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Influence of Stand Establishment Techniques on Yield and Economics of Rice Cultivation in Kuttanad

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Abstract- Field experiment was conducted at Rice Research Station, Moncompu during *kharif* 2012 to study the effect of different stand establishment techniques on yield and economics of rice cultivation in Kuttanad. The experiment was laid out in RBD replicated four times with five treatments in plots of 60 m^2. Mechanized transplanting at 22 x 14 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAT (days after transplanting) followed by hand weeding at 40 DAT significantly influenced the growth and yield attributes and recorded higher grain yield (5350 kg ha^{-1}), straw yield (9140 kg ha^{-1}), gross returns (100090 Rs ha^{-1}), net returns (73303 Rs ha^{-1}) and B: C ratio (3.74). Among the direct seeding techniques, drum seeding with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS (days after sowing) followed by hand weeding at 40 DAS recorded higher gross returns, net returns and B: C ratio. The lowest grain yield (4566 kg ha^{-1}), gross returns (86127 Rs ha^{-1}) , net returns (56777 Rs ha^{-1}) were recorded in broad casting of pre-germinated weeds with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS. The dry weight of weeds were found to be less in treatments with post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} followed by hand weeding at 40 DAS/DAT than conoweeding at 15, 30 and 40 DAT. Conoweeding alone failed to control weeds effectively, but it influences the crop growth and yield by stimulating aeration and root growth.

Index Terms- Broad casting, pre-germinated seeds, manual transplanting, mechanized transplanting, pyrazosulfuron ethyl, conoweeding

I. INTRODUCTION

Kuttanad, the rice bowl of Kerala is a unique wetland ecosystem, lies at an altitude 0.6 to 2.2 m below mean level situated in southern Kerala. About 55,000 hectares, reclaimed from the surrounding backwaters for paddy cultivation is known as puncha lands, these reclaimed holding with an outer bund are made in to cluster of fields called polders or padashekarams. Broadcasting of pre-germinated seeds is the common practice of rice growing in Kuttanad. Since it is a direct seeding technique, both crop and weed seeds germinate together and weeds compete with crop for nutrients, water, space and light and became a biological constraint. For the last few years, infestation of *Leptochloa*, weedy rice and *Echinochlo*a became serious and caused considerable reduction in yield. As a result farmers are forced to skip rice cultivation for one or two seasons. In addition, to maintain the plant population farmers go for higher seed rate lead to severe pest and disease problem which ultimately increase the cost of cultivation.

Comparative trials conducted in India revealed that transplanted crop yield more than the direct seeded crop. Transplanting ensures uniform crop stand, better control of weeds, uniform ripening and less lodging. In spite of these advantages, manual transplanting is quite expensive, laborious, time consuming and causes of lot of drudgery. Manual transplanting takes about 300 to 350 man hours/ha which is roughly 25 % of the labour requirement of crop (Goel *et al*., 2008). In addition to that, lack of skilled labour at the time of transplanting results in to low plant population and eventually low yield (Aslam *et a*l., 2008). Optimizing plant density and timeliness of operation in paddy is considered essential for optimizing yield (Chaudhary *et al*., 2005). In order to get maximum returns from the rice crop, cultivation cost has to be reduced through minimizing the dependence on labour for transplanting. Under such condition mechanized transplanting can be considered as the most promising option as it saves labour, ensures timely planting and attain optimum plant density. Keeping these views in mind an experiment was conducted at Rice Research Station, Moncompu with an objective to study the influence of stand establishment techniques on yield and economics of rice cultivation in Kuttanad.

II. MATERIALS AND METHODS

The field experiment was conducted at Rice Research Station, Moncompu, Kerala (geographically situated at 9 º 5' N latitude and 76 º 5' E longitude and at an altitude 1m below MSL) during *kharif* 2012. The soil is silty clay with pH 5.76, organic carbon 4.6 %, available P and K 58.24 and 172.72 kg ha^{1}, respectively. The experiment was laid out in randomized block design replicated four times in plots of 60 m^2 size with five treatments. The treatments combinations were mechanized transplanting with Yanji 8 row self-propelled transplanter at 22 x 14 cm with early post emergence application of pyrazosulfuron ethyl 10% WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT (T_1), mechanized transplanting with Mahindra walk behind four row transplanter at 30 x 10 cm with conoweeding at 15, 30 and 45 DAT (T_2), drum seeding at 20 x 10 cm with early post emergence application of pyrazosulfuron ethyl 10% WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS (T_3), Manual transplanting at 20 x10 cm with early post emergence application of pyrazosulfuron ethyl 10% WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT (T_4) and broad casting of

pre-germinated seeds with early post emergence application of pyrazosulfuronethyl 10% WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS (T_5). In mechanized and manual transplanting, seedlings were raised by dapog and wet nursery methods, respectively. Fifteen day old seedlings were used for transplanting in both these methods. In drum seeding and broadcasting methods, pre-germinated seeds were used for sowing on the same day when seedlings were transplanted by machine and manual methods. After the land preparation and leveling, sedimentation period of four days was given to avoid the float sinkage in machine transplanted plots with Yanji eight row self- propelled transplanter. The variety used was Uma (MO 16), a medium duration variety. The crop was fertilized with 90:45:45 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. $1/3^{rd}$ dose of N and K_2O and half dose of P_2O_5 were applied at 15 DAT, $1/3^{rd}$ dose of N and K_2O and half dose of P_2O_5 at 35 DAT and remaining $1/3^{rd}$ dose of N and K_2O were applied at 55 DAT.

Observations on growth parameters viz., hills per square meter, plant height, LAI and tillers per square meter were recorded at flowering stage and yield parameters viz., productive tillers per square meter, panicle weight, fertile grains per panicle, 1000 grain weight, grain and straw yield were recorded at harvest. Observations on total weed dry weight were recorded with quadrat of 0.25 m^2 size placed randomly at two representative sites in each plot at 60 and 90 DAS/DAT. Weed samples were collected from each spot, washed in tap water, sun dried first followed by oven drying at 65° until constant weights were obtained. The data on weed dry weight were subjected to square root transformation to normalize their distribution. The cost of cultivation was worked out based on the labour and input cost incurred towards rice cultivation in different establishment techniques. Economics of cultivation was worked out based on the minimum support price for paddy given by the Government of Kerala during *kharif* 2012. All data except gross returns, net returns and B: C ratio was analyzed using ANOVA.

III. RESULTS AND DISCUSSION

Growth attributes

Table 1: Effect of stand establishment techniques on growth attributes of rice at flowering stage

Treatment	Hills per square meter	Plant height (cm)	LAI	Tillers per square meter
Mechanized transplanting at 22 x14 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT	35	100.2	4.14	350
Mechanized transplanting at 30x10 cm with conoweeding at 15, 30 and 45 DAT	33	102.1	4.13	316
Drum seeding at 20x10 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS	50	98.5	3.67	312
Manual planting at 20 x10 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT	48	94.9	3.78	326
Broadcasting of pre-germinated seeds with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS	98	92.3	3.21	296
CD	14	5.9	0.25	34

DAT- days after transplanting, DAS-days after sowing

Hills per square meter were significantly influenced by the establishment techniques (Table 1). Broad casting of pre-

germinated seeds recorded the maximum number of hills per square meter. This was attributed to the fact that in direct seeding uniformity in plant population cannot be assured due to spread of more number of seeds per unit area. This was followed by drum seeding and manual planning at 20x 10 cm spacing. However, in mechanized transplanting methods, no significant difference was found. Mechanized transplanting at 30x10 cm spacing recorded taller plants (102.1) closely followed by mechanized planting at 22x 14 cm spacing (100.2). This was due to the reason that plants were planted at proper row to row and plant to plant spacing leading to reduced competition (Awan *et al*., 2007) and the plants got sufficient space to grow and increased light transmission in the canopy led to increased plant height (Vijayakumar *et al*., 2006). The plants with the lowest height were observed in broadcasting method might be due to higher competition among plants for space, light and nutrients. Similarly the highest LAI (leaf area index) was also recorded in mechanized transplanting (4.14) followed by manual transplanting (3.78) and the lowest LAI was recorded in broadcasting method (3.21). This was owing to the fact that, younger seedlings planted at proper spacing enhanced the root growth which facilitated increased cell division and cell enlargement and more number of tillers with more leaves and subsequently higher photosynthetic rate for increased LAI (Shrirame *et al*., 2000). Tillers per square meter were also significantly influenced by the stand establishment techniques. The highest number of tillers were recorded in mechanized planting at 22 x14 cm (350 No.m^{-2}) followed by manual planting at 20 x10 cm might be due to reduced weed growth (Table 2) and due to the availability of sufficient amount of nutrients and moisture at tiller initiation stage and better establishment of roots (Aslam *et al*., 2008).

Total Weed dry matter

Table 2: Effect of stand establishment techniques on total weed dry matter at 60 and 90 DAT/DAS

Treatment	Total Weed dry matter at 60 DAT/DAS	Total Weed dry matter at 90 DAT/DAS
Mechanized transplanting at 22 x14 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT	19.39 (4.46)	37.32 (6.15)
Mechanized transplanting at 30x10 cm with conoweeding at 15, 30 and 45 DAT	52.64 (7.29)	114.85 (10.74)
Drum seeding at 20x10 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS	26.85 (5.23)	67.07 (8.22)
Manual planting at 20 x10 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT	20.38 (4.57)	53.82 (7.37)
Broadcasting of pre-germinated seeds with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS	46.42 (6.85)	66.25 (8.17)
CD	1.00	2.57

DAT- days after transplanting, DAS-days after sowing

Total weed dry weight was significantly influenced by the stand establishment techniques. Among the five different stand establishment techniques studied, mechanized transplanting at 30 x 10 cm with conoweeding at 15, 30 and 45 DAT (T_2) recorded the highest weed dry matter accumulation. The results indicated that conoweeding alone failed to control weeds effectively. But it improved the root growth by pruning of some upper roots and increasing soil aeration which influenced the plant growth (Table1). Early post emergence application of herbicide had brought out effective weed control at early stage of crop weed competition resulted in low weed biomass production in T_1. While comparing the treatments T_1, T_3, T_4 and T_5, it was observed that the total weed dry matter was found to be more in direct seeding than transplanting. This was due to the fact that in direct seeding both crop and weed seeds emerge simultaneously and the roots of the crop plant could not penetrate deep enough to exploit the soil resources fully, giving adequate chance to the weeds to compete with crop plant (Ehsanullah *et al*., 2007). Among the direct seeding techniques, the total weed dry matter was found to be more in broadcasting of pre-germinated seeds (Table 2). The reason was that in treatment T_4, early emerged weeds were controlled by early post emergence application of pyrazosulfuron ethyl 10 % WP and the seeds were planted at proper spacing the later emerged weeds could be better removed by hand weeding. The findings are in agreement with the

findings of Budhar and Tamilselvan (2002) and Singh and Singh (2010).

Yield attributes

Table 3: Effect of stand establishment techniques on the yield attributes of rice

Treatment	Panicles m^{-2}	Fertile grains per panicle	Panicle weight (g)	1000 grain weight (g)
Mechanized transplanting at 22 x14 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT	343	116.5	3.68	25.88
Mechanized transplanting at 30x10 cm with conoweeding at 15, 30 and 45 DAT	311	127.8	3.75	25.58
Drum seeding at 20x10 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS	306	105.9	3.40	26.03
Manual planting at 20 x10 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT	318	111.0	3.37	25.63
Broadcasting of pre-germinated seeds with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS	281	89.4	2.62	24.68
CD	28	15.2	0.44	NS

DAT- days after transplanting, DAS-days after sowing

Yield attributes of rice were significantly influenced by stand establishment techniques (Table 3). The highest number of panicles per square meter were recorded in mechanized planting at 22 x 14 cm with early post emergence application of pyrazosulfuron ethyl at seven DAT followed by hand weeding at 40 DAT (T_1). This was followed by manual planting at 20 x 10 cm (T_4) and was statistically on par with drum seeding at 20 x10 cm (T3) and mechanized planting at 30 x 10 cm with conoweeding (T_2). Broad casting of pre-germinated seeds (T_5) recorded the lowest number of panicles. This might due to less availability of nutrients and moisture to the crop plants at panicle initiation stage resulting from the crop-weed competition. In the treatment T_2, even though the total weed dry weight was found to be more, it produced significantly higher number of panicles (311 $No.m^{-2}$) than broadcasting of pre-germinated seeds. The reason was that in T_2, the plants were planted at proper spacing and conoweeding at 15, 30 and 45 days after transplanting enhanced the soil aeration and root growth and would favorably influenced the plant growth (Table.1). Significantly higher number of fertile grains per panicle was recorded in the treatment T_2 and was statistically at par with other transplanting methods of crop establishment. The lowest number of grains per panicle was recorded in broadcasting method might be due to less photosynthesis as reflected in LAI at flowering (Table 1). The result is in conformity with the findings of Aslam *et al*. 2008 and Raj *et al*, 2012. Similarly panicle weight was also found to be influenced by establishment techniques. Panicles with more weight was recorded in treatment T_2 which was statistically at par with mechanized planting at 22 x14 cm (T_1), drum seeding at 20 x10 cm (T_3) and manual planting at 20 x10 cm (T_4). Being a varietal character test grain weight was not significantly influenced by the establishment techniques. Similar result is also reported by Ehsanullah *et al*., 2007. However, among the treatments it varied between 24.68 to 26.03 g. .

Yield and economics

Table 4: Effect of stand establishment techniques on yield and economics of rice

Treatment	Grain yield kg ha^{-1}	Straw yield kg ha^{-1}	Gross returns Rs ha^{-1}	Net returns Rs ha^{-1}	B:C ratio
Mechanized transplanting at 22 x14 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT	5350	9140	100090	73303	3.74
Mechanized transplanting at 30x10 cm with conoweeding at 15, 30 and 45 DAT	5000	8905	93905	64397	3.18
Drum seeding at 20x10 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS	4969	8956	93429	68164	3.69
Manual planting at 20 x10 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT	5131	9135	96362	63307	2.92
Broadcasting of pre-germinated seeds with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS	4566	8505	86127	56777	2.93
CD	484	NS	-	-	

DAT- days after transplanting, DAS-days after sowing

Grain yield was significantly influenced by the stand establishment techniques. Grain production, which is the final product of growth and development, is controlled by two factors. First is the potential ability of the plant population to photosynthesize (source) and secondly, the capacity of the spike lets to accept the photosynthates (sink). The sink is composed of panicles per unit area (determined during the vegetative phase), the spikelet number per panicle determined during reproductive stage) and the fertility percentage determined during reproductive and ripening stage as reported by De Datta (1981). Mechanized transplanting at 22 x14 cm with early post emergence application of pyrazosulfuron ethyl at seven DAS followed by hand weeding at 40 DAT (T_1) recorded higher grain yield (5350 kg ha^{-1}) than other establishment techniques. The yield increase was due to the favourable influence on number of tillers, LAI and number of panicles. It was statistically at par with manual planting (5131 kg ha^{-1}), mechanized transplanting at 30 x10 cm with conoweeding at 15, 30 and 45 DAT (5000 kg ha^{1}) and drum seeding (4969 kg ha^{-1}). Javaid *et al.* (2012) also reported higher grain yield in transplanting compared to drill sowing and broadcasting. Broadcasting method of crop establishment failed to enhance the growth and yield attributes (Table 1 and 3) and their cumulative effect drastically reduced the grain yield (Table 4).

Straw yield was not significantly influenced by the stand establishment techniques. The broadcasting of pre-germinated seeds recorded the lowest straw yield (8505 kg ha^{-1}) due to reduction in growth components such as plant height, LAI and tillers per unit area (Table 4). The highest straw yield (9140 kg ha^{-1}) was recorded in treatment T_1 and it was followed by manual planting (T_4) and drum seeding (T_3). Economic analysis revealed that maximum net income and B:C ratio were recorded in mechanized transplanting at 22x 14 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP followed by hand weeding at 40 DAT (T_1). This might be due to higher grain and straw yield and low cost of cultivation. This was followed by drum seeding at 20 x10 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP followed by hand weeding at 40 DAT. Mechanized transplanting at 30 x 10cm with conoweeding recorded B: C ratio of 3.18 which was lower than T_3 might be due to comparatively high labour cost involved in conoweeding. The lowest benefit cost ratio recorded in manual transplanting might be due to high labour cost involved.

IV. Conclusion

Mechanized transplanting at 22 x14 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAT followed by hand weeding at 40 DAT was found to be the best establishment techniques for maintaining optimum plant population, reduced weed growth, higher grain yield, gross returns, net returns and B: C ratio. Mechanized transplanting at 30 x10 cm with conoweeding at 15, 30 and 45 DAT gave better yield than drum seeding but its net returns and B: C ratio was low due to high cost involved in conoweeding. Since the conoweeding enhanced the aeration and rooting its operation could be limited at one time at 40 DAT as an alternative to manual weeding and early emerged weeds could be controlled by the application of herbicide. Drum seeding at 20 x10 cm with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS gave better returns and B: C ratio than broadcasting of pre-germinated seeds with early post emergence application of pyrazosulfuron ethyl 10 % WP @ 20 g ai ha^{-1} on seven DAS followed by hand weeding at 40 DAS. So as an alternative stand establishment technique for sustaining the yield of rice cultivation, mechanized transplanting and drum seeding can be recommended in Kuttanad.

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