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Tillage effects on weed biomass and yield of direct-seeded rice

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ABSTRACT

Field experiments were conducted during the rainy seasons of 2011 and 2012 in Odisha, India to evaluate the efficiency of different tillage practices at beausaning on weed flora and yield of direct-seeded rice (*Oryza sativa* L.). Two passes of ploughing at 5 cm depth and 15 cm spacing with country plough at 'beausaning' showed the highest yield of grain (4.06 t/ha) and straw (4.66 t/ha), which was associated with higher weed control efficiency, effective tillers/hill, panicle length, number of filled grains/panicle, 1000-grain weight and with lower number of non-bearing tillers/hill and sterile spikelet/panicle. The lowest value of all parameters was found in 1 and 2 passes with tractor. Two passes by power tiller was as good as 2 passes by country plough in controlling weeds and achieving higher yield. Though 1 and 2 passes with country plough and power-tiller showed statistically identical result, but the B:C ratio (2.25) was more in later treatment than the former (2.10).

Key words: Beusaning, Direct-seeded rice, Tillage practices, Weed control efficiency, Yield

Rice is the most important cereal grown under direct seeding and transplanting methods. Among this, direct-seeded rice under wet condition is less costly than transplanting due to lower requirement of labour and water (Singh *et al.* 2002, Sharma *et al.* 2007). In view of this, direct-seeded rice is gaining popularity in most of the rice growing countries including India due to its similar or even higher yields than that of transplanted rice (Sarkar *et al.* 2003, Bhusan *et al.* 2007, Farooq *et al.* 2009). The main disadvantage of direct-seeded rice is high weed infestation, because both weed and crop seeds emerge at the same time and compete with each other from germination, resulting yield reduction from 30-35% (Pillai 1977) to 50 to 100% (Rao *et al.* 2007), so effective and timely weed control is a key component for success of production of direct-seeded rice.

For controlling weed and better plant stand, 'beusaning' is done in direct-seeded rice. 'beusaning' (blind cultivation) is an indigenous practice developed by the farmers and largely practiced in Eastern India in 13 million hectares. In this practice, light ploughing is done between 20-30 days of emergence of crop followed by laddering and seedling redistribution (gap filling). This operations helps in loosening of soil, incorporate weeds into soil, thinning of seedling thereby optimize the plant stand.

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In 'beusaning', light ploughing is done with a bullock drawn narrow country plough maintaining a depth of 5±2 cm water in the field. Tillage operation by traditional wooden plough (country plough) pulled by draft animal for 'beusaning' is a slow process and requires more time to complete the operation. More over, draft power shortage is one of the major problems in cultivation. The number of draft animal is decreasing very rapidly among the farmers due to various reasons such as high cost of maintenance, high rate of slaughtering, slow rate of reproduction and reduced pasture areas (Sarkar 1993). In recent years, power tillers and tractors have emerged as good alternatives to meet the acute shortage of draft power. Use of these machineries in 'beusaning' operation kill the weeds and excess plants through pulverization. Therefore, an optimum tillage practice in terms of number of passes, depth and spacing of tillage are to be found for maintenance of optimum plant stand after 'beusaning' operation. The present work was therefore undertaken to find out suitable tillage practices at 'beusaning' on weed dynamics and productivity of direct-seeded rice.

MATERIALS AND METHODS

Field experiment was conducted at Seed Research Farm, Gambharipali, Odisha during rainy season (*Kharif*) 2010 and 2011. The soil of the experimental field was sandy clay loam with pH 6.5, organic carbon 0.43% and available N, P and K content of 272, 13.8 and 136 kg/ha, respectively. The experiment consisted of 7 treatments was laid out in randomized block design with three replications. Rice cultivar '*MTU 1001*' maturing in 135 days was sown in the field during 2nd week of June in both the years with a seed rate of 100 kg/ha. A common fertilizer dose of 80, 40 and 40 kg of N, P and K/ha, respectively was applied as full dose of P_2O_5 at seeding, 50% N and full K_2O at 'beusaning'. The rest 50% N was top dressed in 2 equal splits, *i.e.* 3 weeks after 1st application and at panicle initiation stage of crop. Plant protection measures and irrigations were provided as and when required. The total rainfall received during the crop season was 863.7 and 977.2 mm in 2012 and 2013, respectively.

In power tiller mounted rotavator and tractor mounted 9 tined cultivator, alternate tines were removed to maintain the spacing of 15 and 45 cm, respectively. In the bullock drawn country plough, rows were drawn at a spacing of 15 cm. A shallow submergence with 5±2 cm standing water was maintained during 'beusaning' operation. Laddering was done lightly after ploughing in 'beusaning' operation for making the rice plants unidirectional for workability and flattening the aged weeds.

Weed count (no./m^2) (numbers/0.5 m^2), weed dry weight (g/m^2) (g/0.5m^2) were sampled randomly at two places with the help of 0.50 m^2 quadrate at 4 weeks (before 'beusaning') and 7 weeks after sowing (after 'beusaning'). The 1st and 2nd weed counts were carried out from the same spots in each plot. For recording weed dry weight, weeds cut at ground level with sickle, were sun dried for 3 days followed by oven drying at 65± 5 ^{0}C. Weed population data were analysed after subjecting to square root transformation. Yield and yield attributes of rice were recorded at crop harvest. Weed control efficiency was also calculated on the basis of dry matter production of weeds. Economic analysis was done on the basis of prevailing market price of inputs used and output obtained from each treatment. Both the year's data were subjected for pooled analysis to obtain a trend among results over the years.

RESULTS AND DISCUSSION

Weed flora

Major weed flora in the experimental field were categorized in narrow-leaved (grass and sedges) and broad-leaved (monocot and dicot). The important species were: grasses *Digitaria sanguinalis* (L.) Scop., *Echinochloa crusgalli* (L.) P.Beauv., *Echinochloa colona* (L.) Link, *Panicum repens* (L.), *Cynodon dactylon* (L.) Pers; sedges *Cyperus rotundus* (L.), *Cyperus iria* (L.), *Cyperus difformis* (L.), *Fimbristylis miliacea* (L.) Vahal, *Paspalum distichum* (L.) and broad-leaved weeds (BLW) *Ammania baccifera* (L.), *Ludwigia parviflora* (L.), *Eclipta prostrata* (L.), *Eclipta alba* (L.), *Lippa nodiflora* Nich, *Marsilea quadrifolium* (L.), *Sphenoclea zeylanica* Gaertn., *Commelina benghalensis* (L.). The composition of narrow-leaved (grass and sedges) and broad-leaved weeds (BLW) in weedy check plot was 80.9 and 19.1%, respectively. Emergence of BLW was noticed earlier as compared to sedges and grasses.

Response of weeds to tillage practices

Both narrow-leaved and broad-leaved weeds and their biomass were found to be significant due to tillage in all counts (Table 1). Two passes with country plough, power-tiller and tractor reduced both narrow-leaved and broad-leaved in all counts in comparison to single pass. The lowest weed population (21.3 and 5.0) and dry weight (11.37 and 3.67) and highest weed control efficiency (86.3 and 81.8%) for narrow-leaved and broad-leaved, respectively was recorded in two passes with country plough which was at par with 2 passes by power tiller. In 2 passes, the soil become loose and more weeds were buried in the soil than that of single pass. The minimum weed population and dry weight of weed and weed control efficiency after 'beusaning' (7 WAS) was recorded in two passes with country plough at a spacing of 15 cm and depth of 5 cm, which was at par with 2 passes by power tiller at same spacing and depth. The reduced weed density in wet ploughing by 2 passes of country plough was due to incorporation of more weeds in to the soil. One and 2 passes with tractor at 45 cm spacing recorded higher weed population and dry weight. This was due to wider spacing (45 cm) which loosens the soil in less area and less weeds were uprooted, besides use of heavy machineries affected the tender seedling of rice. Plots without any tillage at 'beusaning' recorded the highest weed population and the dry weight.

Effect on crop

There were significant differences on effective tillers/hill, panicle length, grains/panicle, grain and straw yield due to tillage of rice variety '*MTU 1001*' (Table 2). Among the different tillage implements, 2 passes with country plough recorded the highest grain yield (4.06 t/ha), which was at par with 2 passes with power tiller. Two passes with country plough, power tiller and tractor increased the grain yield by 42.5, 36.8 and 28.1%, respectively over

Table 1. Narrow- and broad-leaved weeds as affected by tillage practices

Tillage	Weed density (no/0.5 m^2)				Weight g/m^2 (g/0.5 m^2)				WCE (%)	
	Narrow-leaved		Broad-leaved		Narrow-leaved		Broad-leaved		Narrow-leaved	Broad-leaved
	4 WAS	7 WAS	4 WAS	7 WAS	4 WAS	7 WAS	4 WAS	7 WAS	7 WAS	7 WAS
T1	11.0 (120)	13.14 (172.3)	5.58 (30.7)	6.12 (37.3)	49.2	83.1	8.3	20.2	0.0	0.0
T2	10.9 (119)	4.61 (21.3)	6.09 (36.6)	2.34 (5.0)	45.8	11.4	3.7	3.7	86.3	81.8
T3	10.7 (115)	4.94 (27.0)	5.64 31.6)	2.69 (6.8)	44.7	20.5	4.7	4.0	75.4	80.4
T4	10.8 (117)	5.61 (31.6)	5.95 (35.6)	2.64 (7.0)	45.7	26.3	5.2	5.4	68.4	73.3
T5	10.6 (112)	6.71 (45.0)	5.90 (34.0)	3.48 (11.7)	37.8	30.5	5.6	5.4	52.6	73.3
T6	10.9 (118)	7.07 (50.0)	5.81 (33.0)	3.48 (11.8)	45.4	35.5	6.3	7.3	57.3	64.0
T7	10.8 (116)	7.57 (57.3)	16.8 (36.0)	4.21 (17.3)	45.1	43.0	7.0	9.7	48.3	52.2
LSD (P=0.05)	NS	1.43	NS	0.62	NS	7.4	NS	3.4	-	-

T1- Tillage fallow (no 'beusaning'), T2- Two passes with country plough, T3- Two passes with power tiller, T4- Two passes with tractor, T5- One pass with country plough, T6- One pass with power tiller, T7- one pass with tractor; WAS- Weeks after sowing, WCE- Weed control efficiency, Figures in parentheses are original values

Table 2. Yield attributing characters, yield and economics of direct-seeded rice using various tillage practices (pooled data of two years)

Tillage	Effective tillers/ hill (no.)	Non - bearing tillers/ hill (no.)	Filled grain/ panicle (no.)	Sterile spikelet/ panicle (no.)	Grain yield (t/ha)			Straw yield (t/ha)			Harvest index (%)	Gross return (x10^3 `/ha)	Net return (x10^3 `/ha)	B:C ratio
					2012	2013	Mean	2012	2013	Mean				
T1	7.5	2.6	88	16.2	2.5	3.2	2.8	3.5	3.9	3.7	43.5	35.62	15.00	1.72
T2	10.3	2.7	107	20.1	3.9	4.2	4.1	4.4	4.92	4.66	46.5	50.75	26.63	2.10
T3	9.5	1.6	105	17.2	3.6	4.2	3.9	4.4	4.7	4.55	46.2	48.75	26.10	2.25
T4	9.5	1.9	104	17.2	3.2	4.1	3.6	4.3	4.54	4.42	45.2	45.62	23.67	2.07
T5	9.3	2.0	99	20.0	3.3	3.7	3.5	4.1	4.6	4.35	44.5	43.62	20.75	1.90
T6	9.3	2.2	98	18.0	3.2	3.4	3.3	4.1	4.18	4.14	44.4	41.37	19.74	1.91
T7	8.5	2.5	93	18.0	3.0	3.1	3.1	3.5	4.1	3.8	44.6	38.25	16.96	1.79
LSD (P=0.05)	0.19	0.21	2.8	0.26	0.4	0.3	0.2	0.6	0.5	0.3				

T1- Tillage fallow (no 'beusaning'), T2- Two passes with country plough, T3- Two passes with power tiller, T4- Two passes with tractor, T5- One pass with country plough, T6- One pass with power tiller, T7- one pass with tractor, WAS- Weeks after sowing, WCE- Weed control efficiency

unweeded check (tillage-fallow). The increased grain yield in these treatments were owing to reduced weed population and weed dry weight and better weed control efficiency (Table 1). Higher number of effective tillers/hill, panicle length, number of filled grain/panicle, 1000- grain weight and lower number of non-bearing tiller/hill and sterile spikelet/panicle were recorded in two passes with country plough followed by power tiller (Table 2).

The highest grain yield in 2 passes by country plough was due to 37.3% higher productive tiller, 15.4% higher panicle length, 21.4% higher filled grains/panicle compared to tillage-fallow. Positive effect of ploughing through country plough causes less number of weed and weed dry weight, optimize plant stand, making soil loosen, which might have permitted the roots to enter in to deep layer for better use of water and mineral nutrients.

The minimum yield and yield attributes in tillage fallow were the result of severe weed competition by uncontrolled weed growth. Straw yield followed almost similar trend as that of grain yield. Ranjit and Suwanketnikom (2005), Jain *et al.* (2006) and Jha *et al.* (2011) also reported increased grain yield of direct-seeded rice by different tillage practices.

The highest harvest index (46.5%) was found in 2 passes with country plough at 15 cm spacing (Table 2). The second highest harvest index was found in 2 passes with power tiller which was followed by 1 passes with tractor at 45 cm spacing. This might be due to higher grain yield in 2 passes with country plough as compared to other tillage operation. The lowest harvest index was found in 1 pass with country plough at 15 cm spacing.

Economics

Two passes with country plough at 'beausaning' in rice fetched higher gross return (₹ 50750/ha), net return (₹ 26630/ha) over tillage fallow. However, 2 passes with power tiller recorded higher B: C ratio (2.25) than that of country plough (2.10) indicating reduced cost in tillage operation of power tiller (Table 2). The tillage fallow recorded the lowest net return and B: C ratio.

Based on the study, it was concluded that two passes with country plough at 'beausaning' direct-seeded rice was superior in terms of improve tillering, grain filling and controling weeds over other method of tillage. However, tillage practice by power tiller are equally effective as compared to the country plough.

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