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Yumnam Sanatombi Devi
Department of Agronomy, College of Agriculture, Central Agricultural University, Iroishemba, Imphal, Manipur, India

M Sumarjit Singh
Department of Agronomy, College of Agriculture, Central Agricultural University, Iroishemba, Imphal, Manipur, India

Jamkhogim Lhungdim
Department of Agronomy, College of Agriculture, Central Agricultural University, Iroishemba, Imphal, Manipur, India

L Nabachandra Singh
Department of Agronomy, College of Agriculture, Central Agricultural University, Iroishemba, Imphal, Manipur, India

Y Bebila Chanu
Department of Agronomy, College of Agriculture, Central Agricultural University, Iroishemba, Imphal, Manipur, India

Corresponding Author:
Yumnam Sanatombi Devi
Department of Agronomy, College of Agriculture, Central Agricultural University, Iroishemba, Imphal, Manipur, India

Effect of crop establishment methods and organic manures on the growth of black aromatic rice

Yumnam Sanatombi Devi, M Sumarjit Singh, Jamkhogim Lhungdim, L Nabachandra Singh and Y Bebila Chanu

Abstract
A field experiment was conducted at the College of Agriculture, CAU, Imphal, Manipur during the kharif season of 2017-18. The design was carried out in split plot with 12 treatments replicated thrice. Crop establishment methods and organic manures had significant impact on growth. The recent data revealed that among the crop establishment methods in both the season S_3 (System of Rice Intensification) resulted in marked increased in growth parameters, viz. plant height, total number of tillers per hill and days to 50 % flowering also earlier in S_3. But leaf area index and dry matter accumulation (g/m^2) were highest in S_2 (Transplanting conventional method) as compared with other establishment methods. Among the manurial combination treatments N1 (Recommended dose of fertilizer) recorded highest growth parameters in first season which was at par with the N_4 (50% FYM + 50 % Loktak phumdi compost) and in second season N_4 (50% FYM + 50% Loktak phumdi compost) showed higher growth parameters.

Keywords: Direct seeded, transplanting, System of rice intensification, Loktak phumdi compost, farm yard manure

Introduction
Black aromatic rice is a type of the rice species *Oryza sativa* L. locally known as Chak- Hao in Manipur which is glutinous, packed with high level of nutrients Till very late, the black rice is not cultivated commercially as the same cannot be used as staple food thereby resulting the limited market acess. But now having realised the inherent unique properties, a good scope for commercial cultivation and value addition of its products for a profitable agro-business have been envisioned. Black rice is popular and mixed with white rice prior to cooking to enhance the flavor, colour and nutritional value (Yang *et al.,* 2003) [31]. Black aromatic rice is considered to be the healthiest rice variety which contains higher levels of proteins, vitamins and minerals than common white rice (Suzuki *et al.,* 2004) [26]. Black aromatic rice owes its colour to potent natural black colouring pigments called anthocyanins which claim an impressive antioxidant activity adding to the health benefits of this rice variety. Supplementation of black aromatic rice in the diet will have a great impact on human health (Asem *et al.,* 2015) [1]. In addition to being a good source of vitamin E, fibre and protein black is shown to reduce inflammation levels in the body. According to findings of the research, black rice consumption contributes to the prevention and management of serious conditions such as high cholesterol levels, arthritis, allergies and even cancer.
Method of establishment is one of the cultural practices, which impacts the rice crop through its effect on growth and development (Gopi *et al*., 2006) [6]. Transplanting is the most dominant and traditional method of establishment in irrigated low land rice. The area under transplanted rice in world is decreasing due to scarcity of water and labour. So, there is need to examine for alternate crop establishment methods to increase the productivity of rice (Farooq *et al*., 2011) [5]. Direct seeding of rice allows early establishment of the succeeding crop and higher profit in areas with certain water supply by utilizing short duration modern varieties and cost efficient herbicides (Balasubramanian and Hill, 2002) [3]. However, this has been accompanied by increase in weed problems and a shift in dominant grassy weeds. The innovative systems of rice cultivation such as System of Rice Cultivation (SRI) is being evolved to increase the growth of irrigated rice. Enhancing the rice productivity through the improvement of growth potential of genotypes and appropriate nutrient management has been the thrust of Indian rice policy. Rice yield and biomass increased rapidly due to increased use of chemical fertilizers. In the recent years, crop productivity has stagnated or decreased in spite of consumption of increased rate of chemical fertilizers. Benefits of organic manures like farm yard manure and compost are well known but the availability is reducing day by day.

These organic manures are not only good sources of nutrients but also improve physical structure of soil (Ramesh *et al*. 2005) [18]. Apart from containing NPK which also contain small amounts of trace elements especially boron, copper, iron, sulphur, zinc and with fair quantity of growth promoting substances. Keeping these points in view the present investigation was undertaken to evaluate the comparative effects of different crop establishment methods and organic manures on growth of black aromatic rice.

Materials and Methods

A field experiment was conducted at the College of Agriculture, CAU, Imphal, Manipur during the *Kharif* season of 2017-18 which is located at 24 ^{0}81' N latitude and 93^{0}89'E longitude and an altitude of 790 m above the mean sea level. The experiment was carried out in split plot design with replicated thrice. The treatments comprised of three establishment method *viz*. direct seeded rice, normal transplanting and SRI in main plots and four nutrient management in sub plots *viz*., Conventional method (60:40:30 kg/ha), 100% RD of FYM, 100% RD of Loktak Phumdi compost and 50 % RD of FYM + 50 % RD of Loktak Phumdi compost. The soil samples were collected randomly from 0 to 15 cm depth from 5 spots of the experimental field just before layout of experiment. The soil of experimental site was clay soil in texture having pH 5.57, organic carbon 1.3 %, available nitrogen 304.51 kg/ha, available phosphorus 18.90 kg/ha and available potassium 142.02 kg/ha. The experimental field was ploughed with the help of tractor drawn plough followed by harrowing and planking followed by flooding and puddling operations done manually. Seeds were sown in the nursery following the recommended package and practices. On the same day direct seeding rice were sown in the experimental plot. 21 days old rice seedlings were transplanted manually at a spacing of 20cm X 10 cm in the experimental field for normal transplanting crop establishment method. 10 days old rice seedlings were transplanted manually at a spacing of 25cm X 25cm in the experimental field for SRI crop establishment method. FYM and Loktak Phumdi Compost were applied 20 days before direct seeding and transplanting as per treatment and well incorporated to the soil. For recommended dose of fertilizer half dose of nitrogen was applied through urea, full dose of phosphorus through SSP and Potassium through MOP were applied as basal. The remaining 50% Nitrogen was top dressed through urea at active tillering stage and panicle initiation stage. Weeding were done during the critical crop weed competition period. Soil analysis of pH, organic carbon, nitrogen, phosphorus and potassium were done as Walkley and Black, 1934, Subbiah and Asija, 1956 and Jackson, 1973) [29, 24, 9]. Observations were recorded from 10 tagged hills in running from each plot by leaving the 3 border rows at 30, 60, 90 and 120 DAS. The leaf area index was calculated by using the formula (Watson, 1952) [30].

$$LAI = \frac{\text{Area of total number of leaves}}{\text{Ground area from which leaves sample are collected}}$$

All data obtained were subjected to analysis of variance (ANOVA) and significant differences between the means were determined using Split plot design at 5% probability level. (Gomez and Gomoz, 1976) [7].

Result and Discussions

Plant height (cm): Observation recorded on plant height of black aromatic rice at different growth stages revealed that the plant height increased with the advancement of crop age and reached the maximum in maturity. At 30 DAS effect of crop establishment and organic manures on plant height (cm) was found non-significant. But at 60 DAS, 90 DAS and 120 DAS plant height (cm) was affected by various crop establishment method and organic manures (Table 1). Among crop establishment method highest plant height was observed in SRI (S_3) followed by normal transplanting (S_2) and lowest in direct seeding (S_1). Higher performance of SRI over other might be due to younger seedlings of SRI provided sufficient nutrients for vegetative growth by effective utilization of phyllochronic concept, bringing about increased growth and development (Shekhar *et al*., 2009) [22]. Similar findings have been made by Munda *et al*., 2007 [15]. Pooled data revealed that among nutrient management application of 50% FYM + 50% Loktak Phumdi compost gave the highest plant height but it was found to be at par with Conventional method (60:40:30 kg/ha) (Table 1). This might be due to vermicompost and FYM contains many humic acids which improves the morphological traits of the crop and thus increases the plant height and reduces the period of slow growth. (Atarzadeh *et al*., 2013) [2].

Total number of tillers per hill: The number of tillers per hill gradually increases up to 90 DAS. At 30 DAS effect of crop establishment and organic manures on total number of tillers per hill was found non-significant. But at 60 DAS, 90 DAS and 120 DAS total number of tillers per hill was affected by various crop establishment method and organic manures (Table 2). Among crop establishment method maximum number of tillers per hill was observed with SRI (S_3) followed by normal transplanting (S_2) and lowest in direct seeding (S_1). Hugar *et al*., (2009) [8] reported that SRI method of cultivation recorded significantly higher number of tillers followed by conventional transplanting and aerobic rice respectively. Rajesh and Thanunathan (2003) [17] observed that the roots of rice plants have least competition under wider spacing so that growth is motivated by sunlight and space for the canopy expansion. Among nutrient management pooled data revealed that application of 50% FYM + 50% Loktak Phumdi compost gave the maximum number of tillers per hill but it was found to be at par with Conventional method (60:40:30 kg/ha). This might be due to higher concentration of macro and micro nutrients in the vermicompost which was attributed to higher rate of N minerization as a result of high cation exchange capacity, slow and gradual release of N could make period, thus enhances the number of productive tillers per m^2 (Sathish Kumar *et al*., 2007). The results are in accordance with the earlier finding of Sharma *et al*. (2013) [21].

Leaf area index: Leaf area index (LAI) is an important plant growth index which determines the capacity of plants to trap solar energy for photosynthesis. LAI increased progressively with the increase in age and reached maximum at 90 DAS and declined thereafter till harvest (Table 3). The maximum value of LAI was recorded in transplanting (S_2) which was followed by SRI (S_3) and least in direct seeding (S_1). This might be due to the number of leaves per unit area to be higher with transplanting method. In case of any plant, leaves are

important organs which have an active role in photosynthesis. Futhermore, dry matter production in rice is significantly related to intercept photosynthetically avtive radiation (Kiniry *et al*., 2001) [10]. Among nutrient management pooled data revealed that application of 50% FYM + 50% Loktak Phumdi compost gave the maximum LAI but it was found to be at par with Conventional method (60:40:30 kg/ha). In present research we found that organic fertilizer alone and in combination with chemical fertilizers significantly increased the flag leaf length over untreated control. Similar finding are reported by Mirza *et al*., (2010) [14]. The more number of tillers and leaves couple with better expansion might have help in enhancing the different growth parameters. Vennila *et al*. (2007) [28] and Surekha *et al*. (2008) [25].

Days to 50 % flowering: Among crop establishment method days to 50% flowering was recorded significantly earlier in SRI, broadcasting and line sowing than conventional transplanting methods. (Table 4) This was due to better root establishment from day of germination and lacks of transplanting shock (Thakur *et al*., 2017) [27]. Similar finding were reported by Laary *et al*. (2012) [13]. Days taken to 50% flowering of rice were affected significantly with the level of nutrients. According to pooled data analysis maximum number of days taken to 50% flowering were recorded with 50% FYM + 50% Loktak Phumdi compost which remained at par with Conventional method (60:40:30 kg/ha). This might be due to better availability of nutrients applied either through fertilizer or in combination of organic sources increased vegetative phase of the crop vis. delayed flowering as compared to sub-optimal supply of nutients to rice crop (Singh, N.P.,2018) [23].

Dry matter accumulation (g/m^2): Dry matter accumulation was influenced significantly by different crop establishments methods (Table 5). The transplanted rice as recommended recorded significantly higher dry matter accumulation than remaining treatment at all the growth stages. Crop dry matter is directly proportional to total biological yield. Similar results were reported by earlier workers Kumar *et al*., (2009) and Senthilkumar, S. (2007) [6]. Application of 50% FYM + 50% Loktak Phumdi compost in rice recorded significantly highest dry matter accumulation which remained at par with Conventional method (60:40:30 kg/ha) at all growth stages. This might be attributed due to the fact that higher availability of nutrients in the soil for plant nourishment and further, organic source release slow and continuous availability of nutrients enhances cell division, elongation as well as various metabolic processes which increased plant growth attributes which ultimately attained the highest source capacity and dry matter accumulation. The results have got close conformity with the findings of Krishna *et al*., (2008) [11], Dutt and Chauhan (2010) [4] and Murthy (2012) [16].

Table 1: Effect of crop establishment methods and organic manures on plant height (cm) of black aromatic rice

Treatment	30 DAS			60 DAS			90 DAS			120 DAS		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
S_1	48.34	65.45	56.62	98.82	106.02	102.42	139.37	143.20	141.28	166.46	178.37	172.41
S_2	46.17	62.16	54.17	108.98	109.69	109.34	148.87	150.36	149.61	179.72	186.09	182.91
S_3	46.43	64.03	55.23	115.08	115.32	115.20	157.84	156.35	157.09	191.63	192.42	192.03
S.Ed±	1.49	1.19	0.99	2.61	1.99	1.49	1.97	0.88	1.13	4.15	3.16	2.75
CD(p=0.05)	NS	NS	NS	7.28	5.52	4.13	5.49	2.44	3.14	11.51	8.78	7.64
N_1	48.11	64.25	56.18	112.03	111.62	111.83	152.64	150.37	151.51	189.15	187.54	188.35
N_2	45.35	62.34	53.85	102.75	107.34	105.05	145.67	147.14	146.41	170.33	180.26	175.29
N_3	46.75	63.31	55.03	105.85	108.61	107.23	146.77	148.41	147.59	172.78	182.63	177.70
N_4	46.97	65.62	56.30	109.88	113.81	111.84	149.69	153.95	151.82	184.82	192.09	188.46
S.Ed±	1.39	1.18	0.96	1.49	1.13	0.82	1.84	0.82	1.06	3.17	2.95	2.02
CD(p=0.05)	NS	NS	NS	3.14	2.38	1.73	3.86	1.72	2.24	6.67	6.20	4.24
Interaction	NS	NS	NS	S	S	S	S	S	S	S	S	S

Table 2: Effect of crop establishment methods and organic manures on number of tillers per hill of black aromatic rice

Treatment	30 DAS			60 DAS			90 DAS			120 DAS		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
S_1	5.07	5.23	5.15	6.39	6.67	6.53	8.07	8.56	8.32	7.71	8.34	8.03
S_2	4.70	4.83	4.76	7.78	7.80	7.79	9.31	9.56	9.43	8.57	9.37	8.97
S_3	4.82	5.02	4.92	9.34	9.44	9.39	10.03	10.21	10.12	9.56	0.37	9.97
S.Ed±	0.44	0.20	0.26	0.53	0.41	0.46	0.25	0.41	0.16	0.19	0.28	0.22
CD(p=0.05)	NS	NS	NS	1.47	1.14	1.29	0.69	1.13	0.45	0.55	0.78	0.61
N_1	5.33	5.07	5.20	8.85	8.65	8.75	10.21	9.83	10.02	9.57	9.65	9.61
N_2	4.40	4.81	4.61	6.72	7.01	6.87	8.13	8.69	8.41	7.69	8.70	8.19
N_3	4.63	4.89	4.76	7.01	7.25	7.13	8.33	8.94	8.64	7.95	8.97	8.46
N_4	5.09	5.34	5.21	8.77	8.98	8.88	9.88	10.30	10.09	9.25	10.12	9.69
S.Ed±	0.39	0.19	0.24	0.26	0.17	0.15	0.18	0.25	0.15	0.16	0.22	0.17
CD(p=0.05)	NS	NS	NS	0.54	0.36	0.32	0.38	0.52	0.32	0.34	0.47	0.37
Interaction	NS	NS	NS	S	S	S	S	S	S	S	S	S

Table 3: Effect of crop establishment methods and organic manures on leaf area index of black aromatic rice

Treatment	30 DAS			60 DAS			90 DAS			120 DAS		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
S_1	0.78	0.79	0.78	1.33	1.35	1.34	1.79	1.84	1.82	1.51	1.52	1.51
S_2	0.73	0.74	0.74	2.05	2.09	2.07	2.75	2.78	2.76	2.34	2.41	2.37
S_3	0.25	0.25	0.25	1.39	1.40	1.39	1.81	1.85	1.83	1.53	1.54	1.53
S.Ed±	0.07	0.06	0.05	0.05	0.05	0.03	0.04	0.05	0.06	0.04	0.05	0.05
CD(p=0.05)	NS	NS	NS	0.14	0.14	0.09	0.12	0.16	0.17	0.10	0.14	0.14
N_1	0.59	0.60	0.60	1.74	1.71	1.72	2.27	2.20	2.23	1.92	1.93	1.92
N_2	0.57	0.57	0.57	1.46	1.48	1.47	1.96	2.03	1.99	1.65	1.67	1.66
N_3	0.58	0.59	0.58	1.46	1.49	1.48	2.04	2.12	2.08	1.70	1.74	1.72
N_4	0.59	0.62	0.61	1.69	1.78	1.73	2.21	2.28	2.24	1.89	1.95	1.92
S.Ed±	0.04	0.04	0.03	0.04	0.04	0.02	0.03	0.05	0.05	0.03	0.04	0.04
CD(p=0.05)	NS	NS	NS	0.08	0.08	0.05	0.08	0.11	0.11	0.06	0.09	0.09
Interaction	NS	NS	NS	S	S	S	S	S	S	S	S	S

Table 4: Effect of crop establishment methods and organic manures on day to 50% flowering of black aromatic rice

Treatments	2017	2018	Pooled
S_1	93.25	91.42	92.33
S_2	95.00	92.83	93.92
S_3	90.58	89.08	89.83
S.Ed±	1.19	0.91	0.97
CD(p=0.05)	3.31	2.53	2.69
N_1	94.22	92.00	93.11
N_2	91.33	89.22	90.28
N_3	92.22	90.44	91.33
N_4	94.00	92.78	93.39
S.Ed±	0.81	0.89	0.70
CD(p=0.05)	1.70	1.89	1.48
Interaction	S	S	S

Table 5: Effect of crop establishment methods and organic manures on dry matter accumulation (g/m^2) of black aromatic rice

Treatment	30 DAS			60 DAS			90 DAS			120 DAS		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
S_1	151.37	151.83	151.60	523.72	556.80	540.26	1110.04	1141.87	1125.96	1679.56	1712.82	1696.19
S_2	134.68	138.93	136.81	635.96	635.57	635.77	1260.16	1264.87	1262.51	1848.73	1867.04	1857.88
S_3	144.12	144.82	144.47	585.41	598.52	591.96	1193.29	1261.12	1204.71	1774.52	1790.75	1782.63
S.Ed±	3.96	0.78	2.11	6.94	5.25	4.63	10.52	12.23	10.43	10.17	11.04	10.12
CD(p=0.05)	11.00	2.18	5.87	19.26	14.59	12.85	29.22	33.96	28.95	28.24	30.64	28.09
N_1	154.23	150.83	152.53	626.26	621.12	623.69	1250.93	1239.83	1245.38	1843.92	1832.04	1837.98
N_2	132.31	135.74	134.03	533.20	564.52	548.86	1119.06	1161.83	1140.44	1685.30	1730.39	1707.84
N_3	136.19	138.69	137.44	544.70	572.05	558.38	1138.11	1170.83	1154.47	1706.89	1743.84	1725.37
N_4	150.84	155.51	153.`17	622.63	630.16	626.39	1243.23	1258.00	1250.62	1834.30	1854.54	1844.42
S.Ed±	2.04	0.75	1.01	6.12	4.51	2.06	9.45	9.42	8.04	10.13	11.01	8.91
CD(p=0.05)	4.28	1.58	2.12	12.85	9.48	4.34	20.05	19.78	16.88	21.29	23.13	18.72
Interaction	S	S	S	S	S	S	S	S	S	S	S	S

Conclusion

The results of the two year study lead to conclusion that for realizing higher and sustainable yield, crop must be established following system of rice intensification and the nutrient management must centre around 50% FYM + 50% Loktak Phumdi compost. However, better performance of individual plant under wider planting geometry does not seem to be high enough to compensate for the overall advantage accured due to large number of plants under closer planting geometry. That why normal transplanting is the popular method in case of meter square.

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