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Influence of tillage and maize based cropping practices on productivity, profitability and soil fertility in uplands of Odisha

P. RAY, P. K. ROUL, T. R. MOHANTY, K. N. MISHRA, S. DASH, A. DASH AND K.C. SAHOO

Orissa University of Agriculture and Technology, Bhubaneswar-751003, Odisha

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ABSTRACT

A field experiment was conducted at Regional Research and Technology Transfer Station (Orissa University of Agriculture and Technology), Kendujhar to study the effect of tillage and cropping practices on yield, economics and soil fertility status in maize based cropping systems during the rainy seasons of 2011 and post rainy season of 2011-12. Maize grown with cowpea under minimum tillage recorded 50.1 q ha^{-1} of grain yield which was comparable to sole maize grown under conventional tillage (52.1q ha^{-1}). Growth of cowpea inter-cropped with maize under conventional tillage was invariably superior to minimum tillage. Maize + cowpea grown under minimum tillage followed by toria as cover crop produced maize equivalent yield of 99.08 q ha^{-1} which was at par with maize + cowpea under conventional tillage followed by toria as cover crop (101.33 q ha^{-1}). Maize + cowpea intercropping system either under conventional tillage or under minimum tillage was superior to growing sole maize under either tillage situations. Toria as post rainy season cover crop performed better than horsegram or no cover crop with respect to economic parameters. There was improvement in soil physico- chemical parameters viz.,BD. pH, organic carbon, available N,P and K by minimum tillage and cover cropping, irrespective of growing maize or maize+cowpea.

Keywords: Conventional tillage, cover crop, cropping system, inter cropping, minimum tillage

Tribal agriculture in Odisha is predominantly practiced in rainfed hill ecologies where maize planting follows the onset of the rains under intensive soil tillage, complete residue removal for animal feeding, and extremely low fertilizer use conditions. These factors promote soil erosion (Alijani *et al.,* 2012), increase runoff and evaporation losses of water, soil compaction and decrease soil organic matter (Hobbs and Gupta, 2003). Particularly affected are the smallholder tribal communities of the hilly regions as in Kendujhar district of the state. Environmental degradation has driven these tribal communities engaged in subsistence agriculture into severe malnutrition and loss of livelihood options. Benefits of conservation agriculture technologies reported elsewhere include reduced production costs (Erenstein and Laxmi 2008), timely field operations, improved soil quality and reduced erosion and higher crop productivity in rainfed conditions. It is generally acknowledged, however, that conservation agriculture (CA) *i.e.* minimum/no-tillage, proper crop rotation and cover cropping practices often must be adjusted to the realities of different production ecologies after a testing (Seeraj and Siddique 2012). Intercropping has been recognized as a beneficial system of crop production and is one of the potent means of better utilization of resources and higher crop production per unit time and area, which can provide substantial yield advantages compared to sole cropping (Behere *et al.,* 2013). Since CA represents an entirely new set of production practices in the hilly terrains of Odisha, this study was conducted at RRTTS, OUAT, Kendujhar to assess the comparative performance of conservation agriculture (Minimum Tillage, Maize + Cowpea intercropping and Cover cropping with Toria / Horsegram) and conventional agriculture (Conventional tillage operations, Sole cropping of Maize and No cover cropping) on productivity, profitability and soil fertility.

Email: roulpvt@gmail.com

MATERIALS AND METHODS

The field experiment was conducted at RRTTS, OUAT, Kendujhar during the rainy season of 2011 and post rainy season of 2011-12. The Research Station is located at 21° 55' N latitude and 85° 37' E longitude with a hot moist and sub-humid climate and comes under the North Central Plateau Agro-climatic Zone of Odisha. During rainy season, the experiment was laid out in randomized block design with four treatments *viz.,* K_1: Conventional tillage with sole maize, K_2: Conventional tillage with maize + cowpea, K_3: Minimum tillage with sole maize, K_4: Minimum tillage with maize + cowpea, which were replicated thrice. In post rainy season, the residual effects of these four treatments (main plot) and direct effect of three cover cropping treatments(sub-plot) *viz.,*R_1: No cover crop; R_2: Toria as cover crop and R_3:Horse gram as cover crop were studied in a split plot design with three replications. The soil of the experimental site was silty loam in texture with pH-7.47, medium in organic carbon (6.58g kg^{-1}), available N (267.1kg ha^{-1}) and P (15.8 kg ha^{-1}) and high in K (341.8 kg ha^{-1}). The conventional tillage plots were given primary, secondary and tertiary tillage with thorough land preparation followed by levelling, where as the minimum tillage plots were levelled only after primary tillage. For sole maize crop, the maize hybrid *Nilesh* was sown with a spacing of 60 x 30 cm and for maize + cowpea intercropping, the cow pea var. *Haryally bush* was inter-cropped with maize in 1:1 ratio with row to row spacing of 30 cm. The spacing adopted for cowpea

was 15 cm from plant to plant within the row. In post rainy season, the test varieties for toria and horsegram was *Parvati* and *Athgarh local* respectively. The test hybrid and or varieties taken here were earlier tested for their performance in the research station and in the farmers' fields in this agro-climatic zone and have got acceptance of the farmers. Both the crops were line sown at row spacing of 30 cm and subsequent thinning of plants was made to maintain plant to plant spacing of about 10 cm within the row. Sowing was done by opening lines using trench hoe after one ploughing and leveling and the seeds were covered with soil after sowing. The maize and maize + cowpea plots were applied the recommended dose of fertilizer *i.e.* 120:60:60 kg N: P_2O_5: K_2O ha^{-1}. One-fourth of nitrogen and full dose of P and K were applied as basal and remaining nitrogen was top dressed twice *i.e.* half at 21 days after sowing and one-fourth at tasseling stage. Earthing up of maize plants was done at the time of 1st top dressing. The toria and horsegram crop were grown with fertilizer doses of 30:15:15 kg N: P_2O_5: K_2O ha^{-1} and 12.5:25 kg N: P_2O_5 ha^{-1}, respectively. All the fertilizers were applied as basal. Growth and yield parameters were recorded as per standard procedures. The gross return, net return (gross return – cost of cultivation) and return $Rs.^{-1}$ invested (gross return/cost of cultivation) were calculated on the basis of prevailing market price of different inputs and outputs.

RESULTS AND DISCUSSION

The rainy season treatments had significant influence on growth parameters of maize at almost all stages of observation (Table 1). The plant height at harvest and LAI at 60 DAS were the highest for maize grown under conventional tillage which was closely followed by maize grown intercropped with cowpea under minimum tillage, both remaining at par with each other. The growth under these treatments were also associated with yield attributing characters *viz.,* length of cob, weight of dry cob, number of seeds per cob etc. However, number of cobs per plant and 1000- seed weight of maize were not influenced by the treatments. Maize grown with cowpea under minimum tillage recorded 50.1 q ha^{-1} of grain yield being *at par* with sole maize grown under conventional tillage (52.1q ha^{-1}), which corroborates the earlier findings of Singh *et al*. (2008) and Sharma *et al.* (2010). Higher growth for sole maize under conventional tillage could be ascribed to a weed free soil environment achieved through conventional tillage (Chauhan *et al*., 2001). Similar yield of maize intercropped with cowpea under minimum tillage could be ascribed to a weed free environment and leguminous effect of cowpea (Thakuria and Loikham, 1991). The superiority in performance of sole maize under conventional tillage than maize intercropped with cowpea under minimum tillage could be ascribed to competition between the component crops in case of latter treatment. Sole maize under minimum tillage produced 14.2% lower yield than maize intercropped with cowpea under minimum tillage (50.1 q ha^{-1}). This could be ascribed to intense crop-weed competition for sole maize under minimum tillage, where as maize intercropped with cowpea could escape this due to a relatively weed free environment achieved from growing of maize and cowpea together. Further, Cowpea crop might have acted as live organic mulch promoting increased microbial activity, better protection of soil surface and more supply of plant nutrients (Mantiamely *et al*., 2005). However, growth of cowpea intercropped with maize under conventional tillage invariably remained superior to its growth under minimum tillage which could ultimately produce 32.3% higher green pod yield than minimum tillage (12.4 q ha^{-1}).

Growing maize + cowpea under minimum tillage followed by toria as cover crop could produce similar maize equivalent yield (99.08 q ha^{-1}) as that of growing maize+ cowpea under conventional tillage followed by toria as cover crop (101.33 q ha^{-1}). The gross return, net return and return per rupee invested from maize + cowpea intercropping either under conventional tillage or under minimum tillage were similar but superior to growing sole maize under these two contrasting tillage situations. This might be due to additional yield of cowpea under these two treatments as compared to rest of the treatments. Moreover, the maize yields were also higher under these two treatments. Toria as a cover crop

Table 1: Effect of tillage and intercropping on yield attributing characters, grain and stover yield of maize

Treatment	Plant height at harvest(cm)	Leaf area index at 60 DAS	No. of cob $plant^{-1}$	Length of cob (cm)	Weight of dry cob (g)	No. of seeds cob^{-1}	1000 seed weight (g)	Grain Yield (q ha^{-1})	Stover Yield (q ha^{-1})
T_1	352.9	4.18	1.2	24.0	156.4	327.5	343.3	52.1	99.00
T_2	305.3	3.49	1.1	21.7	135.6	278.8	342.9	44.4	78.00
T_3	301.5	3.35	1.0	20.7	132.1	269.8	342.5	43.0	77.20
T_4	348.8	4.03	1.2	24.5	153.2	317.8	343.5	50.1	92.70
SEm(±)	**8.78**	**0.11**	**0.04**	**0.58**	**3.86**	**8.25**	**14.18**	**1.10**	**1.91**
LSD(0.05)	**30.39**	**0.37**	**-**	**1.16**	**13.1**	**28.54**	**-**	**4.16**	**7.25**

Note: *T_1: Conventional tillage-maize; T_2: Conventional tillage -maize+ cowpea; T_3: Minimum tillage-maize; T_4: Minimum tillage-maize + cowpea.*

in post rainy season was adjudged as the best in comparision to horse gram and no cover crop for all these economic parameters. These two treatments could register 41.9% and 17.3% higher maize equivalent yield than no cover crop, respectively. The soil physico-chemical properties *viz.,* BD. pH, organic carbon, available N,P and K were also favorably influenced by minimum tillage and cover cropping, irrespective of growing maize or maize+cowpea. Durry *et al.* (2003) have also reported increase in organic carbon and available N under minimum tillage.

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Table 2: Productivity (maize equivalent yield, q ha^{-1}), economics and soil properties as influenced by tillage and cropping practices

Treatment	System productivity	Goss return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Return Rs.$^{-1}$ invested	BD (Mg m^{-3})	pH	Organic carbon (g kg^{-1})
Main plot (Rainy season)							
T_1	63.03	55466	23951	1.76	1.348	7.32	6.44
T_2	85.83	75430	35938	1.91	1.346	7.32	6.51
T_3	63.30	55724	18575	1.50	1.340	7.36	6.74
T_4	84.40	74260	35583	1.92	1.338	7.35	6.84
SEm (±)	**1.04**	**1000**	**386**	**0.02**	**0.002**	**0.011**	**0.019**
LSD (0.05)	**3.59**	**3462**	**1334**	**0.08**	**0.007**	**0.04**	**0.07**
Sub plot (Post rainy season)							
S_1	59.73	52394	26197	2.00	1.348	7.34	6.62
S_2	84.78	74606	37854	2.03	1.342	7.34	6.66
S_3	70.08	61670	13864	1.29	1.344	7.33	6.62
SEm (±)	**0.36**	**376**	**566**	**0.04**	**0.0007**	**0.003**	**0.004**
LSD (0.05)	**1.08**	**1126**	**1692**	**0.13**	**0.002**	**NS**	**0.01**

Note: *T_1: Conventional tillage-maize; T_2: Conventional tillage -maize+ cowpea; T_3: Minimum tillage-maize; T_4: Minimum tillage-maize+cowpea; S_1: No cover crop; S_2: Toria as cover crop; S_3: Horse gram as cover crop*