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RESEARCH PAPER

Effect of conservation tillage and nutrient management practices on system productivity and economics of different crops under rainfed conditions of Karnataka

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Abstract: Field experiment was carried out on a fixed site during *kharif* and *rabi* seasons for four years at Main Agricultural Research Station, Dharwad to evaluate different conservation tillage and nutrient management practices on crop yields in three cropping systems. The results revealed that, no tillage with broad bed and furrow and crop residues retained on the surface (CT_1) and application of recommended dose of fertilizer+ farm yard manure) (NM_2) recorded significantly higher crop yields over other conservation and conventional tillage systems. With respect to system productivity CT_1 recorded significantly higher maize equivalent yield (8.98 t ha^{-1}) as compared to other tillage practices. Among the cropping systems, irrespective of tillage treatments, groundnut-sorghum cropping system recorded significantly higher system productivity (11.14 t ha^{-1}) over other cropping systems. Among the nutrient management practices, application of RDF+FYM recorded significantly higher maize equivalent yield over RDF alone (8.72 t ha^{-1} and 8.35 t ha^{-1}, respectively). The CT_3 was significantly superior with respect to net returns (₹ 77,625 ha^{-1}) over rest of the treatments. Among the interactions, no tillage with flatbed and crop residues retained on the surface with application of RDF alone in groundnut-sorghum cropping system ($CT_3CS_1NM_1$) recorded significantly higher net returns (₹ 1,23,277 ha^{-1}) over other interaction effects.

Key words*:* Conservation tillage, Cropping systems, Nutrient management, Residue cover

Introduction

Degradation of land under rainfed farming situation due to continuous erosion by water and wind, intensive mono cropping systems and bared soil surface have impoverished the soil, resulted in declined soil fertility, stress bearing capacity and crop productivity. Hence, more concentration was focused to develop sustainable agriculture production systems for efficient soil and natural resource management without affecting the environment. Conservation agriculture (CA) has emerged as an effective strategy to achieve goals of sustainable agriculture worldwide. It has the potential to address increasing concerns of serious and widespread problems of natural resource degradation and environmental pollution, while enhancing system productivity. In the world it is being practiced over an area of 120 million ha and found more sustainable under rainfed conditions (Singh and Meena, 2013). It seeks to conserve, improve and make more efficient use of natural resources through integrated management of soil, water, crops and other biological resources in combination with selected external inputs like fertilizers and organic manures. Such a technological package which is resource conserving and contributes for better environment and at the same time enhances production on a sustainable basis.

Conservation agriculture is based on the three principles mainly minimum soil disturbance, maintenance of crop residues on the soil surface and crop diversification. Other elements of conservation agriculture includes improved on-farm rain water management, organic soil cover, direct seeding through the crop residues and appropriate crop rotations to avoid disease and pest problems. When crop residues are retained on the soil surface in combination with no tillage or reduced tillage, it initiates processes that lead to improved soil quality and overall resource enhancement through greater ecological services. Conservation agriculture has emerged as a new paradigm to achieve sustainable agricultural production. In this context, the proposed study was carried out with an objective to evaluate the conservation tillage practices, cropping system and nutrient management practices for efficient utilization of natural resources and higher crop productivity and profitability.

Material and methods

Long term field studies were initiated on a fixed site during 2013-14 at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, and the results of the experiment conducted during *kharif* and *rabi* seasons of 2016-17 were considered for the present article. The studies to evaluate the different conservation tillage and nutrient management practices on crop productivity and profitability in different sequence cropping systems under rainfed conditions were carried out. The soil of the experimental site was *typic Haplustarts* having medium organic carbon content (5.2 g kg^{-1}), low in available nitrogen content (240.8 kg ha^{-1}), high in available phosphorus (26 kg ha^{-1}) and potassium (335 kg ha^{-1}). Data on rainfall distribution during cropping seasons is presented in Fig. 1. Well distribution of rainfall during *kharif* season ensured good crop stand, growth and yield. Whereas in *rabi* the rainfall distribution was erratic, hence, crops during different phenological stages suffered from moisture stress. The rainfall received during cropping period (June 2016 to March 2017) was 462 mm which was 28.7 per cent less than 65 years normal

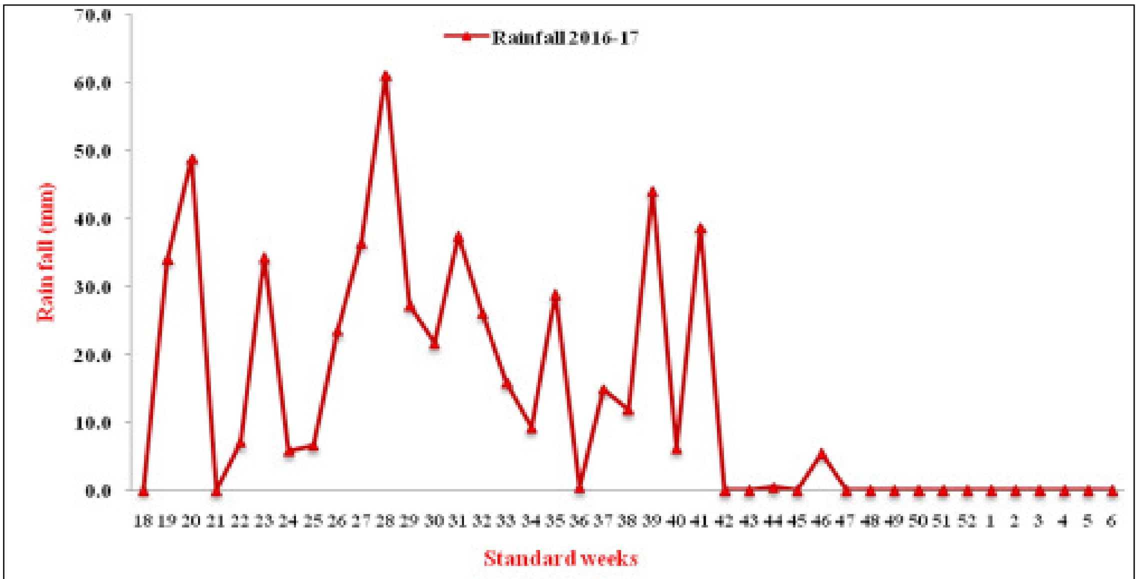

Fig.1 Standard week wise rainfall during cropping season

rainfall (643.2 mm) distributed in 47 rainy days during same period. Atmospheric temperature and relative humidity were normal and did not show any influence on crops.

The experiment was laid out in Strip-split block design with three replications. Main plots consisted of six vertical blocks mainly, CT_1: No tillage with Broad Bed and Furrow (BBF) and crop residues retained on the surface, CT_2: Reduced tillage with BBF and partially incorporation of crop residues, CT_3: No tillage with flat bed with crop residues retained on the surface, CT_4: Reduced tillage with flat bed with partially incorporation of crop residues, CT_5: Conventional tillage with crop residues incorporation and CT_6: Conventional tillage with no crop residues as control. Sub plots in horizontal blocks having three cropping systems in sequence, CS_1: Groundnut - sorghum, CS_2: Soybean - wheat and CS_3: Maize - chickpea, and two sub-sub plots NM_1: Recommended dose of fertilizer (RDF) and NM_2: RDF + Farm Yard Manure (FYM). Rotavator was passed in the standing crop stalk for shredding and partial incorporation of residues treatment plots and rotaslasher was passed to shred the residues and retain on the surface. In conventional tillage with crop residues incorporation plots, residues were incorporated at the time of ploughing and in no residues plots all the crop residues were removed after harvesting of both *kharif* and *rabi* crops and land was ploughed. In conservation tillage treatments, before sowing *kharif* crops, the weeds were killed by spraying contact herbicide paraquat @ 5 ml per litre of water. The BBF were prepared by passing plough at 210 cm distance by forming the furrows of 30 cm width and raised beds were formed with 180 cm top width. Seeds were treated with bio fertilizers on the day of sowing by *Rhizobium* and *PSB* and sowing was carried out using tractor drawn seed cum fertilizer drill. The RDF was applied @ 100:50:25; 25:50:25; 40:80:25; 50:25:0; 50;25:0 and 25:50:0 kg per ha N; P_2O_5 and K_2O for maize, groundnut, soybean, sorghum, wheat and chickpea respectively. FYM @ 7.5, 7.5, 6.0, 2.5, 6.0 and 5.0 t per ha was applied for maize, groundnut, soybean, sorghum, wheat and chickpea, respectively for the treatments having FYM before fifteen days of sowing for *kharif* crops and before one week for *rabi* crops. Pre-emergent herbicide Pendimethalin 35 EC @ 1 kg a.i. ha^{-1} was sprayed for all the treatments uniformly immediately after sowing to manage weeds. Observations on individual crop yields were recorded and the yield obtained from *kharif* and *rabi* crops were converted into maize equivalent yield (MEY) by multiplying yield with prevailing farm gate price of produce and divided by price of maize. Treatment wise cost of cultivation was calculated based on inputs cost, different variable cost items and labour charges at prevailing market prices during 2016-17.

$$\text{MEY (kg ha}^{-1}) = \frac{\text{Crop yield (kg ha}^{-1}) \text{ x Price of crop (q}^{-1})}{\text{Price of maize (q}^{-1})}$$

The data collected from the experimental field and laboratory analysis were subjected to statistical analysis. Standard statistical methods were used (Gomez and Gomez, 1984).

Results and discussion

All tillage and nutrient management practices showed significant influence on crop productivity of both *kharif* and *rabi* crops (Table 1). Among the tillage practices, no tillage with BBF and crop residue retained on the surface (CT_1) recorded significantly higher crop yields in all the crops as compared to rest of the tillage practices and it was at par with no tillage with flat bed and crop residues retained on the surface (CT_3). However, conventional tillage with no crop residues noticed significantly lower crop yield during both *kharif* and *rabi* seasons. Among the nutrient management practices, application of FYM along with inorganic fertilizers recorded significantly higher yield over without FYM.

The increase in yields with CT_1 and CT_3 was mainly due to increased growth and yield attributes in all the crops. Crop residue retention on the surface enhanced the soil moisture

Table 1. Yield of *kharif* and *rabi* crops obtained as influenced by different conservation tillage and nutrient management practices during 2016-17

Treatments	Groundnut ($kg\ ha^{-1}$)	Soybean ($kg\ ha^{-1}$)	Maize ($kg\ ha^{-1}$)	Sorghum ($kg\ ha^{-1}$)	Wheat ($kg\ ha^{-1}$)	Chickpea ($kg\ ha^{-1}$)
Tillage practices (CT)						
CT_1	3331^{a}	1968^{a}	7458^{ab}	1023^{a}	797^{a}	537a
CT_2	3215^{ab}	1881^{ab}	7178^{bc}	966^{b}	748^{ab}	502a-c
CT_3	3297^{ab}	1920^{ab}	7388^{ab}	1001^{ab}	775^{a}	520ab
CT_4	3184^{b}	1839^{b}	7083^{c}	957^{b}	730^{ab}	487bc
CT_5	3221^{ab}	1997^{a}	7542^{a}	900^{c}	695^{bc}	469cd
CT_6	2835^{c}	1640^{c}	6659^{d}	743^{d}	631^{c}	439d
S.Em.±	36.0	36.1	87.0	13.6	21.8	12.3
Nutrient management (NM)						
NM_1	3124^{b}	1818^{b}	7138^{b}	903^{b}	702^{b}	471b
NM_2	3237^{a}	1930^{a}	7298^{a}	961^{a}	757^{a}	514a
S.Em.±	6.2	1.0	1.6	3.0	1.9	1.8
Interactions (CT x NM)						
CT_1NM_1	3285^{c}	1916^{a-c}	7395^{d}	1002^{c}	779^{c}	520c
CT_1NM_2	3377^{a}	2019^{ab}	7521^{b}	1045^{a}	815^{a}	554a
CT_2NM_1	3168^{f}	1840^{b-d}	7112^{h}	945^{e}	730f	484ef
CT_2NM_2	3262^{d}	1922^{a-c}	7244^{f}	987^{d}	767^{cd}	521c
CT_3NM_1	3248^{d}	1875^{a-c}	7322^{e}	977^{d}	753^{de}	505d
CT_3NM_2	3347^{b}	1963^{a-c}	7454^{c}	1024^{b}	797^{b}	536b
CT_4NM_1	3142^{g}	1797^{cd}	7020^{i}	938^{e}	710^{g}	468g
CT_4NM_2	3226^{e}	1880^{a-d}	7146^{g}	976^{d}	750^{de}	505d
CT_5NM_1	3158^{fg}	1934^{a-c}	7456^{c}	864^{f}	655^{i}	442h
CT_5NM_2	3285^{c}	2060^{a}	7628^{a}	936^{e}	736^{j}	496de
CT_6NM_1	2744^{i}	1545^{e}	6525^{k}	691^{h}	584^{h}	406i
CT_6NM_2	2926^{h}	1734^{de}	6793^{j}	795^{g}	678^{g}	472fg
S.Em.±	7.0	4.6	9.3	4.0	5.3	3.9

Figures with same alphabet did not differ significantly at 5 % level of probability

Main plots

CT_1: No tillage with BBF and crop residues retained on the surface

CT_2: Reduced tillage with BBF and incorporation of crop residues

CT_3: No tillage with flat bed with crop residues retained on the surface

CT_4: Reduced tillage with flat bed with incorporation of crop residues

CT_5: Conventional tillage with crop residues incorporation

CT_6: Conventional tillage (no crop residues)

Sub plots

NM_1: RDF (Recommended dose of fertilizer)

NM_2: RDF + Farm Yard Manure

content which is one of the major limiting factors for crop production in rainfed areas. Residues retention on the surface reduced moisture losses by lowering evaporation and improved infiltration of rain water as indicated by higher soil moisture content values. Crop residues are the potential sources for crop nutrients and also help for soil carbon sequestration. Residue retention on the surface will alter microbial activity in the soil, slower decomposition occurs due to low surface area of crop residues available for microbes. It lead to slower and continuous release of nutrients in the soil which makes them available throughout the crop growth and also minimises nutrient losses as compared to crop residue incorporation where faster decomposition occurs and faster release of nutrients. No tillage has positive influence on soil physical and chemical properties.

The crop yields of groundnut, soybean, *rabi* sorghum, chickpea and wheat were converted into maize equivalent yield to interpret the response of cropping systems and presented in Table 2. Data on system productivity of groundnut-sorghum (CS_1), soybean-wheat (CS_2) and maize–chickpea (CS_3) cropping systems differed significantly as influenced by tillage and nutrient management practices. Significantly higher system productivity was observed with all conservation tillage systems as compared to conventional tillage with no crop residue incorporation (CT_6). Further, conventional tillage with crop residue incorporation (CT_5) was also found superior over CT_6. Among the tillage practices CT_1 was found superior over rest of tillage practices and recorded significantly higher maize equivalent yield (9.00 t ha^{-1}). Conventional tillage (CT_6) recorded lower system productivity (7.60 t ha^{-1}) as compared to CT_5 (8.70 t ha^{-1}) and all conservation tillage practices. Irrespective of tillage practices, groundnut-sorghum (CS_1) cropping system produced significantly higher system productivity (11.14 t ha^{-1}) as compared to soybean-wheat (CS_2) and maize-chickpea (CS_3) (5.13 and 9.33 t ha^{-1} respectively). Further, CS_3 recorded significantly higher system productivity over CS_2. Among the nutrient management practices, application of RDF along with FYM (NM_2) recorded significantly higher system productivity (8.72 t ha^{-1}) as compared to NM_1 (8.35 t ha^{-1}). The interaction $CT_1CS_1NM_2$ recorded significantly higher maize equivalent yield (11.92 t ha^{-1}) over rest of the combinations. Similar results were also reported by Usadadiya and Patel (2013) and they revealed that

Table 2. Maize equivalent yield and economics of sequence cropping systems as influenced by different conservation tillage and nutrient management practices during 2016-17

Treatment		Maize equivalent yield (t ha^{-1})			Net returns (₹ ha^{-1})			BC ratio		
Tillage practices (CT)		Nutrient management (NM)			Nutrient management (NM)			Nutrient management (NM)		
Cropping systems (CS)		NM_1	NM_2	Mean (CT)	NM_1	NM_2	Mean (CT)	NM_1	NM_2	Mean (CT)
CT_1	CS_1	11.57^{c}	11.92^{a}	8.98^{a}	120268^{b}	11463^{1e}	74417^{b}	3.88^{c}	3.19^{i}	2.51^{c}
	CS_2	5.31^{x}	5.58^{v}		28332^{w}	20167^{z}		1.62^{y}	1.35^{z}	
	CS_3	9.62^{m}	9.90^{k}		85886^{l}	77220^{p}		2.76^{n}	2.26^{s}	
CT_2	CS_1	11.12^{g}	11.48^{d}	8.60^{cd}	112969^{f}	107439^{i}	68090^{d}	3.64^{e}	3.02^{k}	2.36^{d}
	CS_2	5.06^{z}	5.30^{x}		23859^{y}	15146^{z}		1.51^{z}	1.26^{z}	
	CS_3	9.19^{q}	9.48^{n}		78769^{o}	70357^{s}		2.58^{p}	2.13^{u}	
CT_3	CS_1	11.42^{e}	11.80^{b}	8.84^{b}	123277^{a}	118049^{c}	77625^{a}	4.37^{a}	3.51^{f}	2.76^{a}
	CS_2	5.18^{y}	5.44^{w}		31638^{v}	23299^{y}		1.77^{w}	1.44^{z}	
	CS_3	9.50^{n}	9.75^{l}		89140^{k}	80348^{n}		3.04^{k}	2.43^{r}	
CT_4	CS_1	11.03^{h}	11.35^{f}	8.47^{d}	116859^{d}	110835^{g}	71426^{c}	4.11^{b}	3.30^{g}	2.59^{b}
	CS_2	4.94^{z}	5.18^{y}		27295^{x}	18676^{z}		1.65^{x}	1.35^{z}	
	CS_3	9.03^{r}	9.31^{p}		81727^{m}	73166^{r}		2.83^{l}	2.28^{s}	
CT_5	CS_1	10.95^{i}	11.46^{de}	8.68^{c}	112997^{f}	109573^{h}	71112^{c}	3.80^{d}	3.15^{j}	2.47^{c}
	CS_2	5.09^{z}	5.50^{v}		26689^{x}	20430^{z}		1.60^{y}	1.36^{z}	
	CS_3	9.35^{p}	9.75^{l}		81928^{m}	75056^{q}		2.67^{o}	2.22^{t}	
CT_6	CS_1	9.42^{o}	10.14^{l}	7.60^{e}	97684^{j}	97808^{q}	59216^{e}	3.27^{h}	2.79^{m}	2.19^{e}
	CS_2	4.19^{z}	4.75^{z}		17444^{j}	13697^{j}		1.32^{z}	1.18^{z}	
	CS_3	8.27^{s}	8.82^{t}		66719^{t}	61946^{u}		2.47^{q}	2.10^{v}	
Mean (NM)		8.35^{b}	8.72^{a}		73527^{a}	67102^{b}		2.72^{a}	2.24^{b}	
Mean (CS)										
CS_1				11.14^{a}			111866^{a}			3.50^{a}
CS_2				5.13^{c}			22223^{c}			1.45^{c}
CS_3				9.33^{b}			76855^{b}			2.48^{b}
Sources				S.Em.±			S.Em.±			S.Em.±
CT				0.042			589			0.01
CS				0.029			410			0.01
NM				0.005			63			0.002
CT × CS × NM				0.0019			268			0.01

Figures with same alphabet did not differ significantly at 5 % level of probability

Main plots

CT_1: No tillage with BBF and crop residues retained on the surface

CT_2: Reduced tillage with BBF and incorporation of crop residues

CT_3: No tillage with flat bed with crop residues retained on the surface

CT_4: Reduced tillage with flat bed with incorporation of crop residues

CT_5: Conventional tillage with crop residues incorporation

CT_6: Conventional tillage (no crop residues)

Sub plots

CS_1: Groundnut - Sorghum

CS_2: Soybean - Wheat

CS_3: Maize - Chickpea

Sub-sub plots

NM_1: RDF (Recommended doses of fertilizer)

NM_2: RDF + Farm Yard Manure

application of inorganic fertilizers along with FYM increased wheat grain yield by 4.9 per cent over inorganic fertilizer alone. These results are in accordance with the earlier findings of Sepat and Rana (2013), who found that permanent beds with crop residues retained on the surface gave 25 per cent higher maize grain yield and 28.6 per cent of higher wheat yield as compared to conventional tillage with flat bed. Further, permanent beds with crop residue retained on the surface gave 3.5 per cent higher system productivity as compared to fresh beds with crop residue incorporation. Increase in crop yields under conservation agriculture plots are also reported by Ghuman and Sur (2001), Aulakh *et al.* (2012) and Thierfelder *et al.* (2013).

Increase in maize equivalent yield in CS_1 was mainly attributed to higher groundnut yield during *kharif* and sorghum yield during *rabi* and also good market price for both the crops as compared to rest of the crops. Even though CS_3 is a potential cropping system in this region because of lower rainfall during *kharif* maize yields were decreased, hence lower system productivity was noticed.

Higher system productivity in CT_1 might be due to better conservation of rain water, improved soil aeration and high root proliferation could help the crops for better growth and higher yield (Choudhary and Kumar, 2014). In case of minimum/ no tillage, along with crop residues application influenced positively on soil physical properties mainly bulk density, aggregate stability and water holding capacity (WHC). Decomposition of crop residues favored the crops by improving soil organic carbon (OC) and microbial activity in turn influenced nutrient transformation and their availability (Singh and Sharma, 2005; Narayan and Lal, 2009). Lower yields with conventional tillage might be attributed to degradation of soil physical, chemical and biological properties mainly lower organic carbon and nutrient stratification in the soil, destruction of soil structure and lower WHC of the soil. Similar findings were also reported by Hati *et* *al.* (2014), who observed 9.2 per cent increased soil organic carbon stock in no tillage as compared to conventional tillage.

With respect to economics, CT_3 was found superior over all tillage systems and recorded significantly higher net returns and BC ratio (₹ 77625 ha^{-1} and 2.7, respectively) and followed by CT_1 (₹ 74417 ha^{-1} and 2.51, respectively). Among the conventional tillage treatments CT_5 (₹ 71112 ha^{-1} and 2.47, respectively) was significantly superior over CT_6 (₹ 59216 ha^{-1} and 2.19, respectively). Even though CT_1 recorded significantly higher yield, due to increased cost of cultivation for BBF preparation during both the seasons resulted in lower net returns as compared to flat bed. Among the cropping systems net returns and BC ratio were significantly higher in CS_1 (₹ 111866 ha^{-1} and 3.5) as compared to CS_2 (₹ 22223 and 1.45) and CS_3 (₹ 76855 ha^{-1} and 2.48, respectively). Among the nutrient management practices NM_1 showed significantly higher economics with respect to net returns and BC ratio (₹ 73527 ha^{-1} and 2.72, respectively) as compared to NM_2 (₹ 67102 ha^{-1} and 2.24, respectively). The lower net returns might be due to increased cost of FYM as compared to yield improvement indicating the addition of FYM was had little effect on crop yield and that can be substituted by crop residue retention or incorporation in the system continuously. With respect to economics these results are in accordance with the findings of Thakur *et al.* (2011); Cociu and Cizmas, (2013); Das *et al.* (2014), Sepat and Rana (2013); Jat *et al.* (2014) and Sekar *et al.* (2015). They revealed that increased net returns and BC ratio in conservation tillage was mainly due to reduced fuel burning by reducing tillage intensity and increased crop yields.

Conclusion

Significantly higher system productivity was observed with no tillage with BBF and crop residues retained on the surface, followed by no tillage with flat bed and crop residues retained on the surface as compared to conventional tillage with no crop residues. Application of RDF of crops along with FYM in all the cropping systems produced significantly higher productivity over conventional tillage with application of RDF alone. Groundnut-sorghum cropping system was found to be more productive and profitable as compared to soybean-wheat and maize-chickpea.

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