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Evaluation of chickpea varieties under compartmental bunding in rainfed situation

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ABSTRACT

Compartmental bunding (CB) and improved chickpea varieties were evaluated in ten farmers' fields during rainy-winter (*kharif-rabi*) seasons of 2012-13 in Vertisols at Bellary, India. Adopting improved chickpea varieties of BGD103 and JG11 during winter season increased the grain yields from 12.5 to 15.9%, respectively over locally cultivated A1 variety. The CB that was laid out during July (rainy season) conserved rainwater *in-situ* and further increased the grain yield of chickpea up to 36.7% in BGD103 and 43.9% in JG11. The increase in grain yield from 24.2% (JG11) to 27.8% (BGD103) indicates that CB is effective for *in-situ* rainwater conservation and improving profile soil moisture in Vertisols. However technology gap during study period was higher compared to extension gap and it was attributed to drought situation with only 81.2% of mean annual rainfall. Technology index was higher in this study and varied from 48.3% (Cultivation of BGD103 variety with CB) to 60.6% (Cultivation of JG11 variety without CB) indicating that technology index can be reduced and chickpea yields can be increased and sustained with adoption of improved chickpea production technologies including *in-situ* rainwater conservation practices at farmers fields. Correlation studies also indicate that grain weight, stover weight and total dry matter production per plant ultimately determine the chickpea grain and stover yields in the Vertisols of Bellary region during winter season. Higher gross and net returns with greater B:C ratio was observed with layout of farmers fields with CB and cultivation of JG11 variety.

Key words: Chickpea, Compartmental bunding, Varieties, Vertisols, Winter season.

INTRODUCTION

At global level, climate change impact has become a major concern and its impact felt in rainfed areas of Semi-Arid Tropical (SAT) region. In regional context, climate change has contributed to unpredictable or erratic rainfall pattern resulting in greater runoff, soil loss, including shift in sowing and harvesting period of crops thus leading to reduced yield of winter crops cultivated on residual soil moisture. Nearly 73% of the cropland in the world and about 60% of the cultivated area in India is rainfed and it contributes to 40% of total food production. In India about 93% of sorghum, 94% of pearlmillet, 79% of corn, 87% of pulses, 76% of oilseeds and 64% of cotton cultivated in drylands and it also foster major livestock production systems (Singh *et al.,* 2007; Somasundaram *et al.,* 2014). Building resilience in ecological systems to an optimum level is the best possible way to adapt to climatic variation (Sharma and Rai, 2012; Patil, 2013). In SAT region with low rainfall situations, adaptation to the climate change can reduce the vulnerabilities in agriculture (Chandrasekhara, 2009). Rainfed/dryland eco-system in India is characterized both by erratic rainfall and frequent droughts. In such situations, *in-situ* rainwater conservation can sustain crop yields in the region especially in the drought years with uneven rainfall distribution (Patil and Sheelavantar, 2004; Rao *et al*, 2007; Venkateswarlu and Shanker, 2009). Hence in rainfed areas, the *in-situ* rainwater harvesting through compartmental bunding assumes greater priority.

Pulses being cultivated in rainfed situation especially on scarce soil moisture during winter season with traditional varieties thus the productivity enhancement has remained a major challenge for several decades. The remarkable increase in area and productivity of pulses is not observed as it is witnessed in other commodities over the years. There are technological breakthroughs, which promise to raise the productivity, needs to be demonstrated at farmers' fields with their active participation that build confidence in new technologies. India produced 17.21 Mt of pulses from an area of 24.78 Mha (Nadarajan, 2013) and is projected to produce 32 Mt by 2030 to meet growing demand (Anonymous, 2011). In India about 80% of the total pulse production confined to Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh and Karnataka. However, about 3 Mt of pulses are imported annually to meet the domestic consumption requirement (Anonymous, 2011; Chaturvedi *et al.,* 2010). Chickpea is the major pulse crop cultivated during winter season in the Vertisols of south India.

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In India, chickpea was cultivated on 8.32 Mha and produced 7.50 Mt with productivity of 901 kg ha^{-1} during 2011-12. Adoption of improved varieties can enhance winter pulses productivity by 20 to 25% (Samra, 2009). Keeping in view of these situations, demonstrations were conducted to evaluate the effect of compartmental bunding and improved varieties of chickpea on crop productivity.

MATERIALS AND METHODS

To evaluate the performance of improved chickpea varieties under compartmental bunding (CB), a study was conducted during *kharif* (rainy)-*rabi* (winter) seasons of 2012–13 in ten farmers' fields in Joladarasi, K. Veerapur and Chellagurki villages of Bellary district in Karnataka, India. Land preparation started with medium tillage during second fortnight of February 2012 in all the ten selected farmers' fields. After first rains in the first week of July, all field were harrowed and in the second week, CB were laid out in one hectare area in each field for *in-situ* rainwater conservation using tractor mounted bund maker. The cross sectional area of CB was 0.06 m^2 with 0.3 m bottom and 0.1 m top width, 0.2 m height and 1:1 side slope. The size of smallest compartment that was laid out in the fields across the slope was 10 × 10 m which is designed to harvest rainwater from July to September. Demonstrations were conducted on Vertisols that were derived from granite, gneiss and schist. These soils are classified as Typic-Pellusterts. The infiltration rate of soils is low (<1.0 mm h^{-1}) with a bulk density ranging from 1.18 to 1.26 mg m^{-3} (Black, 1965). Soil pH varied from 8.0 to 8.5 and electrical conductivity of 0.11 dS m^{-1} (Piper, 1966). These soils are low in organic carbon (0.24% to 0.35%) (Piper, 1966) and available N (<250 kg ha^{-1}) (Subbiah and Asija, 1956). Soil available P is low to medium Jackson (1967) whereas available K was high, i.e., >500 kg as K_2O ha^{-1} (Muhr *et al.*, 1965).

This study is a continuation of our earlier study conducted at research farm wherein we evaluated chickpea varieties for their productivity Patil *et al.* (2014). Further our research findings recommended BGD103 variety for normal to above-normal rainfall years and JG11 variety for normal to drought years in Vertisols of northern dry zone of Karnataka, India. In view of this situation we selected BGD103 and JG11 varieties for evaluation in farmers' fields with adoption of *in-situ* rainwater conservation measure (CB) during rainy season along with local cultivar A1. During first week of September all farmers applied 2 to 5 t ha^{-1} of farmyard manure and sown three chickpea varieties from 5th to 10th October after 26.2 mm rainfall that fell from 27th September to 1st October, in lines at 30 × 10 cm spacing. BGD103 and JG11 seeds were treated with *Rhizobium* and *Trichoderma* prior to sowing whereas A1 seeds were sown without seed treatment. We observed only 80 to 85% germination and it was attributed to low soil moisture at sowing. The low rainfall of 63 and 11.8 mm that fell during September and October months respectively was only 51% and 13% of the mean monthly rainfall. Rainfall of 81.0 mm received during November was higher as compared to the mean monthly rainfall of 28.1 mm and it recharged the soil profile which supported better vegetative growth and produced 70% of the normal yields. Weeds were controlled through one hoeing at 20 days after sowing and one manual weeding. The recommended rate of N (25 kg ha^{-1}) and P_2O_5 (50 kg ha^{-1}) was applied at sowing. After 15 days of germination crop was applied with BHC powder to control sucking pests and later at 30 days after sowing (DAS) chickpea was sprayed once with Nuvacron and twice with Fame (45 and 60 DAS) to control *Helicoverpa*. Crop was harvested from 1 to 10 January 2013 at physiological maturity. Five randomly selected plants from three sites in each treatment were harvested and oven dried at 60^{o}C for 48 hours. Weight of plant estimated to compute total dry matter per plant. Standard procedures were used to measure the yield attributes and yield parameters of chickpea. The technology gap, extension gap and technology index were estimated using the following formula given below (Singh and Singh, 2013).

Technology gap = (Potential yield) - (Demonstration yield)

Extension gap = (Demonstration yield) - (Farmer's yield)

$$\text{Technology index} = \frac{\text{Pi} - \text{Di}}{\text{Pi}} \times 100$$

Where,

Pi=Potential yield of ith crop.

Di=Demonstration yield of ith crop.

Variables were analyzed and least significance difference (LSD) test was carried out for analyzed mean square errors using Web Based Agricultural Statistics Software Package (WASP 2.0) of ICAR Research Complex for Goa. Significance and non-significance difference between treatments was derived through procedure provides for a single LSD value (Gomez and Gomez, 1984). Correlation studies among the yield components of chickpea varieties was done using XLSTAT package.

RESULTS AND DISCUSSION

Rainfall and crop performance: The rainfall received during 2012 was 81.2%, (400.7 mm) of the normal mean annual rainfall (493.6 mm) for this region (Table 1). During 2012, crop was sown from 5-10th October after the antecedent rainfall of 26.2 mm received from 26th September to 1st October 2012. Crop season rainfall was only 81.2 mm that fell from 22nd October to 23rd November 2012 in six rainy days. Lower yields of chickpea (70% of normal) were attributed to lower annual rainfall and its ill distribution. Lower soil moisture in the top 45 cm soil profile at sowing resulted in 80-85% germination.

Yield and yield characters: Cultivation of improved varieties of chickpea increased the grain yield from 21.8%

(BGD103) to 29.9% (JG11) over A1 variety cultivated by the farmers in the region (Table 2). Samra (2009) also indicated that adoption of improved varieties in *rabi* pulses enhance productivity by 20 to 25%. Higher yields with improved varieties is attributed to better vegetative growth with greater total dry matter production and grain yield per plant over local variety (A1). Even the stover yields of improved varieties of JG11 and BGD103 was greater by 26% than A1 variety and it was attributed to better vegetative growth with higher dry matter accumulation per plant (Patil *et al.*, 2015).

It was also observed that the rainwater conservation through compartmental bunding has greater influence on chickpea productivity in the Vertisols of Bellary region. Increase in grain yield varied from 24.2% in JG11 to 27.8% in BGD103 with compartmental bunding indicating that the *in-situ* rainwater conserved during rainy season (July to September) improved soil moisture in the soil profile from sowing till harvest and produced better plants with greater dry matter accumulation thus resulting in higher grain yield of chickpea (Table 3). The study in Vertisols also indicated that CB was found to be effective in a low rainfall year probably because of impounding of rain water due to greater surface storage (Selvaraju *et al.*, 1999). The positive effects of moisture conservation practices like ridges and furrows and mulching on plant height and yield attributes of sorghum, cowpea, chickpea, chilli and sunflower have been earlier reported by Somasundaram *et. al.* (2000) and Allolli *et. al.* (2008).

Adopting BGD103 and JG11 varieties increased the chickpea yields from 12.5 to 15.9% over A1 variety (Table 4). These improved varieties BGD103 and JG11 were drought tolerant compared to the local A1 variety cultivated by the farmers and produced higher grain and stover yields. Varieties that were drought tolerant produced higher grain and stover yields even during a drought year (Lutfor Rahaman and Mesbah Uddin, 2000; Patil *et al.*, 2015). Further compartmental bunding increased the chickpea yields from 36.7% (BGD103) to 43.9% (JG11) over A1 variety with moisture conservation practice. Thus it is observed that *in-situ* rainwater conservation along with cultivation of improved chickpea varieties that are suitable for the region can increase yields up to 44% even under drought situations.

Table 1: Rainfall and its distribution at the farmers' fields during study period (2012–13)

Particulars	Year (2012)
Mean annual rainfall	493.6 mm
Annual rainfall during 2012 (mm)	400.7 mm
Percentage of mean annual rainfall during 2012	81.2
Antecedent rainfall (mm)	26.2 (26 September to 1 October 2012)
Crop season rainfall (mm)	89.8
Number of rainy days during 2012	30
Number of rainy days during cropping season	6
Date of sowing of chickpea varieties	5-10 October 2012
Date of harvest of chickpea varieties	1-10 January 2013

Table 2: Grain yield, straw yield, harvest index and yield components of chickpea varieties as influenced by compartmental bunding

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index	Grain yield per plant (g)	Stover yield per plant (g)	Total dry matter per plant (g)
CB JG11	1225	957	56.1	10.54	8.97	19.51
No CB JG11	986	763	56.3	8.62	7.32	15.95
CB BGD103	1163	910	56.0	10.41	8.64	19.05
No CB BGD103	957	761	55.6	8.40	7.31	15.71
Control	851	675	55.7	6.40	6.91	13.31
S.Em±	22.4	17.9	0.2	0.43	0.43	0.78
CD (P = 0.05)	64.3	51.5	NS	1.24	1.22	2.24

Table 3: Chickpea performance with conservation technology

Varieties	Productivity (kg ha^{-1})		Difference in Grain yield (kg ha^{-1})	Per cent increase
	With CB	Without CB		
JG11	986	1225	239	24.2
BGD103	910	1163	253	27.8
Mean	948	1194	246	25.9

Table 4: Chickpea performance with improved technology in the farmers' fields

Technology	Productivity (kg ha^{-1})	Difference in Grain yield (kg ha^{-1})	Per cent increase
Farmers practice (A1 variety without CB)	851	-	-
No CB JG11	986	135	15.9
CB JG11	1225	374	43.9
No CB BGD103	957	106	12.5
CB BGD103	1163	312	36.7

Greater yields with improved varieties and moisture conservation were attributed to better performance of improved varieties under higher moisture situations especially during drought years. Yield increase in different crops both during rainy and post-rainy season was greater during drought years compared to normal and above normal rainfall situations with moisture conservation practices. Thus it indicates importance of moisture conservation practices for sustenance of crop yields in the region during drought years (Singh, 2012). *In-situ* moisture conservation practices provide an advantage in conserving the rainfall in soil profile and reducing the runoff by better water percolation, providing more opportunity time for impounded water to infiltrate into the profile and produce less runoff (Patil and Sheelvantar, 2004; Meerasab and Guled, 2013).

Yield gaps: The technology gap was more and it varied from 1087 with cultivation of BGD103 with CB to as high as 1514 kg ha^{-1} with JG11 without CB (Table 5). Higher technology gap was attributed to a drought year with only 81.2% of average rainfall with its uneven distribution during 2012. The extension gap as compared to technology gap was smaller and varied from 106 to 374 kg ha^{-1}. The technology index varied from 51% (with CB) to 60.6% (without CB) in JG11 and 48.3% (with CB) to 57.5% (without CB) in BGD103. These results indicate that there is lot of scope to increase the chickpea yields with adoption of improved varieties and rainwater conservation measures in Vertisols of Bellary region thereby we can reduce the technology gap, extension gap and technology index (Singh and Singh, 2013). Higher values of technology gap and technology index are attributed to lower rainfall (400.7 mm) received during 2012 with its uneven distribution. These technology gap and technology index are generally reduced during normal to above normal rainfall years/situations. Even the variation with conservation measures among technology gap and technology index are reduced during normal to above normal rainfall years.

Correlation among growth and yield components: Straw yield per ha and per plant, harvest index, grain weight per plant and total dry matter production per plant were positively and significantly correlated with grain yield (Table 6). Similarly grain yield per plant was significantly and positively correlated with grain and stover yield per ha and stover yield per plant and total dry matter production per plant. This indicates that both vegetative and reproductive growth components contribute positively for higher grain and stover yield per ha with both rainwater conservation measures and cultivation of improved varieties of chickpea. The correlation results observed in this study corroborates the results of earlier studies recorded by Kumar *et al.* (2002) and Rao and Kumar (2000) in chickpea, in which seed yield was positively correlated with harvest index, pods/plant, biological yield and secondary branches/plant. These results indicate that seeds weight, stover weight and total dry matter per plant determine the grain and straw yields of chickpea during winter seasons in black soils of Bellary region in South India.

Economics: We found higher gross returns of Rs. 51854 ha^{-1} with more net returns of Rs. 23722 ha^{-1} and B:C ratio of 1.83 with CB laid out fields and cultivation of JG11 variety compared to lower gross, net returns and B:C ratio of Rs. 36062 ha^{-1}, Rs. 11097 ha^{-1} and 1.44, respectively with cultivation of A1 variety and farmers practice. Gross returns, net returns and B:C ratio were higher by 44, 114 and 27%

Table 5: Performance of chickpea varieties as influenced by compartmental bunding at farmers fields

Treatments	Potential yield (kg ha^{-1})	Demonstration yield (kg ha^{-1})	Control yield (kg ha^{-1})	Technology Gap Potential yield– Demonstration yield (kg ha^{-1})	Extension Gap Demonstration yield– Control yield (kg ha^{-1})	Technology index (%)
CB JG11	2500	1225	851	1275	374	51.0
No CB JG11	2500	986	851	1514	135	60.6
CB BGD103	2250	1163	851	1087	312	48.3
No CB BGD103	2250	957	851	1293	106	57.5

Table 6: Correlation studies for compartmental bunding and chickpea varieties in Vertisols

	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index	Grain weight per plant (g)	Stover yield per plant (g)	Total dry matter per plant (g)
Grain yield (kg ha^{-1})	1.000					
Stover yield (kg ha^{-1})	0.991**	1.000				
Harvest Index	0.547**	0.431**	1.000			
Grain weight per plant (g)	0.544**	0.567**	0.128	1.000		
Stover yield per plant (g)	0.335*	0.382**	-0.127	0.786**	1.000	
Total dry matter per plant (g)	0.479**	0.515**	0.019	0.959**	0.928**	1.000

* Non significance at 5% ** non significance at 1%

Table 7: Economics of chickpea cultivation under compartmental bunding in Vertisols

Treatments	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C Ratio
CB JG11	28133	51854	23722	1.83
No CB JG11	27059	39947	12889	1.47
CB BGD103	28171	49234	21064	1.74
No CB BGD103	26630	39947	13318	1.49
Control	24965	36062	11097	1.44
S.Em±	—	997	954	0.03
CD (P = 0.05)	—	2860	2735	0.09

with CB and cultivation of JG11 variety over traditional method of cultivation adopted by the farmers in the region. Formation of CB in the farmers fields during rainy season (June) was more profitable in conserving rainwater *in-situ* thus increasing gross returns by 31%, net returns by 80% and B:C ratio by 22% during a drought year indicating that all farmers in the Vertisol region of SAT in south India should adopt CB in their fields. Greater returns with improved method of cultivation of chickpea by farmers is attributed to higher grain and stover yields due to more soil moisture availability during crop growth period and it was efficiently utilized by JG11 variety and produced higher yields (Tables 2 and 7). Earlier studies at Bellary indicated that improved varieties of chickpea, i.e., JG11 and BGD103 produced higher yields during both drought and normal years over other varieties evaluated (Patil *et al.*, 2014 and 2015). Results of chickpea cultivation in the Thal desert of Pakistan during winter season was most profitable compared to the other pulses with a net returns of Rs. 21653 per ha and benefits: costs ratio of 2.46:1 (Shah *et al.*, 2007).

CONCLUSION

Farmers field studies conducted during rainy-winter (*kharif-rabi*) seasons of 2012-13 to evaluate the performance of CB and improved chickpea varieties indicate that layout of farmers' fields with CB during rainy season (June/July) conserves rainwater *in-situ* and improves the soil moisture availability in the soil profile thus helps in early sowing and higher moisture availability during winter season and produces greater chickpea yields. Further cultivation of improved varieties of chickpea, i.e., JG11 and BGD103 produces greater chickpea yields over local variety of A1. Lay out of farmers fields with CB and cultivation of JG11 chickpea variety produced greater gross returns, net returns and B:C ratio. In conclusion, it is advised to adopt CB to conserve rainwater *in-situ* and cultivate JG11 variety for ensuring sustainable chickpea productivity even during drought years when cultivated on residual soil moisture during winter season in the Vertisols of SAT region of south India for higher productivity and returns.

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