

Effect of crop establishment methods and organic weed management on nutrient uptake, soil fertility and yield of aromatic rice

Abstract

A field experiment was carried out during *kharif*, 2019 in organic block of Instructional-cum-Research farm of Assam Agricultural University, Jorhat, Assam, India to evaluate the effects of systems of rice establishment and organic weed management practices on the yield, nutrient uptake and soil fertility of aromatic rice variety *Kola joha*. The experiment was laid out in split-plot design with systems of establishment in the main plot and organic weed management practices in the sub plot. The transplanting method of establishment resulted significantly higher grain yield (18.17 q ha^{-1}) and nutrient uptake over the direct seeded method. Among the organic weed management practices, the highest grain yield (21.95 q ha^{-1}) and nutrient uptake were recorded with hand weeding at 20 and 40 DAT/DAS which was followed by intercropping of *dhaincha* and incorporation at 40 DAT/DAS (16.90 q ha^{-1}). The highest available N content ($260.86 \text{ kg ha}^{-1}$) in post harvest soil was recorded with intercropping of *dhaincha* and incorporation at 40 DAT whereas the highest available P_2O_5 and K_2O contents of soil were recorded with hand weeding at 20 and 40 DAT/DAS.

Keywords: Aromatic rice, grain yield, nutrient uptake, organic weed management

1. INTRODUCTION

Agriculture in Assam is rice centric and it occupies an area of 2.45 million hectares with a production of 5.23 million tonnes (Anonymous, 2018). The state of Assam has been endowed with wide range of variation of rice cultivars including the aromatic rice cultivars having good demand in the local and export market. Therefore, organic production of aromatic rice could be a profitable livelihood option for the farming community of the state of Assam. The aromatic rice of Assam is a unique class under *sali (kharif)* rice traditionally known as *Joha*. The *Joha* rice cultivars are known for its unique aroma, superfine kernel, good cooking qualities and excellent palatability (Das *et al.*, 2010). Organic rice cultivation has been practiced traditionally by the resource poor farmers of the state of Assam since long back. However, the productivity of these organic rice production systems is quite

low due to improper nutrient, weed and pest management practices. Yield losses due to weeds in low land rice field's ranges from 20-60% and 30-80 % in transplanted and direct seeded rice, respectively (Janiya *et al.*, 2002). Despite the serious threat weeds offer to organic rice production, relatively less research works has been conducted so far exclusively on weed management in organic production system. Therefore, present research was carried out to determine suitable organic method of weed management under suitable system of establishment.

2. MATERIALS AND METHODS

A field experiment was carried out during *kharif* season of 2019 in organic block of Instructional-cum-Research farm of Assam Agricultural University, Jorhat, Assam, India. The climate of the area is subtropical with an average annual rainfall of 204.20 cm. The mean maximum and minimum temperature during the crop growing period ranged from 25.8°C to 34.8°C and 14.6°C to 26°C, respectively. Weekly average relative humidity during the crop growing season ranged from 86 to 99 % during morning hours and 63 to 90 % during afternoon hours. The soils of the experimental site were sandy loam in texture with pH 5.9, medium in organic carbon (0.58%), low in available N (242.5 kg ha⁻¹), low in available P₂O₅ (18.60 kg ha⁻¹) and medium in available K₂O (140.6 kg ha⁻¹). The experiment was laid out in split-plot design with three replications. The size of each plot was 15 m² (5m x 3m). The treatments consisted of two systems of establishment *viz.*, transplanting (SE₁) and direct seeded (wet seeding) method (SE₂) in the main plot and five organic weed management practices *viz.*, weedy check (WM₀), hand weeding at 20 and 40 DAT/DAS (WM₁), weeding with rotary weeder at 20 and 40 DAT/DAS (WM₂), weeding with cono weeder at 20 and 40 DAT/DAS (WM₃) and intercropping of *dhaincha* (*Sesbania aculeata*) and incorporation at 40 DAT/DAS (WM₄) in the sub-plots. The seedlings of traditional aromatic rice variety *Kola joha* was raised organically in nursery bed for the transplanting method of establishment. Pre-germinated rice seeds were manually line sown in the main field as per the treatments of directed seeded method of establishment on the same day of nursery sowing of rice seeds for the transplanted crop. The recommended dose of N for traditional rice variety of Assam @ 20 kg ha⁻¹ was supplied uniformly to all the plots through 1/3 rd each of farm yard manure, vermicompost, and mustard oil cake. The requirement of P and K of the crop was not supplied separately. The 25 days old rice seedlings were transplanted using 2 seedlings per hill. The spacing adopted for both transplanted and direct seeded was 20 x 15 cm. As per the 5th weed management treatment, *dhaincha* seeds were sown on the day of sowing and transplanting in between the rows of rice maintaining one row of *dhaincha* between two rows of rice. Plant samples collected at 60 DAT/DAS and at harvest were oven dried, ground and analyzed for nitrogen by Kjeldahl method (Jackson, 1973), phosphorus by Vanadomolybdate method and potassium by flame photometer method. The uptake of N, P, and K was estimated by multiplying N, P, K content of crop with the dry weight of crop at 60 DAT/DAS and harvest.

$$\text{Nutrient uptake} = \frac{\text{Grain/straw yield hectare}^{-1} (\text{kg ha}^{-1}) \times \text{Nutrient content in grain/straw} (\%)}$$

3. RESULTS AND DISCUSSION

3.1 Grain yield and straw yield

Transplanting (SE_1) of rice recorded significantly higher grain yield (18.17 q ha^{-1}) and straw yield (30.12 q ha^{-1}) as compared to the direct wet seeding (SE_2) method of establishment (11.10 q ha^{-1} , 20.17 q ha^{-1}). This might be due to lesser crop weed competition in transplanted method which resulted in better plant growth and efficient utilization of growth resources. Among the weed management treatments, hand weeding at 20 and 40 DAT/DAS produced the highest grain yield (21.9 q ha^{-1}) and straw yield (35.03 q ha^{-1}) which was followed by intercropping of *dhaincha* and incorporation at 40 DAT/DAS (Table 1). Manual weeding has more advantage because of complete removal of weeds and helps in increasing grain and straw yield. Increased grain and straw yield with hand weeding at 20 and 40 DAS was earlier reported by Barla *et al.* (2016). Intercropping *dhaincha* which added not only valuable plant nutrient through atmospheric fixation of N, but also reduce the occurrence of weed by occupying the interspaces. Thus, led to increased grain and straw yield.

Table 1: Yield (q ha^{-1}) and straw yield (q ha^{-1}) as influenced by systems of establishment and organic weed management practices in aromatic rice

Treatment	Grain yield	Straw yield	Harvest Index (%)
Establishment method			
SE_1 : Transplanting	18.17	30.12	37.23
SE_2 : Direct seeded	11.10	20.57	34.00
SEm_{\pm}	0.18	1.09	0.29
CD ($P=0.05$)	1.09	6.60	1.80
Weed management			
WM_0 : Weedy check	8.38	16.08	34.83
WM_1 : Hand weeding at 20 and 40 DAT/DAS	21.95	35.03	36.80
WM_2 : Weeding by rotary weeder at 20 and 40 DAT/DAS	14.37	24.89	35.43
WM_3 : Weeding by cono weeder at 20 and 40 DAT/DAS	11.58	21.48	35.32
WM_4 : Intercropping of <i>dhaincha</i> and incorporation at 40 DAT/DAS	16.90	29.26	35.66
SEm_{\pm}	1.02	0.61	1.14
CD ($P=0.05$)	3.06	1.85	-
Interaction ($SE \times WM$)			
SEm_{\pm}	1.45	1.40	-
CD ($P=0.05$)	3.99	6.78	-

DAS: Days after sowing, DAT: Days after transplanting

3.2 Nutrient content and uptake of rice at harvest

Systems of rice establishment significantly influenced the nutrient content and uptake of rice grain and straw except for phosphorous content (Table 2). Higher N, P and K uptake by rice grain

and straw were recorded in transplanting method as compared to wet seeding method. Among the organic weed management practices, intercropping of *dhaincha* and incorporation at 40 DAT/DAS (WM₄) recorded significantly the highest nitrogen content of grain (1.1 %) and straw (0.76 %). The phosphorus and potassium contents were recorded highest with hand weeding at 20 and 40 DAT/DAS (WM₁). Hand weeding at 20 and 40 DAT/DAS (WM₁) resulted the highest N, P and K uptake due to higher grain yield and straw yield recorded under this treatment. This finding is in conformity with the findings of Radhakrishnan *et al.* (2010), Ravisankar *et al.* (2008), Fageria (2004).

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Table 2: N, P and K content and uptake of rice at harvest as influenced by systems of establishment and organic weed management in aromatic rice

Treatments	N Content (%)		P Content (%)		K Content (%)		N Uptake (Kg ha ⁻¹)			P Uptake (Kg ha ⁻¹)			K Uptake (Kg ha ⁻¹)		
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment method															
SE ₁ : Transplanting	1.02	0.66	0.26	0.17	0.73	0.99	19.14	20.82	39.96	4.86	5.40	10.26	14.35	30.51	44.86
SE ₂ : Direct seeded	0.96	0.63	0.25	0.16	0.71	0.97	10.46	13.54	24.01	2.76	3.41	6.18	7.98	20.41	28.40
SEm±	0.004	0.004	0.006	0.0073	0.0041	0.003	0.13	0.57	0.60	0.06	0.24	0.18	0.21	0.97	0.93
CD (P=0.05)	0.027	0.02	NS	NS	0.025	0.01	0.79	3.50	3.69	0.37	1.48	1.15	1.30	5.90	5.71
Weed management															
WM ₀ : Weedy check	0.78	0.51	0.21	0.14	0.42	0.82	6.10	8.34	14.45	1.65	2.37	4.02	3.27	13.28	16.55
WM ₁ : Hand weeding at 20 and 40 DAT/DAS	1.08	0.73	0.28	0.19	0.91	1.07	23.6	25.70	49.31	6.05	6.94	13.00	19.86	37.68	57.54
WM ₂ : Weeding by rotary weeder at 20 and 40 DAT/DAS	1.02	0.65	0.26	0.163	0.73	0.99	14.49	16.34	30.83	3.78	4.06	7.84	10.34	24.82	35.16
WM ₃ : Weeding by cono weeder at 20 and 40 DAT/DAS	0.98	0.60	0.25	0.16	0.69	0.96	11.24	13.02	24.27	2.86	3.44	6.31	7.95	20.85	28.80
WM ₄ : Intercropping of <i>dhaincha</i> and incorporation at 40 DAT/DAS	1.1	0.76	0.27	0.17	0.85	1.04	18.55	22.50	41.06	4.73	5.22	9.95	14.42	30.67	45.09
SEm±	0.009	0.006	0.007	0.0075	0.0049	0.008	1.10	0.38	1.29	0.24	0.31	0.44	0.89	0.56	1.26
CD (P=0.05)	0.029	0.01	0.02	0.022	0.014	0.02	3.31	1.15	3.89	0.73	0.95	1.32	2.67	1.69	3.78
Interaction (SE x WM)	NS	NS	NS	NS	NS	NS	S	S	S	S	NS	S	S	S	S

3.3 Available N, P₂O₅ and K₂O content of soil:

Crop establishment methods significantly influenced the available N, P₂O₅ and K₂O contents of post harvest soil (Table 3). The transplanting method resulted in higher nutrient content compared to the direct seeded method. Among the weed management practices, available N content (260.86 kg ha⁻¹) of soil was highest with intercropping of *dhaincha* and incorporation at 40 DAT (WM₄) followed by hand weeding at 20 and 40 DAT/DAS (WM₁) (255.53 kg ha⁻¹). The available P₂O₅ and K₂O content of soil were recorded highest in WM₁ (16.21 kg ha⁻¹, 141.91 kg ha⁻¹) followed by WM₄ treatment (14.81 kg ha⁻¹, 139.76 kg ha⁻¹). Similar findings were reported by Kumar and Sahi, 2016.

Table 3: Effect systems of establishment and organic weed management practices on available N, P₂O₅ and K₂O of soil after harvest of aromatic rice

Treatments	N (kg ha ⁻¹)	P ₂ O ₅ (kg ha ⁻¹)	K ₂ O (kg ha ⁻¹)
Establishment method			
SE ₁ : Transplanting	243	13	138
SE ₂ : Direct seeded(wet seeding)	233	12	135
SEm±	0.37	0.12	0.48
CD (P=0.05)	2.28	0.78	2.96
Weed management			
WM ₀ : Weedy check	202.38	8.30	129.65
WM ₁ : Hand weeding at 20 and 40 DAT/DAS	255.53	16.21	141.91
WM ₂ : Weeding by rotary weeder at 20 and 40 DAT/DAS	239.08	12.26	136.06
WM ₃ : Weeding by cono weeder at 20 and 40 DAT/DAS	232.06	10.23	133.28
WM ₄ : Intercropping of <i>dhaincha</i> and incorporation at 40 DAT/DAS	260.86	14.81	139.76
SEm±	1.64	0.21	0.60
CD (P=0.05)	4.93	0.64	1.81
Interaction (SE × WM)	-	-	-

3.4. N, P and K uptake by weeds at 60 DAT/DAS and at harvest

Systems of establishment significantly influenced the N, P and K uptake by weeds (Table 4). The transplanting method resulted in lower nutrient uptake by weeds compared to wet seeded rice at both the stages of observations. As discussed earlier, the transplanted seedlings established well and competed better with weeds for growth resources than wet seeded seedlings. Similar findings were earlier reported by Chander and Pandey (2001). All the weed management practices recorded significantly lower N, P and K uptake by weeds compared to the weedy check treatment (WM₀). Treatment comprising hand weeding at 20 and 40 DAT/DAS (WM₁) resulted the lowest nitrogen (4.74 kg ha⁻¹) and phosphorus (3.01 kg ha⁻¹) uptake by weeds at 60 DAT/DAS followed by intercropping of *dhaincha* and incorporation at 40 DAT/DAS (WM₄) (5.69, 3.88 kg ha⁻¹), respectively. Potassium uptake (2.99 kg ha⁻¹) was significantly low in hand weeding at 20 and 40 DAT/DAS (WM₁) and found

at par with intercropping of dhaincha and incorporation at 40 DAT/DAS (WM₄) (4.0 kg ha⁻¹). Hand weeding at 20 and 40 DAT/DAS (WM₁) recorded the lowest nitrogen, phosphorus, and potassium uptake (4.26, 1.23 and 4.40 kg ha⁻¹), respectively by weeds followed by intercropping of dhaincha and incorporation at 40 DAT (WM₄) of rice (5.89, 1.76 and 5.76 kg ha⁻¹) at harvest.

Table 4. N, P and K uptake (kg ha⁻¹) by weeds at 60 DAT/DAS and at harvest as influenced by systems of establishment and organic weed management practices in aromatic rice

Treatments	60 DAT/DAS			Harvest		
	N	P	K	N	P	K
Establishment method						
SE ₁ : Transplanting	9.28	6.04	6.30	6.50	1.83	6.09
SE ₂ : Direct seeded (Wet seeding)	13.96	8.54	9.49	13.64	3.79	12.07
SEm±	0.15	0.06	0.15	0.09	0.08	0.10
CD (P=0.05)	0.94	0.41	0.96	0.55	0.51	0.64
Weed management						
WM ₀ : Weedy check	25.22	15.11	17.75	19.92	5.54	17.90
WM ₁ : Hand weeding at 20 and 40 DAT/DAS	4.74	3.01	2.99	4.26	1.23	4.40
WM ₂ : Weeding by rotary weeder at 20 and 40 DAT/DAS	9.17	5.78	5.94	8.30	2.15	6.92
WM ₃ : Weeding by cono weeder at 20 and 40 DAT/DAS	13.27	8.67	8.79	12.35	3.38	10.43
WM ₄ : Intercropping of <i>dhaincha</i> and incorporation at 40 DAT/DAS	5.69	3.88	4.0	5.89	1.76	5.76
SEm±	0.27	0.14	0.54	0.23	0.07	0.18
CD (P=0.05)	0.81	0.42	1.62	0.69	0.22	0.55
Interaction (SE × WM)	S	S	S	S	S	S

4. CONCLUSION

Hand weeding at 20 and 40 DAT/ DAS was found to be the best organic weed management practice for maximization of yield, nutrient uptake and soil fertility maintenance under both transplanted and direct seeded method of rice establishment of aromatic rice. Intercropping of *dhaincha* and incorporation at 40 DAT/ DAS was found to be the next best alternative organic weed management practice for aromatic rice.

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