ISSN (Online): 2349-1183; ISSN (Print): 2349-9265
TROPICAL PLANT RESEARCH
The Journal of the Society for Tropical Plant Research
7(2): 472–475, 2020
DOI: 10.22271/tpr.2020.v7.i2.055

Research article

Response of chickpea (*Cicer arietinum* L.) to conservational agricultural practices for enhancing productivity under rainfed conditions in vertisols

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Abstract: Conservational agricultural practices involving tillage and crop residues retention were evaluated to enhance the productivity of chickpea during *rabi* in vertisols under rainfed conditions through field experiment conducted for four consecutive years (2015–16 to 2018–19) at Regional Agricultural Research Station, Nandyal, Andhra Pradesh. The investigation was carried out with three tillage methods (Conventional tillage - two harrowings + planking; Reduced tillage - one harrowing + planking and Zero tillage) and two types of crop residue (*kharif* sown foxtailmillet) retention (with crop residue retention @ 2.5 t ha^{-1} and without crop residue retention) and sown at spacing of 30 cm × 10 cm in split plot design replicated four times. Pooled analysis of experimental results indicated that significantly higher soil moisture was observed in zero tillage (23.1 % and 20.5 %) and crop residue retention @ 2.5 t ha^{-1} (22.7 % and 20.3 %) at 15 DAS and 30 DAS respectively. A significantly higher number of pods (25.0 plant^{-1}), seed yield (1192 kg ha^{-1}) and net returns of Rs 21,959 ha^{-1} was observed in conventional tillage and was at par with reduced tillage (22.7 plant $^{-1}$, 1127 kg ha^{-1} and Rs 21,088 ha^{-1} respectively). A significantly higher number of pods (25.3 plant^{-1}), seed yield (1222 kg ha^{-1}), net returns (Rs 22,268 ha^{-1}) with BCR of 1.76 was observed with crop residue retention @ 2.5 t ha^{-1}.
Keywords: Chickpea - Conventional tillage - Reduced tillage - Crop residue retention - Seed yield.

[Cite as: Basha SJ, Jayalakshmi V, Ahammed SK & Kamakshi N (2020) Response of chickpea (*Cicer arietinum* L.) to conservational agricultural practices for enhancing productivity under rainfed conditions in vertisols. *Tropical Plant Research* 7(2): 472–475]

INTRODUCTION

Conventional agriculture (CA) consists of zero/ minimum tillage, crop residue retention/ growing cover crops and adoption of suitable cropping systems, leads to reversal of the process of land degradation when practiced continuously through a significant reduction in runoff and soil loss (Castro *et al.* 1991) as well as improvement in soil physical, chemical and biological properties (Lal 2010). Conventional tillage (CT) addressed global food security challenges which holds much promise in managing agro-ecosystems for improved and sustained productivity, increased profits while preserving/enhancing the resource base and environment (Hobbs *et al.* 2008, Friedrich *et al.* 2012). The positive effects of improving crop yields are significant in dryland farming areas wherein no-till in combination with residue retention and crop rotation significantly increases crop productivity in dry climates, suggesting it might become an important strategy for adapting to climate-change in regions around the world as they become drier (Cameron *et al.* 2015). Among the countries in the world, India is the largest producer and consumer of chickpea. It is grown over an area of about 9.85 mha with a production of 10.32 m and a productivity of 1048 kg ha^{-1} (Directorate of economics and statistics 2019). In the present investigation, the effect of conventional agricultural practices involving tillage and crop residues retention was evaluated for enhancing the productivity of chickpea under rainfed conditions in vertisols of Andhra Pradesh.

Received: 11 April 2020 Published online: 31 August 2020
https://doi.org/10.22271/tpr.2020.v7.i2.055

MATERIAL AND METHODS

The experiment was conducted in chickpea during *rabi* at RARS, Nandyal (ANGRAU), Andhra Pradesh for four consecutive years (2015–16 to 2018–19) with three tillage methods (Conventional tillage - two harrowing + planking; Reduced tillage -one harrowing + planking and Zero tillage) applied in main plots and two types of crop residue (*kharif* sown foxtailmillet) retention (with crop residue retention @ 2.5 t ha^{-1} and without crop residue retention) were applied to sub plots and sown at spacing of 30 cm × 10 cm in split plot design with four replications. The chickpea variety sown was Nandyal Sanaga (NBeG 3). Crop residue @ 2.5 t ha^{-1} of short duration foxtailmillet grown preceeding to chickpea was retained as per treatment. All the recommended package of practices was adopted to raise chickpea. Soil samples were collected and soil moisture at different intervals was calculated by gravimetric method. Observations were recorded from five randomly selected plants from each treatment in each replication to estimate the growth and yield parameters. The data were recorded on soil moisture and quantitative traits such as plant height (cm), number of branches, days to 50% flowering, number of pods per plant, test weight (g) and seed yield (kg ha^{-1}) and the mean values of all the parameters were subjected to statistical analysis by adopting Fisher's method of analysis of variance at 5% level of significance as outlined by Gomez & Gomez (1984).

RESULTS AND DISCUSSION

Soil moisture

The pooled analysis of variance was significant for soil moisture, growth and yield parameters due to tillage methods and crop residue retention (Table 1). Tillage methods influenced the soil moisture at 15 DAS and 30 DAS. Significantly higher soil moisture (23.1 %) at 15 DAS and at 30 DAS (20.5%) was observed in zero tillage and was at par with reduced tillage (21.7% and 19.5% respectively). Significantly lower soil moisture (20.5% and 18.9%) was observed in conventional tillage at 15 DAS and 30 DAS respectively. Crop residue (*kharif* sown foxtailmillet) retention (@ 2.5 t ha^{-1}) influenced the soil moisture at 15 DAS and 30 DAS. Significantly higher soil moisture (22.7% and 20.3%) was observed with crop residue retention (@ 2.5 t ha^{-1}) at 15 DAS and 30 DAS respectively. Recent studies showed that conservational tillage was effective in increasing soil water content and water use efficiency and this positive effect was particularly evident in dry land areas or in drought years when compared to traditional tillage. It could be due to enhanced soil capacity for conserving water, increased water infiltration along with reduced run off and evaporation. Fan *et al.* (2014) found that no-tillage soil contained between 2.5% (vol/vol) more water in the top 0–30 cm than when using a moldboard plough. Chen *et al.* (2014) found that no-till with stubble retained had more water - stable aggregation.

Table 1. Soil moisture, growth parameters, seed yield and economics as influenced by tillage methods and crop residue retention.

Treatments	**Soil moisture (%) 15 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**Plant height (cm)**	**No. of branches/ plant**	**No of Pods/ plant**	**Test weight (cm)**	**Seed yield (kg ha^{-1})**	**Net returns (Rs ha^{-1})**	**BCR**
Tillage methods											
Conventional tillage	20.5	18.9	13.1	10.9	35.3	10.2	25.0	28.2	1192	21959	1.72
Reduced tillage	21.7	19.5	13.6	11.3	34.7	9.8	22.7	28.3	1127	21088	1.74
Zero tillage	23.1	20.5	14.3	11.8	34.1	9.5	21.0	27.8	1032	17897	1.65
S.Em±	0.3	0.4	0.5	0.3	0.6	0.5	0.9	0.8	46		
CD (P=0.05)	1.2	1.5	NS	NS	NS	NS	3.8	NS	142		
Crop residue retention (CRR)											
With CRR	22.7	20.3	13.9	11.5	35.1	10.3	25.3	28.3	1222	22268	1.76
Without CRR	20.8	19.0	13.4	11.1	34.3	9.4	20.5	28.0	1012	18373	1.65
S.Em±	0.3	0.3	0.2	0.2	0.4	0.4	1.1	0.6	52		
CD @ 5 %	0.9	0.9	NS	NS	NS	NS	3.6	NS	158		
Interactions	S	S	NS	NS	NS	NS	S	NS	S		

Growth parameters and seed yield

Different tillage methods did not significantly influence plant height, number of branches $plant^{-1}$ and test weight. Significantly higher number of pods (25.0 $plant^{-1}$) and seed yield (1192 kg ha^{-1}) was observed in conventional tillage and was at par with reduced tillage (22.7 $plant^{-1}$ and 1127 kg ha^{-1} respectively). Significantly lower pods (21.0 $plant^{-1}$) and seed yield (1032 kg ha^{-1}) was observed in zero tillage. The higher net returns (Rs 21,959 ha^{-1}) was observed in conventional tillage and higher benefit cost ration (BCR) of 1.74 was observed in reduced tillage. The number of branches $plant^{-1}$, days to 50% flowering and test weight did not influenced by crop residue retention. The results were in concurrence with the findings of Basha *et al.* (2018) in chickpea. Significantly higher number of pods (25.3 plant^{-1}), seed yield (1222 kg ha^{-1}), net returns (Rs 22,268 ha^{-1}) and BCR of 1.76 was observed with crop residue retention (@ 2.5 t ha^{-1}). This might be due to the conservation of moisture due to crop residue retention. Interaction effects of tillage methods and crop residue retention on soil moisture at 15 DAS and 30 DAS (Table 2) and the number of pods and seed yield (Table 3) was significant. Zero tillage with crop residue retention recorded higher soil moisture at 15 DAS (24.7 %) and at 30 DAS (19.7 %) whereas conventional tillage without crop residue retention recorded lower soil moisture at 15 DAS (21.8 %) and at 30 DAS (18.4 %). The higher number of pods (27.2 plant^{-1}) and seed yield (1286 kg ha^{-1}) was observed under conventional tillage with crop residue retention when compared to zero tillage without crop residue retention (18.0 plant^{-1} and 893 kg ha^{-1}). The management of crop residues can have direct and indirect effects on crop yield (Pittelkow *et al.* 2015). Crop residues that cover the soil act as physical barriers, making it less susceptible to the erosive action of raindrops and wind (Johnson *et al.*, 2016). Moreover, the maintenance of crop residues favors infiltration (Valim *et al.* 2016) and the storage of water in the soil (Tormena *et al.* 2017). In a climate change scenario, the maintenance of crop residues on the soil might increase the conservation of soil moisture and decrease the effects of droughts.

Table 2. Interaction effect of tillage methods and crop residue retention on soil moisture (%).

Tillage methods	At 15 DAS			At 30 DAS		
	With Crop residue retention	Without Crop residue retention	Mean	With Crop residue retention	Without crop residue retention	Mean
Conventional tillage	21.3	19.7	20.5	19.4	18.4	18.9
Reduced tillage	22.2	21.2	21.7	19.7	19.3	19.5
Zero tillage	24.7	21.5	23.1	21.8	19.2	20.5
Mean	22.7	20.8		20.3	19.0	
	S.Em±	CD @ 5 %		S.Em±	CD @ 5 %	
Tillage methods	0.3	1.2		0.4	1.5	
Crop residue retention	0.3	0.9		0.3	0.9	
Interactions	0.4	1.4		0.5	1.7	

Table 3. Interaction effect of tillage methods and crop residue retention on number of pods per plant and seed yield.

Tillage methods	No. of pods/plant			Seed yield (kg ha^{-1})		
	With Crop residue retention	Without Crop residue retention	Mean	With Crop residue retention	Without crop residue retention	Mean
Conventional tillage	27.2	22.8	25.0	1286	1097	1192
Reduced tillage	24.6	20.8	22.7	1209	1045	1127
Zero tillage	24.0	18.0	21.0	1171	893	1032
Mean	25.3	20.5		1222	1012	
	S.Em±	CD @ 5 %		S.Em±	CD @ 5 %	
Tillage methods	0.9	3.8		46	142	
Crop residue retention	1.1	3.6		52	158	
Interactions	1.2	4.1		62	211	

CONCLUSION

It could be concluded that conventional tillage with crop residue retention (@ 2.5 t ha^{-1}) could be effective for soil moisture conservation and higher seed yield and net returns. Increased soil moisture is necessary for the improvement in agricultural productivity in mature conventional tillage systems as compared to traditional tillage systems.

ACKNOWLEDGEMENTS

We are thankful to All India Co-ordinated Research Project (AICRP) on Chickpea and Regional Agricultural Research Station, Nandyal (ANGRAU), Andhra Pradesh for providing the facilities for conduct of the experiment.

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