteria)	20.87	20.89
RDF + *Rhizobium* culture + PSB	21.12	21.17
SEm±	0.9	0.69
CD at 5%	NS	NS
Weed management (Sub-plot)		
Pendimethalin @ 1.0 kg a.i. ha^{-1} PE	20.76	20.77
Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb*Imazethapyr 0.060 kg a.i. ha^{-1} (POE)	20.83	20.82
Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb*clodinafop 0.060 kg a.i. ha^{-1} (POE)	20.89	20.90
Two hand weeding (25 and 50 DAS)	20.95	20.96
Weedy check	20.43	20.42
SEm±	0.3	0.30
CD at 5%	NS	NS

Conclusions

From the above overall study, it is recommended that to obtain higher growth attributes and protein of chickpea crop should be grown by inoculation with RDF + *Rhizobium* culture + PS Balong with application of Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) *fb* clodinafop 0.060 kg a.i. ha^{-1} as post emergence under ago-climatic conditions of Ayodhya region of Eastern Uttar Pradesh.

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