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Effect of Crop Establishments Methods and Nutrient Management on Productivity and Profitability of Rice (*Oryza sativa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Crop Research Center, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, with compare the production potential under different crop establishment methods and nutrient management and also to find out the economic viability of this cultivar for soil quality. The treatments comprised of Main Plot Puddled Transplanted Rice (C_1), Un-puddled Transplanted Rice (C_2) and Raised-Bed Planting (C_3) Sub Plot Control (N_1), 100% NPK (150: 75:60) (N_2), 50% RDN + FYM @15ton ha^{-1} (N_3), 50% RDN + vermicompost @

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5ton ha^{-1} (N_4), 50% RDN + FYM @15 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1} (N_5) and 50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1} (N_6). revealed that crop establishment methods treatment C_1 (Puddled Transplanted Rice) and Nutrient management N_6 (50% RDN + vermicompost @ 5ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}) exhibited significant influence on yield attributes and yields of rice as compared to the application of Un-Puddled Transplanted Rice and control treatment.

Keywords: Rice; FYM; Verimcompost; Bio-stumulant; production potential; profitability.

1. INTRODUCTION

"Rice (*Oryza sativa* L.) is the most important cereal crop and a staple food for one third of the world population. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. To safeguard and sustain the food security in India, it is quite important to increase the productivity of rice under limited resources, especially water. It contains 7-8% protein, 3% fat and 3% fiber. 100 gms of uncooked rice contains 80.40 g of carbohydrates, of which 63.6% is starch, however, when rice is cooked, the starch content drops dramatically. It occupies 162.97 mha of area, producing 495.03 million tonnes of rice with an average productivity of 3.04 t/ha in the world. In India, rice occupies an area of 43.79 mha with production and productivity of 116.42 and 2.65 t/ha, respectively" [1]. "The major rice growing states in India are West Bengal, Uttar Pradesh, Assam, Bihar, Orissa and Madhya Pradesh. Uttar Pradesh is the 2 largest rice state after West Bengal in the country, which rice is grown over an area of 5.75 mha with a production of 15.54 mt and the productivity of 2.70 t/ha" [1]. "About 63 per cent of total rice area is situated in Uttar Pradesh, Bihar, West Bengal, Assam, Orissa and Madhya Pradesh. Demand for rice is going to increase every year and it is estimated that by year 2025 the requirement would be 140 mt. In India out of total rice, Basmati rice is grown on an area of 2.12, producing 8 mt of Basmati rice with an average productivity of 3.77 t/ha. Out of this 8 mt, 4 mt is exported and remaining 4 mt is used for domestic purpose" [2].

"Conservation farming practices including tillage practices that are important for rice. Tillage practices increase yield water productivity and nutrient availability to plant. Tillage affects the organic carbon content of soil, bulk density of soil, aeration etc. Various tillage practices were found to exert a significant influence on soil disturbances, aggregate stability, and organic. In Asia, rice is commonly grown by transplanting seedlings into puddle soil (land preparation with wet tillage). Puddling benefits rice by reducing water percolation losses, controlling weeds, facilitating easy seedling establishment, and creating anaerobic conditions to enhance nutrient availability, but repeated puddling adversely affects soil physical properties by destroying soil aggregates, reducing permeability in subsurface layers, and forming hard-pans at shallow depths. Tillage practices greatly influence the soil physical properties which in turn affects the soil structure. Soil physical properties and conservation tillage are influenced by surface and internal drainage, nature and amount of clay, climate, drainage, physiographic, vehicular traffic, soil and crop management systems" [3].

"Crop establishment is a sequence of events that includes seeding, seed germination, seedling emergence, and development to the point where seedlings can be expected to grow to maturity" [4]. "Rice production methods in any area are determined by the environment, ecology, and socioeconomic conditions of that area. In lowland areas, the majority of people use techniques such as conventional transplanting after puddling, whereas in upland areas, DSR is used" [3]. "Conventional transplanting methods on puddled soil account for about 77 percent of global rice production" [5,6]. "The traditional rice crop transplanting system (TPR) necessitates a huge quantity of labour, water, capital, and energy, and as a result, it has become less profitable in recent years due to a scarcity of these resources" [5]. According to Tuong and Bouman, producing 1kg of rice in a conventional transplanted system (TPR) requires about 2500 L (average) of water [7].

"The Raised bed techniques offer a useful option to reduce the limitations of transplanted paddy. It also offers the advantage of faster and easier planting, ensure proper plant population and reduce labour. Raised beds are formed by moving soil from the furrows to the area of the bed, thus raising its surface level. The furrows serve as irrigation channels, drains and traffic lanes. Generally, two to six rows are planted on the top of each bed for rice crop" [8]. "Raised bed dimensions and configurations vary with soil type and available machinery. The ability of the soil to 'sub' (*i.e.* allow the lateral movement of irrigation water into the centre of the bed) is a key determinant of bed dimensions. For sandy loam soils that sub easily, growers use bed widths at 1.37 m centres for all crop types like rice, wheat. Soils do not sub as well; narrower beds at 0.67 m centres are frequently used. Bed height may also vary with soil conditions and field slope. Higher beds are frequently used on soils that sub well and have flatter grades and longer run lengths, while beds of a lower height are used on steeper graded fields. The flat top of the bed varies from 0.37 to 1.07 m in width. Furrow irrigation used with raised beds requires growers to adopt a whole-farm planning approach to deal with drainage water and the integration of on farm drains and drainage water recycling systems, to increase both water use efficiency and drainage water quality control" [9].

A number of studies have been conducted to quantify the water footprint of a large variety of different crop products and crops [10]. "These studies provided a broad-brush to the global picture since the primary focus of these studies was to establish a first estimate of global virtual water flows and/or national water footprints. More recently, though a few studies have separated global water consumption for crop production into green and blue water with a better spatial resolution" (Hanasaki et al. 2010) [11,12] but still information on water footprints based on inflow and outflow of water at farm level under different management practices are lacking.

The stagnation in production and profitability of food grains for the past few years has become a matter of concern and is posing serious threat to our national food security soil health degradation has emerged as a major factor responsible for the stagnation in agricultural production. The degradation of soil health in many intensively cultivated areas is manifested in terms of loss of soil organic matter, depletion of native soil fertility due to imbalanced and non-scientific use of fertilizer, which is now one of the major constraints in improving crop productivity.

"An integrated use of both organic manures and chemical fertilizers has emerged as a promising option not only for maintaining higher productivity but also for providing maximum stability to crop production in intensive farming systems. The interactive advantages of combining organic and inorganic sources of nutrients in integrated nutrient management have proved superior to the use of each component separately. Judicious use of organic manures, such as farmyard manure, green manuring and rice straw along with chemical fertilizers improves soil physical, chemical and biological properties and enhance productivity in both the reasons. It is essential to identify such practices which bring more sustainability to the production system, beside improving the productivity of the system and soil health" (Urkurkar et al., 2010).

"Long-term studies indicated that supplying of plant nutrients only through chemical fertilizers lead to depletion of SOM and declined the soil productivity" [13]. Therefore, "to maintain soil health for long-term sustainability of crop production system application of organic manures, compostalong with fertilizers have commonly been advocated. Whereas farmyard manure increased nutrient availability as compared to the chemical fertilizers application" [14]. "Depletion of soil fertility because of the use of high analysis fertilizers renders the deficiency of macronutrients particularly N. Increasing productivity of rice will continue to be a major challenge because the demand of the growing population needs to be met with a limited area of arable land. Fertilizer N has contributed immensely to the current level of productivity and will play a key role in the future rice production. Nutrients supplied exclusively through chemical sources, though enhances yield initially, but the yields are not sustainable over the years. Even the introduction of high yielding varieties and intensive cultivation with excess and imbalanced use of chemical fertilizers and irrigation showed reduction in the soil fertility status and yield by 38 per cent of rice crop" [13].

"Using judicious combination of chemical and organics for achieving enhanced and sustainable production by adopting integrated nutrient supply is imperative" [15]. Integrated use of organics and fertilizers for improving the long-term productivity of rice-wheat cropping system [16] and the profitability of organic sources such as straw and FYM when used as a complementary dose to inorganic N, P and K in intensive rice-rice systems [17]. The combined use of mineral fertilizers, FYM and vermi-compost which may resolve the practical limitation of input availability, but which may also benefit crop N synchrony and N loss reduction through interactive effects between both types of inputs. The interactive advantage of combining organic and inorganic sources of the nutrients in integrated nutrient management system has proved superior to the use of its each component separately besides, restoring soil fertility and crop productivity. This approach may also help to check the emerging deficiency of nutrients other than N, P and K and favourably affects physical, chemical and biological environment of the soil.

2. MATERIALS AND METHODS

The experiment was carried out at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) to study the influence of different crop establishment methods and nutrient management on water productivity and profitability of rice in Split Plot Design (Table 1), replicated three times. The maximum and minimum temperatures recorded were 41.3 ºC and 15.8 ºC during the crop growth period. Relative humidity ranges between 44.1-95.2% during crop growth period. The area receives mean annual rainfall between 587.6-369.8 mm. The soil of the experimental field was sandy loam in texture, low in available nitrogen (180.4 kg ha^{-1}) and organic carbon (0.45%), medium in available phosphorous (15.7 kg ha^{-1}) and potassium (280.0 kg ha^{-1}) and slightly alkaline (pH 7.8) in reaction with electrical conductivity of 0.25 dS m^{-1}. The crop variety Pusa Basmati-1 was sown on June 20 & 23, 2022 & 2023 and harvested on 20 & 25 October 2022 & 2023. "The seed rate was 30 kg ha^{-1}. The recommended dose of nitrogen (80 kg ha^{-1}) was applied in two equal split, the half as basal and the remaining half was top dressed 2 times at the time of first and second irrigation. The whole quantity of potassium (40 kg ha^{-1}) was applied as basal dose through Murate of Potash at 8-10 cm depth along with half dose of nitrogen prior to sowing. Phosphorous was applied as basal dose (60 kg ha^{-1}) through DAP. Vermicompost (5 t ha^{-1}) and Bio-stumulant G (20 kg ha^{-1}) were applied in the field as per treatments and was thoroughly mixed at the time of sowing. One thinning was done after 30 days of sowing to maintain a plant to plant distance of about 20 cm. Weeding and hoeing operation were performed manually after first and second irrigation at proper soil moisture condition of the soil. At the harvest, number of grains $panicle^{-1}$, 1000 grains weight, seed yield and straw yield were calculated. Economics of treatments were computed on the basis of prevailing market price of inputs and outputs under each treatment. The total cost of cultivation of crop was calculated on the basis of different operations performed and materials used for raising the crop including the cost of fertilizers and seeds. The cost of labour incurred in performing different operation was also included. Statistical analysis of the data was done as per the standard analysis of variance technique for the experimental designs following SPSS software based programme, and the treatment means were compared at P<0.05 level of probability using t-test and calculating CD values" [18].

3. RESULTS AND DISCUSSION

3.1 Effect of Different Crop Establishment Methods and Nutrient Management on Yield Attributes of Rice

Yield attributes *viz*., Panicle length, Number of panicle, Number of grains $panicle^{-1}$ and weight of 1000 grains of rice were affected significantly by various treatments involving different establishment methods and nutrient management (Table 1 and Fig. 1).

From the given data (Table 1) it can be inferred that crop establishment methods the maximum panicle length (24.8 & 25.3 cm) were produced in the treatment C_1 (Puddled Transplanted Rice) followed by C_3 (Raised-Bed Planting). Among the nutrient management treatment the maximum panicle length (25.3 & 25.8) recorded in N6 (50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20 kg ha^{-1}), which was at par with N5 (50% RDN + FYM @15 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}). However, the lowest panicle length (22.5, 23.0 & 21.3, 21.7) was recorded in treatment C2 (Un-puddled Transplanted Rice) N_1 (Control), which was significantly lower than rest of the other treatments. The results were in accordance with those reported by Kumar and Chandra, [15], Naresh et al. [19] and Chandankute et al. [20].

Significantly higher number of panicle (134.1 & 137.5) was recorded under crop establishment methods in treatment C_1 (Puddled Transplanted Rice) followed by C_3 (Raised-Bed Planting). Treatment C_2 (Un-puddled Transplanted Rice) recorded the lowest number of panicle (127.7 & 130.9). Among the nutrient management treatment, the maximum number of panicle (137.4 & 140.8) recorded in N_6 (50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20 kg ha^{-1}), which was at par with N_5 (50% RDN + FYM @15 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}) and N_4 (50% RDN + vermicompost @ 5 ton ha^{-1}). It might be due to increased and prolonged availability of nutrients from integrated use of vermicompost and Bio-stumulant G, which ultimately resulted in rapid cell multiplication and cell elongation under sufficient nutrient supply. The results were in accordance with those reported by Jnanesha and Kumar, [21], Pandey et al. [22] and Yogeswari and Porpavai [23].

It is evident from the data that under crop establishment methods the significantly higher number of number of grains panicle^{-1} (149.1 & 152.6) were produced in treatment C_1 (Puddled Transplanted Rice) followed by C_3 (Raised-Bed Planting). Treatment C_2 recorded lowest number of grains panicle^{-1} (137.5 & 140.8). Among the nutrient management treatment, the maximum number of grains panicle^{-1} (144.9 & 148.5) recorded in N_6 (50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20 Kg ha^{-1}), which was at par with N_5 (50% RDN + FYM @15 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}), N_4 (50% RDN + vermicompost @ 5 ton ha^{-1}) and N_3 (50% RDN + FYM @15 ton ha^{-1}) during 2022 and 2023. Adequate nutrients availability to the crop as a result of increment in photosynthesis as well as growth led to increase in the number of grains panicle^{-1}. These findings were almost similar to the results reported by Sah et al. [24] and Kumar et al. [25].

Crop establishment methods, the maximum 1000- grain weight (23.6 & 23.7 g) was recorded in C_1 (Puddled Transplanted Rice) followed by C_3 (Raised-Bed Planting), whereas the lowest 1000-grain weight (20.2 & 20.3 g) was recorded in C_2 (Un-puddled Transplanted Rice). Among the nutrient management treatment, the maximum 1000- grain weight (23.5 & 23.6) recorded in N_6 (50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20 Kg ha^{-1}), which was at par with N_5 (50% RDN + FYM @15 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}), N_4 (50% RDN + vermicompost @ 5 ton ha^{-1}) and N_3 (50% RDN + FYM @15 ton ha^{-1}) during 2022 and 2023. The nutrient management application of vermicompost, FYM and Bio-stumulant G might increase availability of plant nutrients which

Table 1. Effect of different crop establishment methods and nutrient management on yield attributes characters of rice

Treatments		**Yield attributes**							
		Panicle length (cm)		**No. of panicle**		**No. of grain per panicle**		**1000 grain weight (g)**	
		2022	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
(A) Crop establishment methods									
Puddled Transplanted Rice	C_1	24.8	25.3	134.1	137.5	149.1	152.6	23.6	23.7
Un-puddled Transplanted Rice	C_2	22.5	23.0	127.7	130.9	137.5	140.8	20.2	20.3
Raised-Bed Planting	C_3	22.9	23.4	130.5	133.7	139.9	143.3	22.1	22.2
SE(m)±		**0.15**	**0.16**	**0.53**	**0.54**	**0.76**	**0.78**	**0.25**	**0.25**
C.D. (P=0.05)		**0.52**	**0.55**	**1.83**	**1.87**	**2.61**	**2.69**	**0.86**	**0.87**
(B) Nutrient Management									
Control	N_1	21.3	21.7	112.2	115.1	138.4	141.8	20.1	20.2
100% NPK (150: 75:60)	N_2	22.8	23.2	132.5	135.8	140.7	144.2	21.5	21.6
50% RDN + FYM @15 ton ha^{-1}	N^3	23.6	24.1	131.8	135.2	143.2	146.6	22.7	22.5
50% RDN + vermicompost @ 5 ton ha^{-1}	N_4	23.8	24.3	134.9	138.3	143.6	147.1	22.5	22.8
50% RDN + FYM @15 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}	N_5	24.3	24.9	135.7	139.1	144.1	147.5	23.2	23.4
50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}	N_6	25.3	25.8	137.4	140.8	144.9	148.5	23.5	23.6
SE(m)±		**0.44**	**0.46**	**1.47**	**1.51**	**1.38**	**1.41**	**0.47**	**0.48**
C.D. (P=0.05)		**1.27**	**1.31**	**4.22**	**4.32**	**3.94**	**4.03**	**1.36**	**1.38**

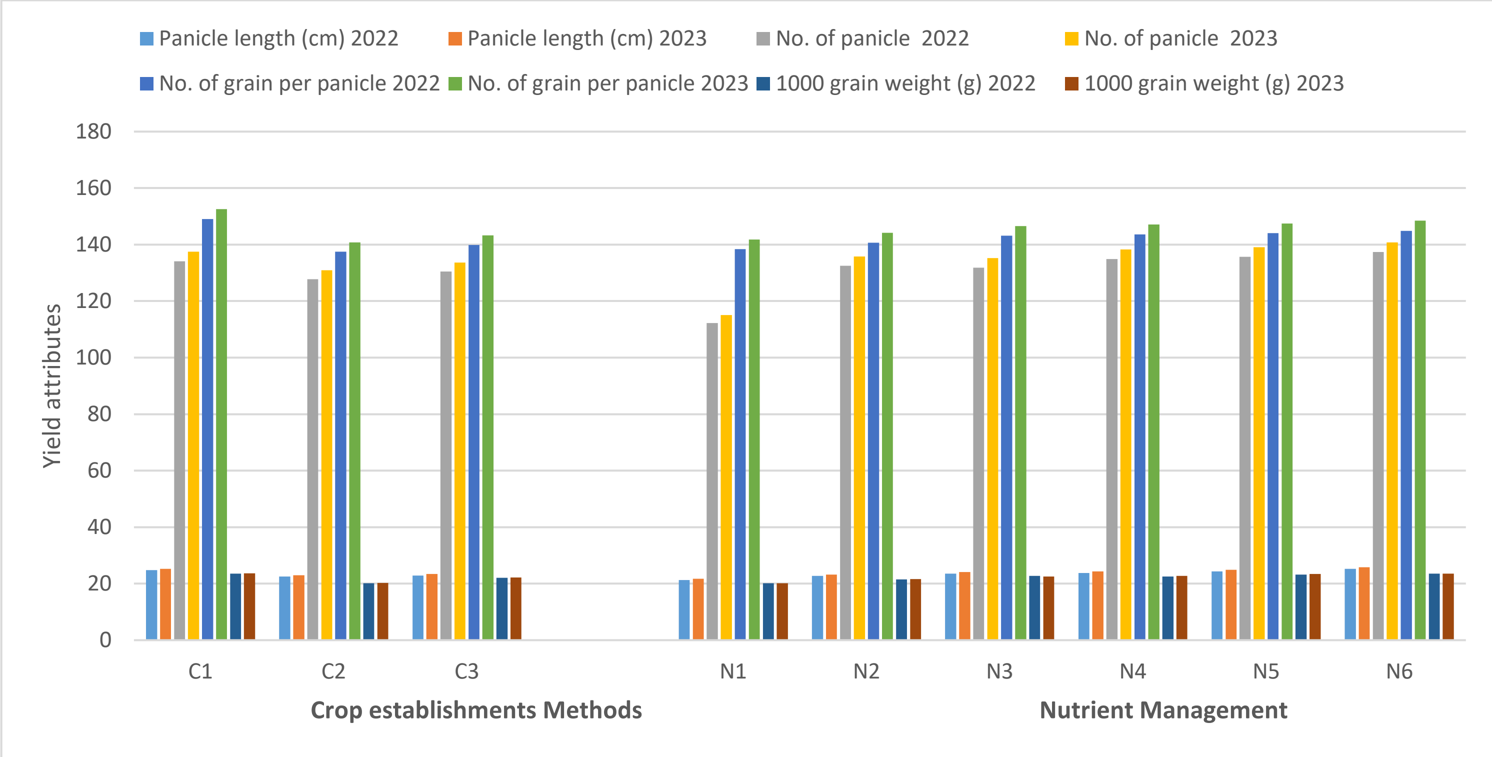

Fig. 1. Effect of different crop establishment methods and nutrient management on yield attributes of rice

Table 2. Effect of different crop establishment methods and nutrient management on yield and harvest index of rice

Treatments		Yield (q ha^{-1})`						Harvest index (%)	
		Grain		Straw		Biological			
		2022	2023	2022	2023	2022	2023	2022	2023
(A) Crop establishment methods									
Puddled Transplanted Rice	C_1	44.19	46.01	67.31	70.13	111.50	116.14	39.63	39.28
Un-puddled Transplanted Rice	C_2	38.46	40.04	60.58	63.12	99.04	103.16	39.30	38.60
Raised-Bed Planting	C_3	42.07	43.79	65.04	67.77	107.11	111.56	39.04	39.02
SE(m)±		**0.83**	**0.86**	**0.93**	**0.97**	**1.15**	**1.20**	**0.57**	**0.56**
C.D. (P=0.05)		**2.87**	**2.98**	**3.23**	**3.35**	**3.98**	**4.15**	**NS**	**NS**
(B) Nutrient Management									
Control	N_1	27.94	29.08	54.73	57.02	82.67	86.11	33.86	33.84
100% NPK (150: 75:60)	N_2	42.56	44.30	64.25	66.95	106.82	111.26	39.83	39.81
50% RDN + FYM @15 ton ha^{-1}	N^3	43.16	44.92	66.25	69.03	109.41	113.96	39.19	39.18
50% RDN + vermicompost @ 5 ton ha^{-1}	N_4	45.16	47.02	68.58	71.46	113.75	118.48	39.68	39.66
50% RDN + FYM @15 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}	N_5	47.26	49.20	69.26	72.17	116.53	121.37	40.59	40.57
50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}	N_6	48.78	50.72	70.07	73.01	118.85	123.80	40.95	40.92
SE(m)±		**1.30**	**1.35**	**1.66**	**1.72**	**2.19**	**2.28**	**0.90**	**0.89**
C.D. (P=0.05)		**3.72**	**3.87**	**4.74**	**4.93**	**6.26**	**6.52**	**2.57**	**2.55**

result into better nourishment of plants and the formation of bold seeds, ultimately increased weight of grain. The results were similar to the findings reported by Khan et al. (2009) and Mouriya et al. (2013).

3.2 Effect of Different Crop Establishment Methods and Nutrient Management on Productivity

Data with regard to the effect of crop establishment methods and nutrient management on grain yield, straw yield, biological yield and harvest index of rice crop are mentioned in Table 2 and depicted in Fig. 2.

Among the various crop establishment methods, the treatment C_1 (Puddled Transplanted Rice) exhibited significantly higher grain yield (44.19 & 46.01 q ha^{-1}), which was statistically at par with C_3 (Raised-Bed Planting). Treatment C_2 (Un-puddled Transplanted Rice) recorded lowest grain yield of 38.06 & 40.04 q ha^{-1}. About 14.8 & 14.9% increase in seed yield was recorded by C_1 (Puddled Transplanted Rice) over treatment C_2 (Un-puddled Transplanted Rice) during 2022 & 2023. Among the nutrient management treatment, the highest grains yield (48.78 & 50.72) recorded in N_6 (50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20 Kg ha^{-1}), which was at par with N_5 (50% RDN + FYM @15 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}) and N_4 (50% RDN + vermicompost @ 5 ton ha^{-1}) during 2022 and 2023. The maximum grain yield was recorded due to integrated application of vermicompost, FYM and Bio-stumulant G. This might be due to slow release of nutrient from vermicompost and FYM leading to reduced loss of nitrogen and efficient use of Macro and micronutrients. The production of growth promoting and antifungal substances by Bio-stumulant G and nitrogen fixation was possibly the reason for higher yields.

In the same way, straw yield of rice (Table 2) was significantly influenced by different crop establishment methods and nutrient

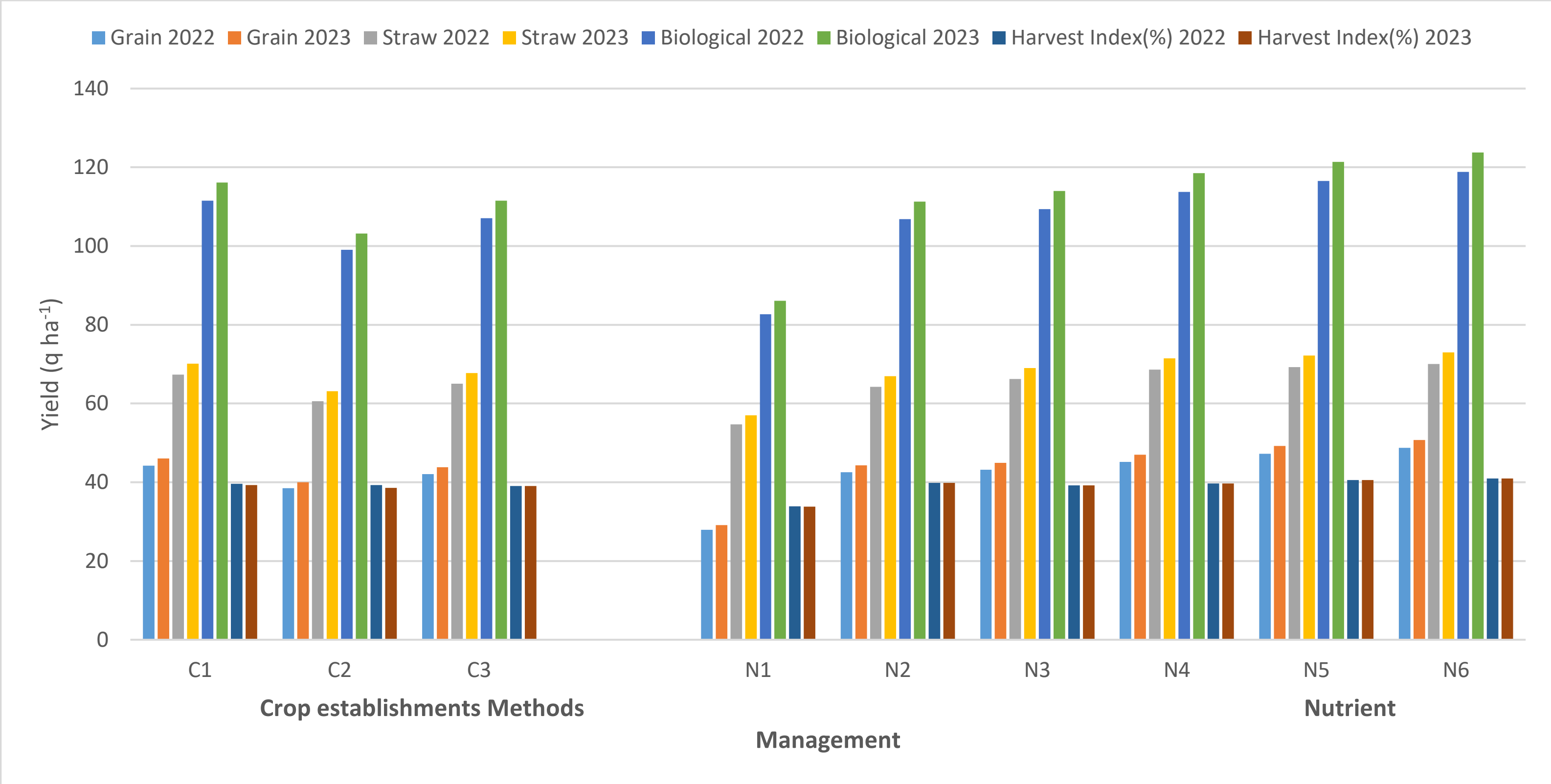

Fig. 2. Effect of different crop establishment methods and nutrient management on yield and harvest index of rice

Fig. 3. Economics of rice as effect of different crop establishment and nutrient management

management treatments. Results revealed that the differences in straw yield were found significant due to different treatments. Under crop establishment methods significantly higher straw yield 67.31 & 70.13 q ha^{-1} was recorded under C_1 (Puddled Transplanted Rice), it was statistically at par with C_3. The lowest straw yield (60.58 & 63.12 q ha^{-1}) was recorded in C_2 (Un-puddled Transplanted Rice). Among the nutrient management treatment, the highest straw yield (70.07 & 73.01) recorded in N_6 (50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20 Kg ha^{-1}), which was at par with N_5 (50% RDN + FYM @15 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}), N_4 (50% RDN + vermicompost @ 5 ton ha^{-1}) and N_3 (50% RDN + FYM @15 ton ha^{-1}) during 2022 and 2023. The lowest straw yield recorded in N_1 (Control) treatment. Similar trend was observed in Biological yield, under crop establishment methods, the maximum harvest index (39.63 & 39.28%) was recorded in C_1. The lowest harvest index recorded with C_3 (Un-puddled Transplanted Rice) plot. Among the nutrient management treatment, the highest harvest index (40.95 & 40.92) recorded in N_6 (50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20 Kg ha^{-1}) followed by N_5 (50% RDN + FYM @15 ton ha^{-1} + Bio-stumulant G @ 20Kg ha^{-1}), N_4 (50% RDN + vermicompost @ 5 ton ha^{-1}) and N_3 (50% RDN + FYM @15 ton ha^{-1}) during 2022 and 2023. The increase in straw yield was mainly due to increased growth attributing characters like plant height and grains $panicle^{-1}$. The use of organic manure like vermicompost, FYM and Bio-stumulant G in conjunction with macro and micronutrients had profound effect on vegetative growth due to improved nutrients availability in the soil for longer time with progressive decompositions of FYM. These findings in conformity with the results of Chandankute et al. [20], Rahman et al*.* [26] and Bhandari et al*.* [27].

4. CONCLUSION

All the growth, yield attributes and yield of rice improved with the application of crop establishment methods and nutrient management achieved maximum value with Puddled Transplanted Rice and 50% RDN + vermicompost @ 5 ton ha^{-1} + Bio-stumulant G @ 20 Kg ha^{-1}. By applying micronutrients, grain and straw have higher N content as well as higher P and K content. A standard NPK fertilizer dose that includes micronutrients can both maintain soil fertility and increase the availability of micronutrients in the soil.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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