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EFFECT OF DUAL BIO-INOCULANTS ON GROWTH, YIELD, ECONOMICS AND UPTAKE OF NUTRIENTS IN CHICKPEA GENOTYPES

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ABSTRACT

A field experiment was conducted during winter seasons of 2009-10 and 2010-11 Rewa (M. P.) to study the effect of dual bio-inoculants on growth, yield, economics and uptake of nutrients in chickpea genotypes. Amongst the chickpea genotypes, JG-130 gave maximum grain (27.04 q ha^{-1}) and straw yield (31.89 q ha^{-1}) with the net income of `. 92756 ha^{-1} followed by JG-11 and Vijay. However, the grain protein was highest (24.3 %) in Vijay genotype. Amongst the bio-inoculants, Rhizobium + phosphorus-solubilizing bacteria (PSB) recorded the highest grain (30.44 q ha^{-1}), straw (34.99 q ha^{-1}) yield and grain protein (24.4 %) with the highest net income of `.108079 ha^{-1}. The second best treatment was Rhizobium + Azotobacter. The yield and net income were further augmented when JG-130 was grown with Rhizobium + PSB. The uptake of N, P, K and S was significantly higher in grain and straw of JG-130 over JG-11 and Vijay. The nutrients uptake by grain and straw was significantly higher due to Rhizobium + PSB over the single bio-inoculants. The highest total nutrients uptake by chickpea, due to Rhizobium + PSB, was 151.4 kg N, 18.0 kg P, 71.9 kg K and 18.1 kg S ha^{-1}.

Key words: Chickpea genotypes, dual bio-inoculants, growth, yield, economics nutrients uptake

INTRODUCTION

Chickpea is one of the important pulse crop of Madhya Pradesh where serious efforts are being made to economize the productivity by growing recently developed well-promising varieties.Dual inoculation of bio-inoculants in legumes not only reduces the input of chemical fertilizers but also reduces the cost of the system itself in terms of photosynthetic drain. Positive effect of phosphorus-solubilizing bacteria (PSB) and plant growth promoting rhizobacteria (PGPR) on legume *Rhizobium* symbiosis is well documented for effective nodulation (Sarna *et al.*, 2008). Phosphorus is released in soil from inorganic compound due to local accumulation of lactic acid and action of H_2S developed by microbial metabolism. These organisms are known to produce amino acid, vitamins, growth promoting substances like IAA and gibberelic acid which helps better growth and yield.The combined inoculation increases the yield which may be due to the antagonistic interaction of PGPR with various soil borne pathogens or due to production of metabolites for plant growth by increasing nutrient ability which is reflected in grain yield. The non-symbiotic *Azotobacter* sp. provides positive influence on nodulation and N_2 fixing efficiency of *Rhizobium* in legumes (Sarna *et al.*, 2008). The beneficial effects of *A. chroococcum* are attributed to production of plant growth hormones, improved nutrient uptake and antagonistic effect on plant pathogens (Parmar and Dadarwal, 1997). Due to fertility variations in different soil types, the response of a certain chickpea genotype to different microbial sources of nutrients is highly inconsistent, location and even site specific. Since very little information is available on these aspects, the present research work was carried out using chickpea genotypes.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* seasons of 2009-10 and 2010-11 at the Agriculture-cum-Research Farm, Beenda-Semariya Road, Rewa (M.P.). The soil of the experimental field was clay-loam having pH 7.1, electrical conductivity 0.23 dS m^{-1}, organic carbon 5.8 g kg^{-1}, available N 248 kg ha^{-1}, available P_2O_5 14.1 kg ha^{-1}, available K_2O and 404 kg ha^{-1} and available S 13.0 kg ha^{-1}. The rainfall received during the winter months was 78.8 and 101.8 mm in 2009-10 and 1010-11. The treatments comprised three chickpea genotypes (JG-11, JG-130 and Vijay) in main plots and six bioinoculant treatments (control, *Rhizobium*, *Azotobacter*, phosphate-solubilizng bacteria (PSB), Rhiz. + Azoto. and Rhiz. + PSB) in the sub-plots. The experiment was laid out in split-plot design with three replications. Chickpea genotypes were sown on 16 October, 2009 and 24 October, 2010 @ 80 kg seed/ha at 30 cm row spacing. A uniform dose of 20 kg N and 50 kg P_2O_5 ha-^{1} was applied through diammonium phosphate and 20 kg S ha-^{1} through elemental sulphur as basal dose in all the treatments. Before sowing, the seed were inoculated with Rhizobium or Azotobacter biofertilizer using 20 g/kg

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seed, and during sowing PSB (phosphate-solubilizing bacteria) was applied in the same furrows @ 20 g/kg seed mixed with FYM as per treatments. The crop was grown as per recommended package of practices. The crop was harvested on 20 March, 2010 and 28 March, 2011. The chlorophyll content in leaves was estimated at 60 days stage by acetone extraction method (Witham *et al.*, 1971). The nitrogen content in grain was determined by Kjeldahl method (Jackson, 1973). The protein content in grain was obtained by multiplying the per cent N content in grain with 6.25. Grain and straw were digested in diacid (HNO_3 and $HClO_4$) mixture for estimation of P, K and S. Phosphorus was determined by molybdovanadate yellow colour method, K by flame photometer and S by turbidimetric method. The nutrients uptake was calculated by multiplying the grain or straw yield with the per cent nutrient content in grain or straw.

RESULTS AND DISCUSSION

Nodulation and physiological parameters

Amongst the chickpea genotypes, JG-130 recorded significantly higher root nodulation, dry matter production and chlorophyll content in leaves. This may be due to rapid plant growth and development of new leaves which proved photosynthetically more active. Thus, the increased photosynthetic surface (leaf area) induced competition for light and shadding of leaves. The significant differences in physiological parameters in different genotypes might be owing to their genetic variability (Rajput *et al.*, 2004). It is a natural phenomenon that the chlorophyll content in leaf tissue varies with species, age of plants and growth seasons. Increase in chlorophyll content with age of plants may be due to high magnesium and protein contents of leaves (Srivastava *et al.*, 2012).

Table 1: Root nodulation, chlorophyll content and yield parameters of chickpea as influenced by genotypes and bio-inoculants (Pooled for 2 years)

Treatments	Root nodules/ plant at 50 DAS	Dry weight of root nodules /plant (g)	Dry matter/ plant at 50 DAS (g)	Chlorophyll content (mg /g leaf weight) (95 DAS)	Pods/ plant	Seeds / pod	1000-seed weight (g)
Genotypes							
JG-11	23.7	0.47	1.59	0.15	60.6	1.1	260.5
JG-130	24.0	0.50	1.71	0.29	64.8	1.2	277.5
Vijay	17.0	0.48	1.62	0.228\	56.9	1.1	238.6
CD (P=0.05)	2.00	NS	0.11	0.04	2.34	0.019	1.64
Bio-inoculants							
Control	17.9	0.39	1.47	0.18	35.1	1.0	236.8
Rhizobium	20.4	0.51	1.63	0.21	56.9	1.2	262.5
Azotobacter	23.0	0.43	1055	0.20	60.6	1.1	252.6
PSB	20.9	0.45	1.62	0.22	62.9	1.1	259.1
Rhiz. + Azoto.	21.5	0.52	1.70	0.24	68.4	1.2	267.4
Rhiz. + PSB	25.6	0.59	1.84	0.27	80.7	1.3	274.7
CD (P=0.05)	1.07	0.02	0.11	0.03	1.34	0.015	1.08

The dual inoculation of Rhizobia plus P-solubilizing bacteria resulted in significantly higher root-nodulation (25.6 nodules/plant) and chlorophyll content (0.277 mg g^{-1} leaf weight) in leaves. The second best mixed inoculation was *Rhizobium* plus *Azotobacter* which appeared to have supplemented the growing plants with fixed N only as well as growth promoting substances. Positive effect of PSB and PGRP on legume *Rhizobium* symbiosis is well documented in early events of nodulation (Sarna *et al.*, 2008). The maximum chlorophyll content after multiple inoculation with R+Az+PGPR, was recorded followed by dual inoculation with R+Az Srinivasan *et al.* (1985) has reported a positive and significant correlation between photosynthesis and nitrogen fixation.

Yield-attributes and yield

The number of pods/plant, seeds/pod, 1000-seed weight and seed weight/plant were augmented significantly in JG-130 over other genotypes. The higher yield attributes of JG-130 may be owing to maximum increase in dry matter production as well as chlorophyll contents in leaves. The variation in these parameters among the genotypes is mainly due to the fact that such parameters are genetically governed (Shrivastava *et al.*, 2000; and Singh *et al.*, 2004). The grain yield was significantly higher (27.04 q ha^{-1}) in JG-130 over the remaining genotypes which may be due to higher yield attributes of this genotype. The productivity parameters are based on the cumulative effect of the genetic ability and production efficiency of the genotypes, their fertility management and the agro-climatic conditions. The best performance of JG-130 over others might be ascribed to its physiological role in synthesis and partitioning of the biomass (Patel *et al.*, 2012). The mixed inoculation of *Rhizobium* + PSB resulted in significant rise in all the yield-attributes over the other treatments. However,

Table 2: Yield and quality parameters and economical gain from chickpea as influenced by genotypes and bio-inoculants (Pooled for 2 years)

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	Net income (`. ha^{-1})	B:C ratio	Grain protein content (%)	Protein yield (kg ha^{-1})
Genotypes							
JG-11	24.06	30.02	44.59	79249	3.56	23.66	570.5
JG-130	27.04	31.89	45.85	92756	4.01	23.60	`640.0
Vijay	23.26	28.83	44.73	75574	3.44	24.36	567.3
CD (P=0.05)	0.28	0.30	NS	--	--	0.15	7.2
Bio-inoculants							
Control	19.73	23.54	45.67	60175	3.00	23.41	461.2
Rhizobium	24.81	29.74	45.54	82429	3.66	23.79	590.0
Azotobacter	23.37	29.66	44.05	75967	3.45	23.84	557.5
PSB	22.95	30.43	43.13	74108	3.39	23.57	540.4
Rhiz. + Azoto.	27.42	33.12	45.39	94400	4.05	24.16	662.1
Rhiz. + PSB	30.44	34.99	46.57	108079	4.48	24.47	744.5
CD (P=0.05)	0.23	0.24	1.21	-	-	0.14	6.2

the second best treatment was *Rhizobium* + *Azotobacter*. The higher yield attributes under these treatments might be due to increased growth and chlorophyll content in leaves as a result of increased microbial population and their biochemical activities as well as improved biological properties of the soil. All these favourable situations eventually brought about greater accumulation of carbohydrates, proteins and their translocation to the reproductive organs which in turn increased the yield components. Consequently the yield parameters were also found in the higher range in the above mentioned mixed bioinoculant treatments. These results are in close agreement with those of Verma *et al.* (2000), Tomar *et al.* (2001) and Zaidi *et al.* (2003).

Grain quality and net income

Amongst the genotypes, Vijay recorded significantly higher grain protein (24.36 %), however the protein yield and net income were found highest from JG-130 (640 kg ha^{-1} and Rs.92756 ha^{-1}, respectively). The higher grain protein in Vijay may be owing to the increased synthesis of protein through amino acids as a result of N-metabolism (Dwivedi and Bapat, 1998). The higher protein yield from JG-130 was due to its increased productivity. Similarly the highest net income was owing to the highest grain yield. Amongst the bio-inoculant treatments, *Rhizobium* + PSB recorded significantly higher grain protein (24.47%), protein yield (774.5 kg ha^{-1}) as well as net income (Rs.108079 ha^{-1}, followed by *Rhizobium* + *Azotobacter*. The response of dual biofertilizers in improving seed quality may be attributed to their significant role in regulating the photosynthesis, root enlargement and better microbial activities.

Uptake of nutrients

The uptake of N, P, K and S was, in general, higher in chickpea grain than in straw (Table 3). The nutrients uptake was significantly higher in JG-130, whereas lower uptake in case of JG-11 and Vijay genotypes. The significant variation in nutrients uptake by genotypes was in accordance with the similar variations in their nutrient content and grain yield. The leading role of JG-130 may be due to the fact that the larger part of these nutrients absorbed by the plant would have migrated into the seeds (Tiwari

Table 3: Nutrient uptake of chickpea as influenced by genotypes and bio-inoculants (Pooled for 2 years)

Treatments	Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})		Sulphur (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Genotypes								
JG-11	91.9	25.9	9.9	3.6	29.2	27.9	7.6	6.0
JG-130	102.4	28.3	11.5	4.1	33.3	30.1	9.0	6.8
Vijay	90.7	25.3	9.6	3.6	28.2	26.6	7.6	5.9
CD (P=0.05)	1.07	0.80	0.61	0.14	0.47	0.32	0.16	0.11
Bio-inoculants								
Control	73.8	19.9	7.7	2.5	22.5	21.4	6.0	4.2
Rhizobium	94.4	25.6	9.8	3.6	29.6	27.4	7.8	6.1
Azotobacter	90.4	25.6	9.7	3.7	28.5	27.5	7.6	5.7
PSB	86.5	26.5	9.8	3.9	28.0	28.3	7.5	6.4
Rhiz. + Azoto.	105.9	29.3	11.5	4.2	34.1	31.2	9.1	7.2
Rhiz. + PSB	119.1	32.3	13.3	4.7	38.6	33.3	10.3	7.8
CD (P=0.05)	1.01	0.64	0.48	0.12	0.37	0.28	0.14	0.12

et al., 2006).The impact of *Rhizobium* + PSB increased the nutrients uptake by chickpea biomass significantly over the remaining treatments. However, the second best treatment was *Rhizobium* + *Azotobacter*. *Rhizobium* + PSB producing a total removed of 151.43 kg N, 17.96 kg P, 71.91 kg K and 18.14 kg S ha^{-1}. The higher uptake of nutrients under different treatments might be owing to increased total biomass in these treatments. These results corroborate with those of Pathak *et al.* (2003), Singh *et al.* (2004), Sharma *et al.* (2006) and Singh *et al.* (2008). Under the present day of heavy crises of costly chemical fertilizers and deteriorating soil health, the addition of eco-friendly, renewable and cheaper biofertilizers would go a long way in bringing out efficient and economical utilization of chemical fertilizers. Chickpea var. JG-130 grown with *Rhizobium* + PSB recorded maximum grain yield and net income.

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