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RESEARCH ARTICLE

Evaluation of weed competitiveness of rice varieties under two rice establishment methods

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ABSTRACT

An experiment was conducted during two consecutive *boro* seasons of 2015–16 and 2016–17 at the research farm of Regional Rainfed Lowland Rice Research Station, ICAR-National Rice Research Institute, Gerua, Hajo, Assam, India, to study the weed competitiveness of rice cultivars under two establishment methods. The split plot design with three replications was used with two rice establishment methods *i.e.*, wet-seeded rice (WSR) and transplanted (TPR) in main plots and 10 hybrids and high yielding varieties (HYVs) of rice in subplots. The weed density of grasses, sedges and broad-leaved weeds (BLWs) at all growth stages were significantly higher with WSR as compared to TPR. The maximum weed density was recorded at 30 days after seeding (DAS) in WSR and at 15 DAS in TPR and later there was a decline in weed density due to the shift in crop-weed competition balance in favour of rice. The maximum weed biomass was observed at 60 DAS. The rice established by transplanting recorded higher growth, yield attributes, grain and straw yield. Among, the rice cultivars, Naveen recorded the lowest weed density and biomass at 30 DAS while Tulasi and Mandya Vijaya recorded the lowest weed density and biomass at 45 and 60 DAS which indicated their competitiveness against weeds. Due to better competitiveness, Naveen produced more vigorous plants and yield attributes which resulted in significantly higher grain and straw yield followed by Tulasi and KRH 2. Thus, for higher rice productivity in the shallow lowlands of Assam, transplanting of rice may be suggested using rice cultivars Naveen, Tulasi and KRH2 that were more competitive in suppressing weeds.

Keywords: Cultivar competitiveness, Direct-seeded rice, Establishment methods, Transplanted rice, Weed management

INTRODUCTION

Weed management is the major challenge to the success of boro rice which is also known as summer rice in Southern Asia. Weeds are the most severe and widespread biological constraints to rice production in the World. Weeds cause heavy yield losses in rice, to the extent of complete crop failure under severe infestation conditions. Irrespective of the method of rice establishment, weeds are a major impediment to rice production due to their ability to compete for resources. In general, weeds problem in transplanted rice is lower than that of direct-seeded rice because of puddling and stagnation of water in transplanted rice during early growth stage of crop (Rao *et al.* 2015). But in some cases where continuous standing water cannot be maintained particularly for the first 45 days, weed infestation in transplanted rice also may be as high as direct-seeded rice. Uncontrolled weeds in transplanted rice causes 45-51% loss to productivity (Singh *et al.* 2017), whereas under direct-seeded rice weeds cause yield loss up to 80% (Jabran *et al.* 2012; Rao *et al.* 2017).

Competition for nutrients constitutes an important aspect of weed-crop competition. Nitrogen has been the most important element in crop-weed competition as it is extensively used in crop production. Weeds generally absorb mineral nutrients faster than the crop plants and accumulate them in huge amount in their tissues. To increase the efficiency of the applied inputs, weed management is one of the important operations in both transplanted rice and direct-seeded rice. Highly nutrient efficient rice hybrids and high yielding varieties (HYVs) having fast growth rate and ability to suppress the weeds are very useful to maintain weed population below economic threshold level (Mahajan and Chauhan 2013; Ramesh *et al.* 2017). Close spacing of rice cultivars also attribute to suppress weed density and weed biomass (Aggarwal and Singh 2015; Ramesh *et al.* 2017). Transplanting of younger seedlings produced more vigorous plant canopy which resulted in higher yield attributes and grain yield under rainfed shallow lowland (Singh *et al.* 2018). The use of weed-competitive rice cultivars in rice belts is a

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highly effective strategy to reduce cost of production and provide alternative solutions to the unavailability of herbicides (Dimaano *et al.* 2017). Thus, the present study was carried out to evaluate hybrids and HYVs of rice for their competitiveness against weeds under two rice establishment techniques.

MATERIALS AND METHODS

Field experiment was carried out during *boro* season of 2015–16 and 2016–17 at the research farm of Regional Rainfed Lowland Rice Research Station, ICAR-National Rice Research Institute, Gerua, Hajo, Assam which is located at 28^0 14^1 59^{11} N latitude, 91^0 33^1 44^{11} E longitudes and at an altitude of 49 m above mean sea level and characterized in the long-term by sub-tropical monsoon type climate with annual average rainfall 1500 mm. The soil was clay loam texture, having pH of 6.1, high in organic carbon (1.12%), medium in available nitrogen (286 kg/ha), high in available P (36.15 kg/ha) and medium in available potash (305 kg/ha). The experiment was carried out using split plot design with two crop establishment techniques i.e., wet-seeded rice (WSR) and transplanted rice (TPR) in main plots and 10 hybrids and HYVs of rice in subplots. These were replicated thrice. Rice seedlings of 45 days were transplanted and dry seeds were sown carefully on 15^{th} February according to the treatments in the well-puddled experimental plots. The spacing of 20 cm × 15 cm was maintained. A fertilizer dose of 80-40-40 kg/ha of N-P-K was applied as urea, di-ammonium phosphate (DAP) and muriate of potash (MOP) in the field. One-third urea and full dose of DAP and three fourth of MOP were applied as basal dose at the time of final land preparation and incorporated well into the soil. Remaining two-third of urea was applied in two equal splits at 40 and 70 days after transplanting (DAT) while one fourth MOP was applied at panicle initiation. All other agronomic practices were kept normal and uniform for all the treatments of the experiment. Data on weeds, *viz*. weed density and weed dry matter accumulation (biomass) were recorded at 15 days interval after planting. Weed sampling was done by placing a quadrat of 1 m^2 randomly in each plot to determine the weed density and biomass. From each quadrat, weeds were separated species wise and the number counted and sorted into three categories *i.e.*, grasses, sedges and broad-leaved weeds. For recording dry matter accumulation, weed samples were sun-dried for 2-days then oven-dried at 70°C until constant weight recorded. Grain and straw yield were recorded at harvest. The data were subjected to analysis of variance (ANOVA) and results were presented at 5% level of significance (P = 0.05).

RESULTS AND DISCUSSION

Weed density and biomass

The weed flora observed across the treatments comprised of 15 species of weeds which were mainly dominated by sedges and grasses. The dominant weed flora includes *Scirpus juncoides* Roxb, *Cyperus difformis* L., *Cyperus iria* L., *Echinochloa colona* (L.) Link, *Echinochloa crus-galli* (L.) P. Beauv., *Monochoria vaginalis* (Burm. f.) C. Presl ex Kunth, *Ludwigia octovalvis* (Jacq.) P.H. Raven., *Cyperus rotundus* L., *Leersia hexandra* Sw., *Paspalum distichum* L., *Pistia stratiotes* L., *Eclipta prostrate* (L.) L., *Leptochloa chinensis* (L.) Nees, *Fimbristylis miliacea* (L.) Vahl and *Marsilea minuta* L. Weed density of grasses, sedges and broad-leaved weeds (BLWs) at almost all stages found significantly higher under WSR as compared to TPR (Table 1). Grasses, sedges and BLWs density were not affected much at 15 DAS while the maximum weed density of grasses, sedges and BLWs were recorded with IIRR Dhan 44, PA 6444 and Dhanrasi at 15 DAS, respectively. All the rice cultivars recorded the highest grasses density at 30 DAS and later declining trend was observed until harvest which was mainly due to their competitive growth as compared to grasses. Sedges density was the maximum at 45 DAS for all rice cultivars. However, BLWs density initially high at 15 DAS and thereafter declining trend was recorded which was mainly due to competitive growth and water stagnation at later growth stages. All rice cultivars shown differential category-wise weed density which was mainly due to their weed competitiveness growth behaviour.

Total weed density and biomass were significantly higher with WSR as compared to TPR at all growth stages (**Table 2**). Total weed density in WSR increased at the highest level at 30 DAS and thereafter it gradually started decreasing while TPR recorded the maximum weed density at 15 DAS and thereafter it declined to at minimum level at 60 DAT. It might be due to more competition occurred between rice and weeds which eliminated weaker weed plants in later stages. The maximum weed biomass was recorded at 60 DAS with both the establishment of WSR and TPR which might be due to more mature weeds resulted higher dry weed biomass. Parida *et al.* (2020) found that the weed density and weed biomass were significantly higher under dry-DSR as compared to TPR. Farooq *et al.* (2017) also reported less accumulation of weed dry biomass with TPR establishment method.

The total weed density and biomass were highly influenced by the hybrids and HYVs of rice. Initially at 15 DAS, all cultivars have non-significant effect on total weed density and biomass which might be due to lack of crop-weed competition and slow growth of crop. Naveen recorded the lowest total weed density and biomass while the maximum values for same obtained with PA 6444 at 30 DAS and at harvest. Rice varieties Tulasi and Mandya Vijaya registered the lowest total weed density and biomass at 45 and 60 DAS, respectively. It was noticed that two rice hybrids PA 6444 and KRH 2 recorded higher total weed density and biomass at all vegetative stages which indicated that hybrids were lesser weed competitiveness as compared to HYVs.

Rice growth, yield attributes and productivity

Rice growth and yield attributes were significantly affected by the rice establishment techniques except 1000-grain weight (**Table 3**). Transplanted rice recorded significantly higher plant height, tillers/m^2, panicles/m^2, panicle length and weight, filled grains/panicle and chaffy grains/panicle which subsequently led to significantly higher grain and straw yield and harvest index over the WSR. Due to less weed pressure, TPR recorded significantly higher grain and straw yield than WSR under uncontrolled weeds situation. The higher productivity with TPR is mainly due to very less weed competition and favourable environment that led to higher values for yield attributes of rice. Higher grain yield of rice

Table 1. Effect of rice establishment methods and rice varieties on category-wise weed density (2-year mean data)

Treatment	Grassy weed density (no./m^2)					Sedges weed density (no./m^2)					Broad-leaved weed density (no./m^2)				
	15 DAS/ DAT	30 DAS/ DAT	45 DAS/ DAT	60 DAS/ DAT	Harvest	15 DAS/ DAT	30 DAS/ DAT	45 DAS/ DAT	60 DAS/ DAT	Harvest	15 DAS/ DAT	30 DAS/ DAT	45 DAS/ DAT	60 DAS/ DAT	Harvest
Rice establishment methods															
Wet-seeded rice	185.9	538.5	301.9	301.3	177.1	110.9	320.7	493.1	542.8	164.4	56.7	11.7	19.7	36.5	11.1
Transplanted rice	22.7	7.5	11.6	9.8	9.5	28.5	40.5	26.3	27.2	22.1	19.9	7.8	9.2	6.1	7.9
LSD (p=0.05)	55.5	134.7	39.4	67.06	24.09	25.04	67.29	163.94	139.41	20.95	18.96	NS	7.32	18.13	NS
Rice varieties															
Mandya Vijaya	109.3	301.3	170.7	136.2	53.3	65.3	187.3	294.0	282.7	158.0	42.0	9.8	15.3	20.7	11.3
Dhanrasi	106.7	276.0	155.3	118.3	98.7	74.7	167.3	243.3	234.7	124.7	46.0	14.0	12.0	12.0	8.7
PA6444	108.0	361.3	109.3	107.5	158.7	82.0	210.0	396.7	330.7	98.7	40.7	14.0	15.3	18.7	5.3
KRH2	86.7	264.0	126.7	157.8	123.3	74.0	184.0	322.0	311.3	121.3	38.7	15.3	7.3	19.3	9.3
IR 64	111.3	296.0	236.0	209.3	99.3	71.3	174.7	164.0	317.3	56.7	42.0	8.7	15.3	21.3	16.7
IIRR Dhan 44	133.3	225.3	196.0	225.8	41.3	76.7	180.7	234.7	270.0	139.3	40.7	6.7	12.0	36.0	12.0
Tulasi	94.0	308.7	119.3	197.8	148.7	72.0	158.0	213.3	235.3	26.0	37.3	9.3	20.0	12.7	8.7
CR 2829	100.0	304.7	158.0	177.8	84.0	58.7	220.7	232.0	298.0	95.3	32.7	7.2	6.7	20.7	8.0
Naveen	107.3	174.0	142.0	150.0	94.0	68.0	176.7	264.0	272.0	30.7	32.7	5.5	26.0	36.7	8.7
Sahabhagi Dhan	86.0	218.7	154.0	75.2	31.3	54.7	146.7	232.7	298.0	82.0	30.0	7.17	14.7	15.3	6.0
LSD (p=0.05)	NS	93.1	51.9	36.11	23.96	NS	41.80	47.75	36.47	31.60	NS	5.86	8.77	9.75	NS

DAS = days after seeding; DAT = days after transplanting

Table 2. Effect of rice establishment methods and rice varieties on total weed density and biomass (2-year mean data)

Treatment	Total weed density (no./m^2)					Total weed biomass (g/m^2)				
	15 DAS/ DAT	30 DAS/ DAT	45 DAS/ DAT	60 DAS/ DAT	Harvest	15 DAS/ DAT	30 DAS/ DAT	45 DAS/ DAT	60 DAS/ DAT	Harvest
Rice establishment methods										
Wet-seeded rice	353.5	870.9	811.5	788.6	352.5	7.1	167.4	150.0	190.3	82.1
Transplanted rice	71.1	55.8	47.1	43.2	39.5	2.1	9.2	8.5	9.4	8.9
LSD (p=0.05)	45.7	199.95	197.94	152.71	52.79	3.84	22.79	43.73	34.55	13.19
Rice varieties										
Mandya Vijaya	216.7	498.5	480.0	439.5	222.7	3.8	95.4	88.4	94.3	52.2
Dhanrasi	227.3	457.3	410.7	365.0	232.0	5.1	90.5	76.2	78.8	54.1
PA6444	230.7	585.3	521.3	456.8	262.7	5.1	128.5	95.2	98.4	61.6
KRH2	199.3	463.3	456.0	488.5	254.0	3.2	80.8	83.3	105.7	59.6
IR 64	224.7	479.3	415.3	548.0	172.7	5.0	80.1	76.1	118.1	39.7
IIRR Dhan 44	250.7	412.7	442.7	531.8	192.7	3.8	69.1	81.0	114.7	44.4
Tulasi	203.3	476.0	352.7	445.8	183.3	5.8	100.1	65.0	96.5	42.5
CR 2829	191.3	532.5	396.7	496.5	187.3	8.3	70.9	73.1	108.6	43.2
Naveen	208.0	356.2	432.0	458.7	133.3	2.8	70.2	79.6	99.3	27.1
Sahabhagi Dhan	170.7	372.5	401.3	388.5	119.3	3.0	97.3	74.4	84.1	30.3
LSD (p=0.05)	NS	92.95	62.65	36.77	38.61	NS	27.57	10.80	7.40	8.90

DAS = days after seeding; DAT = days after transplanting

Table 3. Effect of rice establishment methods and rice varieties on growth, yield attributes and yield of rice (2-year mean data)

Treatment	Plant height (cm)	Tillers (m^2)	No. of panicles (m^2)	Panicle length (cm)	Panicle weight (g)	Filled grains/ panicle	Chaffy grains/ panicle	1000-grain weight (g)	Straw yield (t/ha)	Grain yield (t/ha)			Harvest index
										2015 -16	2016 -17	Pooled	
Rice establishment methods													
Wet-seeded rice	88.1	92.4	88.3	21.3	2.09	81.8	14.7	22.4	1.95	1.19	1.22	1.21	0.32
Transplanted rice	95.3	212.9	209.1	24.3	2.26	110.9	19.8	22.6	4.93	3.74	3.90	3.82	0.41
LSD (p=0.05)	3.12	18.19	6.11	2.63	0.04	14.06	4.89	NS	0.59	0.66	0.91	0.64	0.06
Rice varieties													
Mandya Vijaya	96.3	158.5	169.7	24.5	2.16	102.6	18.3	18.6	3.40	2.18	2.22	2.20	0.33
Dhanrasi	104.3	147.3	141.5	23.5	2.23	101.0	18.4	21.7	4.37	2.72	2.31	2.52	0.27
PA6444	92.5	105.5	101.8	24.3	2.18	100.9	20.1	20.8	3.27	2.36	2.38	2.37	0.21
KRH2	89.9	163.8	154.7	24.2	2.28	120.5	24.2	23.2	3.25	2.63	2.90	2.76	0.43
IR 64	77.9	163.3	157.3	21.1	2.04	67.1	11.6	25.9	3.11	1.88	1.96	1.92	0.33
IIRR Dhan 44	89.0	127.3	122.7	22.1	1.86	123.1	14.1	24.0	2.88	2.34	2.49	2.41	0.44
Tulasi	76.3	168.7	163.5	18.8	1.70	64.4	9.8	22.5	3.34	2.59	3.05	2.84	0.44
CR 2829	100.8	182.5	177.0	23.2	2.49	81.6	18.3	23.3	3.40	2.50	2.29	2.40	0.35
Naveen	97.0	181.3	174.8	23.3	2.45	107.7	16.6	20.9	4.50	3.23	3.30	3.26	0.39
Sahabhagi Dhan	93.2	128.2	123.8	23.3	2.36	94.7	20.9	24.1	2.91	2.22	2.71	2.46	0.45
LSD (p=0.05)	5.82	23.21	19.26	2.02	0.11	18.72	5.13	1.32	NS	0.46	0.34	0.57	0.08

with machine and manual transplanting over direct-seeded rice was also reported (Ramulu *et al.* 2020).

Growth and yield parameters of any variety mainly depends on its genetic make-up and environmental situations. All the tested rice varieties showed the varied growth and yield attributes values (**Table 3**). Rice variety Dhanrasi recorded significantly taller plants (104.3 cm) followed by CR 2829, Naveen and Mandya Vijaya. However, rice varieties Tulasi and IR 64 recorded the lowest plant height among the tested rice varieties. Rice varieties CR 2829 and Naveen recorded significantly higher number of tillers/m^2 (182.5 and 181.3) and number of panicles/m^2 (177 and 174.8), respectively. The lowest values for tillers/m^2 (105.5) and panicles/m^2 (101.8) were recorded with rice hybrid PA 6444. The maximum panicle length was observed with rice variety Mandya Vijaya and was statistically at par with Dhanrasi, PA 6444, KRH 2, CR 2829, Naveen and Sahabhagi Dhan. However, the heavier panicles were recorded with CR 2829 and Naveen while Tulasi recorded the shortest and the lightest panicles among all the rice varieties. The maximum chaffy grains per panicle were recorded in rice hybrid KRH 2 which also remained at par with another hybrid PA 6444 and Sahabhagi Dhan. However, the minimum chaffy grains per panicle were observed in Mandya Vijaya. IR 64 recorded the highest 1000-grains weight followed by Sahabhagi Dhan and IIRR Dhan 44. The comparatively higher values of plant height and yield attributes like tillers/m^2, panicles/m^2, panicle length and weight with Naveen resulted the maximum grain and straw yield and remained significantly superior over all varieties except Tulasi and KRH 2. Thus, Naveen, Tulasi and KRH 2 rice cultivars had better weed competitiveness due to their vigorous growth and yield attributes under shallow lowland conditions. The least grain and straw yield were obtained from rice variety IR 64 followed by CR 2829 and rice hybrid PA 6444 due to their least competitiveness against weeds. The weed competitive rice cultivar should have weed suppressing traits like uniform crop establishment, high and early seedling vigour with rapid leaf area development during the early vegetative stage for weed suppression, allelopathic effect, and herbicide-resistance (Gibson and Fischer 2004; Zhao 2006, Mahajan and Chauhan 2013; Dass *et al.* 2013; Dimaano *et al.* 2017).

Conclusion

It can be concluded that transplanting of rice using rice cultivars Naveen, Tulasi and KRH 2, that have more vigorous growth, helps in suppressing weeds and obtaining higher rice productivity in the shallow lowlands.

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