Plant Archives Vol. 26, Supplement 2, 2026 pp.3144-3149 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-2.400

EFFECT OF ESTABLISHMENT METHODS AND SOLID AND LIQUID ORGANIC MANURES ON GROWTH OF BLACK RICE (*Oryza sativa* L.)

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(Date of Receiving : 06-05-2026; Date of Revision : 29-06-2026; Date of Acceptance : 21-07-2026)

ABSTRACT

A field experiment was conducted in certified organic field SMOF, SHUATS during *Kharif* season (2022 and 2023) to study the impact of establishment methods, various solid and liquid organic manures on growth of black rice. The experiment was carried out in split split plot design replicated thrice with 18 treatments. Treatments comprised of two establishment methods (Conventional and SRI), three solid organic supplements (100% FYM, 100% poultry manure and 100% vermicompost) each in combination with three different liquid organic supplements (3% panchagavya, 3% jeevamrutham and 3% vermiwash, respectively). All the individual factors had significantly influence on the growth characters of Black Rice The higher growth parameters at 20 DAT and 40 DAT was recorded among establishment methods in Transplanting, among solid organic manures in Poultry manure and among liquid organic manures in Panchgavya.
***Keywords* :** Black rice, organic manure, poultry manure, panchagavya, growth, SRI.

Introduction

Black rice (*Oryza sativa* L.) is a unique rice variety characterized by a black-colored bran layer that covers the endosperm. Upon cooking, the endosperm develops a deep purple coloration. Compared with white rice, black rice generally requires a longer cooking duration and possesses a comparatively sticky texture. Owing to its distinctive appearance and sweet, nutty flavour, black rice has gained considerable popularity in several Asian countries, including China, Japan, Thailand, and South Korea. Historically, in ancient China, black rice was referred to as “forbidden rice” because it was regarded as a premium grain reserved exclusively for emperors and the royal family. According to the findings reported by Budhar and Mani (2008), China possesses the largest share of global black rice resources (62%), followed by Sri Lanka (8.6%), Indonesia (7.2%), India (5.1%), Philippines (4.3%), and Bangladesh (4.1%), while smaller quantities are distributed across Malaysia, Thailand, and Myanmar. Black rice possesses strong free radical scavenging and antioxidant properties, making it an important natural source for the development of antioxidant-rich food products (Sui *et al*., 2016).

Studies have also reported that SRI enhances both crop yield and water productivity (Mazumdar *et al.*, 2016). SRI and it’s improved transplanting practices have been reported to effectively reduce weed infestation and nitrogen depletion caused by weeds, thereby enhancing yield attributes and overall crop productivity (Singh *et al*., 2021). Similarly, Kumar *et al*. (2021) observed that various growth and yield parameters were significantly higher under the SRI system. The adoption of alternate wetting and drying (AWD) irrigation practices within SRI further improves water-use efficiency and can reduce water losses by approximately 30–40% compared to conventional rice cultivation methods.

Reduced application of organic manures adversely affects the carbon-to-nitrogen (C/N) ratio, soil biological activity, soil aggregation, and nutrient cycling processes (Gandla *et al*., 2023). Organic farming practices have been shown to enhance the biomass and abundance of below-ground biodiversity, thereby improving soil food-web structure compared with conventional farming systems, which often exhibit degraded soil structure (Ghadimi *et al*., 2021). In this context, organic manures and biofertilizers play a crucial role in sustainable agricultural production because of their beneficial effects on the physical, chemical, and biological properties of soil, as well as their contribution to long-term soil fertility and agricultural productivity (Ramesh *et al*., 2008).

Liquid organic manures play a vital role in enhancing crop growth by supplying readily available nutrients, beneficial microorganisms, enzymes, and growth-promoting substances. In the present study, liquid organic formulations such as Vermiwash, Jeevamrutha, and Panchagavya were applied at 20-day intervals after sowing. These bio-enhancers improve nutrient uptake, stimulate microbial activity in the rhizosphere, and promote overall plant vigor. Regular application of liquid organic manures also contributes to improved soil health, increased resistance to biotic and abiotic stresses, and enhanced crop productivity under organic farming systems (Golakiya *et al*., 2019).

Material and Methods

A research trial was conducted at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during *kharif* season of 2022 and 2023 black rice was transplanted through conventional transplanting 20 x 10 cm and SRI with spacing of 25 cm x 25 cm. The location is situated at 25.57o N latitude, 87.19o E longitude and at an altitude of 98 m above mean sea level. In conventional transplanting method, seedlings were transplanted with a definite spacing of 20 cm x 10 cm with 2 seedlings each. Whereas, in SRI transplanting method, 12 days old seedlings were transplanted with a definite row to row and plant to plant spacing of 25 cm x 25 cm with 1 seedling each. For this, on well ploughed and levelled fields, raised nursery beds of 10 m × 1 m x 0.15 m (length, breadth, and height) were prepared with a 30 cm distance between two beds. Pre-soaked seeds that have already germinated are distributed on well-puddled and smoothed soil. At the time of nursery bed preparation, organic manure is spread as a thick layer. Seedlings are spread on a thin layer of soil.

When required, water was applied in the field. Excess irrigation and/or heavy precipitation, on the other hand, were drained. Irrigation was stopped10 days prior to rice harvest because the crop had reached physiological maturity. manual weeding was carriedout twice during the crop growth period for controlling the weeds on 25th and 45th days after transplanting.

At every 20 days' interval, observations such as plant height, number of total tillers/hill, crop growth rate and relative growth rate. Solid organic manures *viz.* Framyard manure, Poutry manure and Vermicpompost were applied to fulfil the nitrogen requirement. Liquid manures- Vermiwash, Jeevamrutha and Panchgavya were applied to black rice crop at an interval of every 20 days after sowing. Necessary aftercare operations were followed as per the recommendations. No major pest and disease incidences were noticed during crop growth. Experimental data collected was subjected to statistical analysis by adopting Fisher's method of Analysis of Variance (ANOVA) as outlined by Gomez and Gomez (1984). Critical Difference (CD) values were calculated whenever the 'F' test was found significant at 5 per cent level.

Result and Discussion

Effect of Establishment method

Data recorded on 20 DAT revealed that maximum plant height was recorded in SRI (30.99, 35.44 and 33.21 cm). Similarly, significantly taller plant at 40 DAT (67.07, 62.58 and 64.83 cm) was recorded in SRI. This response reflects SRI's physiological benefits, including elevated cytokinin levels and reduced transplanting stress from younger seedlings, fostering superior internodal elongation and biomass partitioning to stems, as mechanistically linked by Priyanka *et al*. (2013) and Pasha *et al*. (2014).

There was no significant effect of establishment methods on number of tillers at 20 DAT in all three instances. However, maximum number of tillers in both the years and pooled at 20 DAT was recorded in SRI having 1.74, 1.89 and 1.81 tillers/hill. Similarly, at 40 DAT (15.14, 13.90 and 14.52 tiller/hill) significantly higher number of tillers/hill was recorded in SRI. Increased plant height and tiller numbers under SRI might be due to shallow planting of younger seedling in resulting in extensive root system that absorbing more nutrients from the soil consequently enhancing emergence of more tillers from the lower nodes compared to conventional method besides increasing plant height. Similar observations were also noticed by Mohanty *et al*. (2014), Thakur *et al*. (2016), Mondal *et al*, 2017 and Hosain *et al*. (2018).

There was no significant effect of establishment method on dry weight of black rice at 20 DAT. Maximum dry weight was recorded in SRI method of transplanting having 1.48, 1.41 and 1.44 g/plant. However, at 40 DAT significantly highest dry weight of 5.92, 6.13 and 6.03 g/plant in first, second year and pooled was recorded in SRI. In SRI-established black rice, dry matter accumulation was initially lower at the tillering stage compared to conventional methods, attributable to reduced tiller density and canopy interception of solar radiation, resulting in diminished photosynthetic photon flux capture and biomass synthesis. These dynamics align with observations by Aggarwal and Singh (2015) and Shantappa *et al*. (2014).

There was significant effect of establishment method on crop growth rate of black rice at 0-20 DAT. Significantly higher crop growth rate was recorded in Conventional method of transplanting having 3.63, 3.48 and 3.55 g/m^2/day. Further, significantly highest crop growth rate at 20-40 DAT (9.93, 10.48 and 10.21 g/m^2/day). This superiority stems from reduced mutual shading via wider spacing and younger seedlings that minimize transplanting shock, sustaining elevated CGR through panicle initiation, as corroborated by Thakur *et al*. (2016), Thakur *et al*. (2011) and Sridevi and Chellamuthu (2015).

Effect of solid organic manure

Experiment conducted revealed that at 20 DAT there was no significant effect of any solid organic manures on plant height and maximum was obtained in both the years and pooled 28.37, 28.67 and 28.52 cm in PM. Further significantly higher plant height for the duration of 40 DAT was recorded in PM for the duration of both the years and pooled having 63.37, 59.81 and 61.59 cm. However, VC was statistically at par with PM. Organic fertilizers promote crop growth through gradual nutrient solubilization, improved soil microbial biomass, and auxin-mediated root proliferation, aligning with findings from Hammed *et al*. (2019) and Purbajanti *et al*. (2019). Vermicompost outperforms FYM owing to its higher nutrient density, enriched enzyme activity, and accelerated release kinetics via earthworm gut processes, facilitating superior nutrient uptake efficiency.

At 20 DAT there was no significant effect of solid organic manure regardless Poultry manure recorded maximum number of tillers 1.62, 1.86 tiller/hill in first year and pooled, and 1.86 tiller/hill with the application of Vermicompost. However, at 40 DAT (13.99, 13.60 and 13.97 tiller/hill) significantly highest number of tillers was recorded in Poultry manure in both the years and pooled. Organic sources offer more balanced nutrition to the plants, especially micro nutrients which has caused better affectivity of tiller in plants grown with poultry manure and vermicompost (Kumar *et al*., 2023). Similar results also reported by Anvesh *et al*. (2023) and Alam *et al*. (2021).

Regarding dry weight at 20 DAT no significant effect of organic manure was recorded in black rice. However, maximum dry weight was recorded with application of Vermicompost in first year and pooled (1.48 and 1.44 g/plant) and in second year dry weight 1.42 g/plant was recorded in PM. Further, at 40 DAT in the second year and pooled Vermicompost (6.40 and 6.13 g/plant) and in first year Poultry manure (5.90 g/plant) recorded significantly higher dry weight. Both FYM and PM were statistically at par with VC in second year and pooled and in the case of first year both FYM and VC were statistically at par with PM. Increased dry matter accumulation in plots treated with poultry manure and vermin-compost may be attributed to the ongoing, slow release of nutrients that have allowed the leaf area duration to increase, giving plants the chance to increase their photosynthetic rate, which may have in turn resulted in higher dry matter accumulation. Altaf *et al.*, 2012 and Gandla *et al.*, 2023 all came to similar conclusions.

At 0-20 DAT no significant effect of organic manure was recorded in crop growth rate of black rice. However, maximum crop growth rate was recorded with application of Vermicompost in first year and pooled (2.45 and 2.38 g/m^2/day) and in second year crop growth rate 2.34 g/m^2/day was recorded in PM. Similarly, at 20-40 DAT even though non-significant, maximum crop growth rate both the year and pooled was recorded in Poultry manure (7.12, 7.45 and 7.28 g/m^2/day). Enhanced metabolic activities and photosynthetic rate that result in an improvement in the accumulation of dry matter at the successive growth stages may be the cause of the improved growth and development of the crop plants in the current investigation (Rasool *et al.,* 2023). This in turn leads to an increase in the crop growth rate and relative growth rate in all stages of plants (Reddy *et al*., 2023).

Effect of Liquid organic manure

In both the years and pooled at 20 DAT there was no significant effect of liquid organic manures on plant height. Maximum plant height in 2022, 2023 and pooled 28.38, 27.98 and 28.18 cm was recorded in Panchgavya. However, at 40 DAT significantly higher plant height was recorded in second year and pooled (59.58 and 60.42 cm) in Panchgavya and in first year in Vermiwash having 61.90 cm, during first year Panchgavya was statistically at par with Vermiwash and further, in second year and pooled Vermiwash was statistically at par with Panchgavya. Panchgavya and vermiwash elicited significantly superior black rice plant height from 40 DAT onward, with Panchgavya dominating due to its rich profile of phytohormones (auxins, gibberellins), amino acids, and beneficial microbes that enhance cell division, internodal elongation, and photosynthetic efficiency via upregulated chlorophyll synthesis and nitrogen assimilation according to Sudheer *et al.*, 2025, Kuttibai *et al.*, 2023, and Saranraj and Thiruppathi 2015.

There was no significant effect at 20 DAT of liquid organic manures on number of tillers. However, at 40 DAT (14.17, 13.09 and 13.63 tillers/hill) significantly highest number of tillers were recorded in Panchgavya, Vermiwash was recorded to be statistically at par with Panchgavya. Panchagavya significantly boosted tiller numbers per hill in black rice via its auxin-rich composition and microbial consortia (Lactobacillus, yeast), which stimulate axillary bud outgrowth and cytokinin-mediated meristem proliferation during tillering (Saranraj and Thiruppathi, 2015).

In both the years and pooled of 20 DAT there was no significant effect of liquid organic manure on dry weight. However, maximum dry weight was recorded in first year and pooled in Vermiwash (1.49 and 1.45 g/plant), while in the second year maximum was recorded in Panchgavya (1.42 g/plant). At 40 DAT significantly higher data was recorded in Panchgavya (5.90, 6.09 and 6.00 g/plant) in both the years and pooled. In both the years and pooled Vermiwash was seen to be statistically at par data with Panchgavya. Panchgavya significantly elevated dry matter accumulation in black rice across first year, second year, and pooled data, primarily through its multifaceted biostimulant action—including phytohormones (IAA, GA3), beneficial microbes (*Azospirillum*, *Lactobacillus*), and amino acids—that augment photosynthesis, chlorophyll content, and C/N partitioning for superior biomass synthesis as corroborated by Maheswari *et al.*, 2017, Parmeshwari *et al.*, 2025 and Golakiya *et al.*, 2019.

In the duration of 0-20 DAT there was no significant effect of any of the liquid organic manures on crop growth rate. However, maximum crop growth rate was recorded in Vermiwash in first year and pooled. However, maximum crop growth rate in second year was recorded in Panchgavya. Further, in the duration of 20-40 DAT significantly higher crop growth rate was recorded in Panchgavya in both the years and pooled (7.33, 7.68 and 7.51 g/m^2/day). However, in all three instances Vermiwash was statistically at par with Panchgavya. Panchgavya via auxin-gibberellin synergies and lactic acid bacteria boosting photosynthetic efficiency, and vermiwash via humic acids and PGPR-mediated nutrient mobilization resulting in superior biomass accrual post-tillering which results in higher growth parameters *viz.* Relative growth rate. Their statistical parity reflects comparable upregulation of Rubisco activity and source-sink translocation, as corroborated by Parmeshwari *et al*. (2025) and Yogendra *et al*. (2024).

Conclusion

At 20 and 40 DAT among establishment methods Transplanting, among solid organic manures Poultry manure and among liquid organic manures panchgavya recorded significantly higher growth parameters.

Table 1 : Effect of establishment methods, solid and liquid organic manure on growth parameters of Black rice at 20 DAT

Treatments	20 DAT											
	Plant height			No. of tillers			Dry weight			CGR 0-20 DAT		
	2022	2023	pooled	2022	2023	pooled	2022	2023	pooled	2022	2023	pooled
Conventional	23.82	26.31	25.06	1.37	1.70	1.53	1.45	1.39	1.42	3.63	3.48	3.55
SRI	30.99	35.44	33.21	1.74	1.89	1.81	1.48	1.41	1.44	1.23	1.17	1.20
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	S	S	S
SEm±	0.32	0.63	0.48	0.06	0.04	0.01	0.02	0.03	0.03	0.01	0.07	0.04
CD (P=0.05)	-	-	-	-	-	-	-	-	-	0.24	1.18	0.63
FYM	25.53	24.12	24.83	1.47	1.72	1.59	1.44	1.41	1.42	2.44	2.32	2.36
PM	28.37	28.67	28.52	1.62	1.80	1.86	1.45	1.42	1.43	2.41	2.34	2.32
VC	28.31	27.84	28.07	1.57	1.86	1.71	1.48	1.40	1.44	2.45	2.31	2.38
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEm±	0.46	0.55	0.47	0.05	0.14	0.06	0.04	0.03	0.03	0.10	0.04	0.06
CD (P=0.05)	-	-	-	-	-	-	-	-	-	-	-	-
Panchgavya	28.38	27.98	28.18	1.46	1.69	1.58	1.43	1.42	1.42	2.35	2.47	2.37

Jeevamrut	25.73	24.96	25.34	1.60	1.72	1.66	1.48	1.38	1.43	2.40	2.35	2.26
Vermiwash	24.10	25.69	24.90	1.60	1.97	1.78	1.49	1.40	1.45	2.48	2.35	2.41
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEm±	0.34	0.34	0.24	0.09	0.12	0.07	0.04	0.02	0.02	0.06	0.05	0.04
CD (P=0.05)	-	-	-	-	-	-	-	-	-	-	-	-

FYM- Farmyard manure, PM- poultry manure, VC- Vermicompost

Table 2 : Effect of establishment methods, solid and liquid organic manure on growth parameters of Black rice at 40 DAT

Treatments	**40 DAT**											
	Plant height			**No. of tillers**			**Dry weight**			**CGR 20-40 DAT**		
	2022	**2023**	**pooled**	**2022**	**2023**	**pooled**	**2022**	**2023**	**pooled**	**2022**	**2023**	**pooled**
Establishment methods												
Conventional	53.79	51.37	52.58	10.80	10.40	10.60	5.52	5.38	5.45	9.93	10.48	10.21
SRI	67.07	62.58	64.83	15.14	13.90	14.52	5.92	6.13	6.03	3.70	3.93	3.82
F-test	S	S	S	S	S	S	S	S	S	S	S	S
SEm±	0.39	0.52	0.87	0.50	0.38	0.33	0.04	0.03	0.03	0.14	0.18	0.08
CD (P=0.05)	7.03	9.40	4.19	8.99	6.90	5.95	0.80	0.53	0.59	2.48	3.17	1.51
Solid organic manure												
FYM	56.79	52.30	54.54	11.59	11.06	11.47	5.41	5.64	5.53	6.51	6.99	6.75
PM	63.37	59.81	61.59	13.99	13.60	13.97	5.90	5.79	5.84	7.12	7.45	7.28
VC	61.12	58.82	59.97	13.33	11.93	12.63	5.87	6.40	6.13	6.82	7.19	7.00
F-test	S	S	S	S	S	S	S	S	S	NS	NS	NS
SEm±	0.40	0.76	0.48	0.36	0.43	0.18	0.09	0.07	0.08	0.18	0.14	0.15
CD (P=0.05)	2.45	4.64	2.95	2.20	2.63	1.11	0.54	0.44	0.49	-	-	-
Liquid organic manure												
Panchgavya	61.26	59.58	60.42	14.17	13.09	13.63	5.90	6.09	6.00	7.33	7.68	7.51
Jeevamrut	58.12	54.11	56.11	10.62	11.71	11.17	5.62	5.44	5.53	6.32	6.80	6.56
Vermiwash	61.90	57.24	59.57	13.12	12.64	12.88	5.69	5.84	5.77	6.79	7.15	6.97
F-test	S	S	S	S	S	S	S	S	S	S	S	S
SEm±	0.57	0.57	0.39	0.63	0.63	0.44	0.06	0.05	0.05	0.12	0.12	0.12
CD (P=0.05)	3.46	3.456	2.38	1.96	3.82	2.66	0.34	0.331	0.321	0.74	0.757	0.705

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