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Research Article

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Effect of Conservation Tillage Systems and Nutrient Management Practices on Productivity and Economics of Crops in Different Crop Sequences under Rainfed Conditions

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ABSTRACT

Field studies were carried out during third year of the fixed site in kharif and rabi seasons of 2015-16 at MARS, Dharwad to evaluate different conservation tillage systems and nutrient management practices on crop yields in three sequence cropping systems. No tillage with BBF and FB, crop residues retained on the surface and application of inorganic fertilizers along with FYM (CT_1NM_2 and CT_3NM_2) were recorded significantly higher yields in all the cropping systems in both the seasons over other treatments and conventional tillage systems. With respect to system productivity CT_1 and CT_3 recorded significantly higher maize equivalent yield (7914 and 7786 kg ha^{-1}) as compared to other tillage practices. With respect to cropping systems groundnut followed by sorghum has recorded higher productivity over rest (9575 kg ha^{-1}). Between the nutrient management application of RDF along with FYM found significantly superior over RDF alone (7629 and 7266 kg ha^{-1} respectively). CT_3 found significantly superior with respect to net returns over rest of the treatments (₹60654 ha^{-1}). Among the interactions $CT_1CS_1NM_1$ recorded significantly higher net returns (₹ 95777 ha^{-1}) and found superior over other interactions.

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

INTRODUCTION

Degradation of land under rainfed farming situation due to continuous erosion by water and wind, intensive mono cropping systems and bared soil surface has 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 on farm management of soil and natural resource efficiently 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.

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In the world it is being practiced over an area of 120 million ha and found more sustainable under rainfed conditions[12]. 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 represents a resource saving and efficient agriculture that contributes to environmental conservation and at the same time enhances production on a sustainable basis.

This 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 include improved on-farm water management, organic soil cover, direct seeding through the crop residue 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. CA has emerged as a new paradigm to achieve sustainable agricultural production. In this context, the proposed study aims to evaluate the conservation agriculture practices on efficient utilization of natural resources and crop productivity and profitability.

MATERIAL AND METHODS

Long term field studies were initiated on a fixed site during 2013-14 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, and the results of the year 2015-16 conducted during *kharif* and *rabi* seasons 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}), medium in available phosphorus (26 kg ha^{-1}) and high in available potassium (335 kg ha^{-1}). Data on weather conditions during cropping seasons was presented in Fig. 1. The distribution of rainfall in the cropping period was erratic, hence crops suffered from moisture stress during different phenological stages. The annual rainfall received during 2015-16 cropping season was 621.0 mm distributed in 42 rainy days. It was 14 per cent lower than the average rainfall of 65 years (715.3 mm). The rainfall received during cropping period (June-2015 to March-2016) was 471.2 mm which was 26.7 percent lesser than 65 years normal (643.2 mm) distributed in 32 rainy days during same period. Atmospheric temperature was higher than normal average but it does not affect crop growth and relative humidity also did not show any influence on crops.

The experiment was laid out in strip-split block design with three replications. Main plots consist of six vertical blocks mainly, CT_1: No tillage with 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: RDF (Recommended dose of fertilizer) and NM_2: RDF + FYM (Farm Yard Manure). Rotavator was passed in the standing crop stalk for shredding and partial incorporation of residue treatment plots and to shred the residues and retention on the surface rotaslasher was passed, in conventional tillage with crop residue incorporation plots residues were incorporated at the time of ploughing where as in no residue plots all the crop residues were removed after the harvesting and land was ploughed. Before kharif crop sowing in conservation tillage treatment the weeds were killed by spraying the contact herbicide paraquat @ 5ml l^{-1} of water. 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 for all the treatments as per the recommendation where as FYM was applied as per the treatments before fifteen days of sowing for kharif crops and before one week for *rabi* crops. Pre-emergent herbicide was sprayed for all the treatments uniformly 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 2015-16.

$$\text{MEY (kg ha}^{-1}\text{)} = \text{Maize grain yield (kg ha}^{-1}\text{)} \times \frac{\text{crop yield (kg ha}^{-1}\text{)} \times \text{Price of crop}}{\text{Price of maize}}$$

RESULTS AND DISCUSSION

Crop yields of both kharif and rabi seasons were represented in table 1. All tillage and nutrient management practices showed significant influence on crop productivity. All the conservation tillage practices found superior over conventional tillage practices. Among all 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 on 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. Between the nutrient management practices application of FYM along with inorganic fertilizers recorded significantly higher yield over without FYM.

This increased yields in CT_1 and CT_3 was mainly due to increased growth and yield attributes in all the crops. Crop residue retention on the surface may influenced the soil moisture content which is one of the main limiting sources for crop production in rainfed conditions. It reduces moisture losses by reducing evaporation and improves infiltration. 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 which leads to slower and continuous release of nutrients in the soil which makes nutrient available throughout the crop growth and also minimises nutrient losses in the soil as compared to crop residue incorporation where faster decomposition occurs and faster release of nutrients. Residue retention for longer duration also increases soil organic carbon content, and favours more microbial activity by altering good soil temperature and microclimatic conditions and helps to reduce loss of top fertile soil by erosion. Where as in case of no residue treatment soil may prone to moisture losses due to more evaporation which affects crop growth. No tillage has positive influence on soil physical and chemical properties. Minimum or reduced soil disturbance helps in build-up of soil structure and aggregation, repeated cultivation of soils may partially improve soil conditions favourable for crops but in long term use, will degrade physical conditions of soil by affecting the structure and aggregation. Soil organic carbon and nutrient losses are more in repeated tillage due to photo decomposition and volatilisation which can be minimised by reducing tillage intensity. These results are in accordance with the earlier findings of Sepat and Rana[10], they found 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 Thierfelder *et al*[14].; Ghuman and Sur[5],; Aulakh *et al*[2].

The crop yields of groundnut, soybean, *rabi* sorghum, chickpea and wheat were converted in to maize equivalent yield (MEY) 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) also found superior over CT_6. Among the tillage practices CT_1 and CT_3 found superior over rest of tillage practices and recorded significantly higher maize equivalent yield (7914 and 7786 kg ha^{-1} respectively) however in CT_6 lower yields were observed (6697 kg ha^{-1}) as compared to CT_5 (7251 kg ha^{-1}) and all conservation tillage practices. Irrespective of tillage practices groundnut-sorghum (CS_1) produced significantly higher crop productivity (9575 kg ha^{-1}) as compared to soybean-wheat (CS_2) and maize-chickpea (CS_3) (6646 and 6122 kg ha^{-1} respectively), and which CS_2 differed significantly with each other as compared to CS_3. Between the nutrient management practices application of RDF along with FYM (NM_2) recorded significantly higher system productivity (7629 kg ha^{-1}) as compared to NM_1 (7266 kg ha^{-1}). Among the interactions $CT_1CS_1NM_2$ recorded significantly higher maize equivalent yield (10269 kg ha^{-1}) over rest of the combinations. Similar results were also found by Usadadiya and Patel[15], they revealed that application of inorganic fertilizers along with FYM has increased wheat grain yield by 4.9 percent over inorganic fertilizer alone.

Increased maize equivalent yield in CS_1 was mainly because of higher groundnut yield in *kharif* and sorghum yield in *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 lesser *kharif* rainfall maize yields were decreased hence lower system productivity has recorded.

Higher system productivity in CT_1 and CT_3 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[3]. In case of conservation tillage treatments minimum/ no soil disturbance along with crop residues application influenced positively on soil physical properties mainly bulk density, aggregate stability, water holding capacity (WHC) *etc*. and decomposition of crop residues favored the crops by improving soil organic carbon (OC) and microbial activity in turn influenced on nutrient transformation and availability[3,8,11]. Lower yields with conventional tillage plot may 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*[6]., after three experimental years, they found 9.2 per cent increased soil organic carbon stock in no tillage as compared to conventional tillage. Similarly, nutrient stratification in conservation tillage practice was also recorded by many authors. Stratified nutrients especially in 0-15 cm surface soil may be attributed to steady supply of nutrients to crops throughout growing period which enhanced better crop growth and yield parameters as compared to conventional tillage practices.

However with respect to economics CT_3 found superior over all tillage systems and recorded significantly higher net returns and B-C ratio (₹ 60654 ha^{-1} and 2.3) and CT_1 and CT_4 were next best (₹57279 and 55066 ha^{-1}, 2.10 and 2.15 respectively) treatments. Between the conventional tillage treatments CT_5 was significantly superior over CT_6 (₹ 44696 and 36945 ha^{-1}, 1.83 and 1.68 respectively). Even though CT_1 recorded significantly higher yield, due to increased cost of cultivation for BBF preparation in both the seasons has reduced net returns as compared to flat bed. Among the cropping systems net returns and B-C ratio were significantly higher in CS_1 (₹ 82696 ha^{-1} and 2.65) as compared to CS_2 and CS_3 (₹ 41623 and 28818 ha^{-1}, 1.84 and 1.54 respectively). Between the nutrient management NM_1 found significantly higher economics with respect to net returns and B-C ratio (₹ 54335 ha^{-1} and 2.18) as compared to NM_2 (₹ 47757 ha^{-1} and 1.83), this 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 Anup Das *et al*[1].,; Cociu and Cizmas[4],; Sepat and Rana[10],; Thakur *et al*[13].,; Jat *et al*[7].,; Sekar *et al*[9]. They revealed that increased net returns and B-C ration in conservation tillage is mainly due to the reduced fuel burning by reducing tillage intensity, increased crop yields.

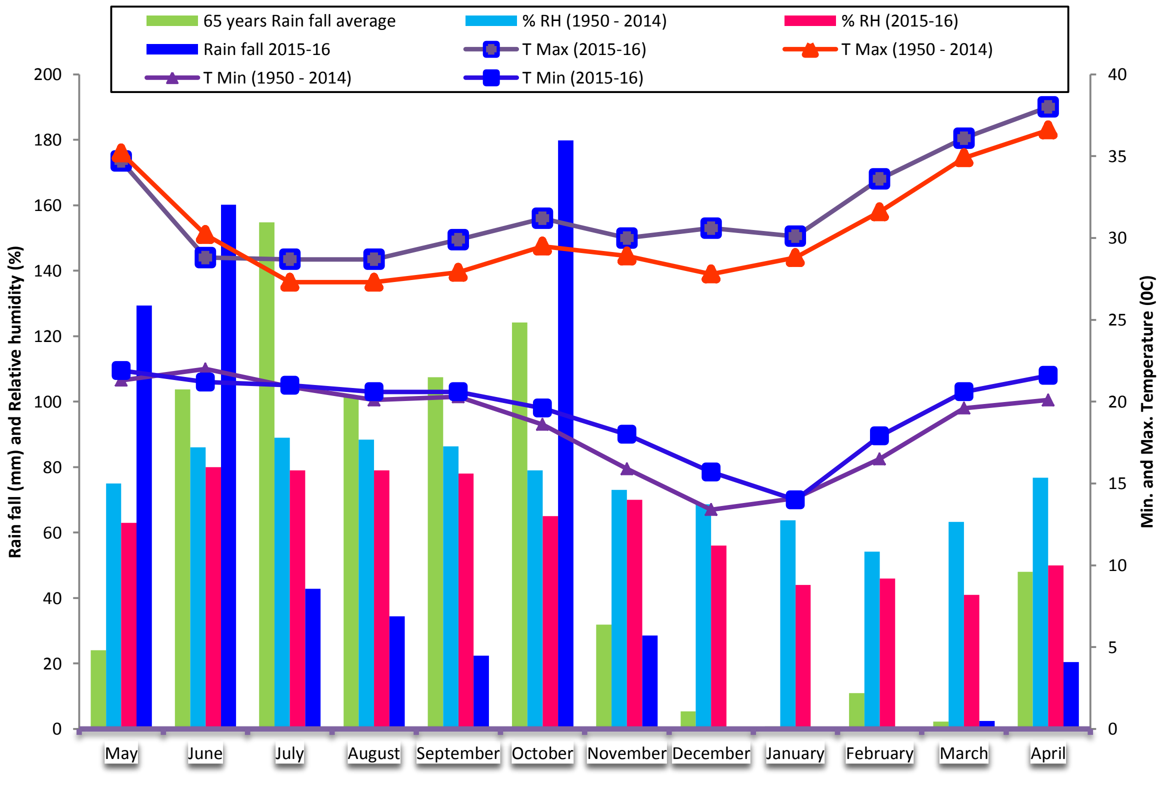

Fig. 1: Mean monthly mateorological data for the experimental year (2015-16) and the mean ofpast 65 years (1950-2014) at Main Agricultural Research Station, UAS, Dharwad

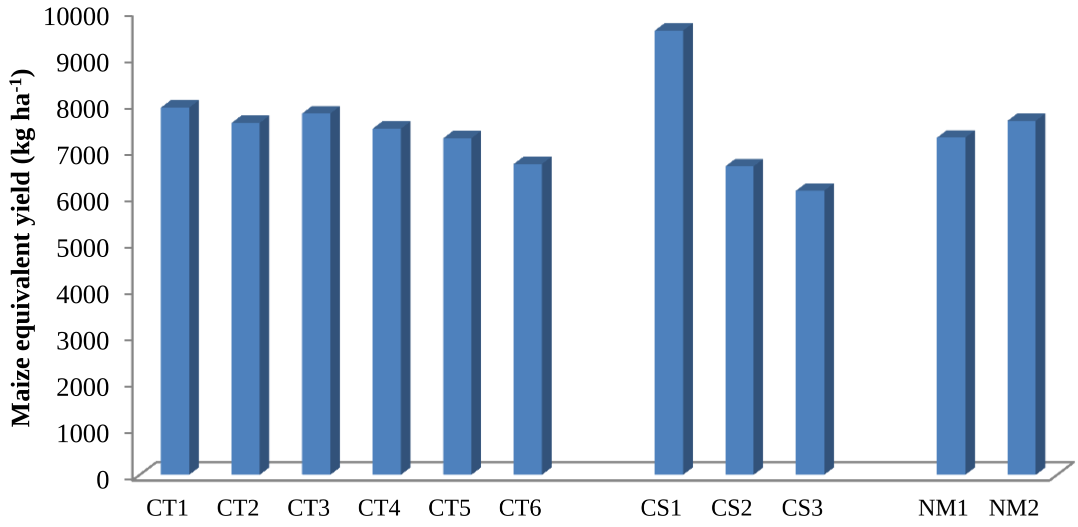

Fig. 2: Maize equivalent yield (kg ha^{-1}) as influenced by conservation tillage, sequence cropping systems and nutrient management practices

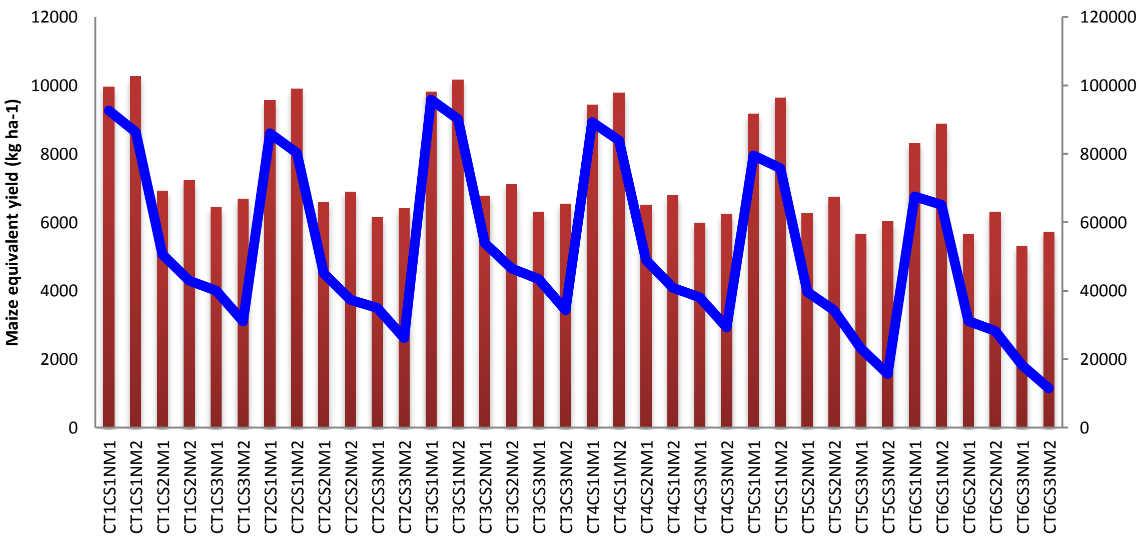

Fig. 3 Interaction effects of tillage, cropping systems and nutrient management practices on system productivity

Table 1: Yield of *kharif* and *rabi* crops (kg ha^{-1}) obtained as influenced by different conservation tillage and nutrient management practices during 2015-16

Treatment	Groundnut	Soybean	Maize	Sorghum	Wheat	Chickpea
Tillage practices	**dry pod (kg ha^{-1})**	**(kg ha^{-1})**	**(kg ha^{-1})**	**(kg ha^{-1})**	**(kg ha^{-1})**	**(kg ha^{-1})**
CT_1	2432a	1423a	3318a	1893a	1862a	1394a
CT_2	2352ab	1344bc	3152a-c	1804bc	1788ab	1344a
CT_3	2403ab	1394ab	3251ab	1869ab	1831ab	1365a
CT_4	2322ab	1323c	3080bc	1780c	1762ab	1310a
CT_5	2261b	1290c	3003cd	1760c	1730b	1224b
CT_6	2111c	1229d	2797d	1542d	1551c	1172b
S.Em ±	46.6	17.9	67.6	23.4	35.5	25.9
Nutrient management						
NM_1	2264b	1286b	3045b	1739b	1710b	1261b
NM_2	2363a	1381a	3155a	1810a	1798a	1342a
S.Em ±	2.0	4.3	2.6	2.4	5.2	2.3
Interactions (CT X NM)						
CT_1NM_1	2390c	1386c	3270c	1872b	1827c	1361d
CT_1NM_2	2473a	1459a	3367a	1914a	1897a	1427a
CT_2NM_1	2311e	1300e	3100f	1770e	1760e	1309g
CT_2NM_2	2392c	1387c	3203d	1837c	1816cd	1379c
CT_3NM_1	2358d	1354d	3208d	1841c	1794d	1332f
CT_3NM_2	2448b	1434b	3294b	1897a	1869b	1399b
CT_4NM_1	2275f	1286e	3032h	1752f	1734f	1274h
CT_4NM_2	2370d	1360d	3127e	1808d	1790d	1346e
CT_5NM_1	2205g	1243f	2937i	1712g	1665g	1176j
CT_5NM_2	2317e	1337d	3070g	1807d	1794d	1272h
CT_6NM_1	2043i	1148g	2723k	1487i	1481i	1115k
CT_6NM_2	2179h	1311e	2870j	1597h	1620h	1228i
S.Em ±	6.3	7.8	6.34	5.5	8.0	4.4

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 + FYM (Farm Yard Manure)

Table 2: Maize equivalent yield and economics of sequence cropping systems as influenced by different conservation tillage and nutrient management practices during 2015-16

Treatments		**Maize equivalent yield (kg ha^{-1})**			**Net returns (₹ ha^{-1})**			**B:C**		
Tillage (T)		**Nutrient management**			**Nutrient management**			**Nutrient management**		
Cropping systems (CS)		NM$_1$	NM$_2$	**Mean**	NM$_1$	NM$_2$	**Mean**	NM$_1$	NM$_2$	**Mean**
CT$_1$	**CS$_1$**	9964c	10269a	10116a	92637b	86400e	89519ab	2.98	2.51	2.75
	CS$_2$	6917m	7223k	7070e	50623l	42909p	46766fg	2.09	1.74	1.92
	CS$_3$	6430r	6679o	6555gh	40058r	31046u	35552jk	1.80	1.50	1.65
	Mean	7770	8057	7914a	61106	53452	57279b	2.29	1.91	2.10
CT$_2$	**CS$_1$**	9560f	9905c	9733bc	85988e	80312g	83150c	2.80	2.38	2.59
	CS$_2$	6589p	6894m	6742e-g	45042o	37310s	41176hi	1.95	1.63	1.79
	CS$_3$	6139t	6404r	6271h-j	34978t	26188x	30583l	1.68	1.41	1.55
	Mean	7430	7734	7582b	55336	47937	51636c	2.14	1.81	1.98
CT$_3$	**CS$_1$**	9819d	10167b	9993ab	95777a	90149c	92963a	3.30	2.72	3.01
	CS$_2$	6778n	7108l	6943ef	53848k	46473n	50160f	2.31	1.88	2.09
	CS$_3$	6300s	6541pq	6420g-i	43397p	34278t	38838ij	1.97	1.60	1.78
	Mean	7632	7939	7786a	64341	56967	60654a	2.52	2.07	2.30
CT$_4$	**CS$_1$**	9427g	9791d	9609c	89288d	83884f	86586bc	3.09	2.58	2.83
	CS$_2$	6504q	6782n	6643fg	49016m	40908q	44962gh	2.16	1.76	1.96
	CS$_3$	5990u	6253s	6121i-k	38060s	29240u	33650kl	1.83	1.50	1.67
	Mean	7307	7609	7458b	58788	51344	55066b	2.36	1.95	2.15
CT$_5$	**CS$_1$**	9166h	9643e	9405c	79564g	75748h	77656d	2.63	2.28	2.46
	CS$_2$	6262s	6742n	6502gh	39628r	34355t	36992i-k	1.82	1.57	1.70
	CS$_3$	5667uw	6024u	5845k	23191y	15689z	19440m	1.41	1.23	1.32
	Mean	7031	7470	7251c	47461	41930	44696d	1.96	1.69	1.83
CT$_6$	**CS$_1$**	8307j	8880i	8594d	67546i	65065j	66305e	2.39	2.10	2.24
	CS$_2$	5657w	6303s	5980jk	31160u	28207w	29683l	1.65	1.47	1.56
	CS$_3$	5313x	5721v	5517l	18233z	11459z	14846n	1.32	1.17	1.25
	Mean	6426	6968	6697d	38979	34910	36945e	1.79	1.58	1.68
NM Mean		7266b	7629a		54335a	47757b		2.18	1.83	
CS Mean										
CS$_1$		9575a			82696			2.65		
CS$_2$		6646b			41623			1.84		
CS$_3$		6122c			28818			1.54		
Sources		**S.Em ±**			**S.Em ±**			**S.Em ±**		
CT		62			867			0.02		
CS		122			1714			0.03		
NM		5			70			0.00		
CT × CS		107			1497			0.03		
CT × NM		12			171			0.00		
CS × NM		9			121			0.00		
CT × CS × NM		21			296			0.01		

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 dose of fertilizer)

NM$_2$: RDF + FYM (Farm Yard Manure)

CONCLUSION

No tillage with BBF and crop residues retained on the surface and application of RDF along with FYM in all the cropping systems produced significantly higher productivity over conventional tillage without crop residues and application of RDF alone. No tillage flatbed with residues retention on the surface was found most profitable under rainfed conditions.

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