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Influence of Different Management Practices and Fertilizer Levels on the Growth and Yield of Rice in Sodic Soil

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A field experiment was conducted during *rabi* season of 2017-2018 at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirapalli to enhance the rice yield in sodic soil through combined application of different management practices and fertiliser level. The experiment was laid out in split plot with three replications. There are six main plot treatments *viz.,* Rice transplanting (M_1), Rice wet seeding (M_2), Daincha incorporation followed by rice wet seeding (M_3), Rice wet seeding + daincha inter cropping (M_4), Daincha incorporation followed by rice wet seeding + biofertiliser (M_5), Rice wet seeding + daincha inter cropping + biofertiliser (M_6). Subplot treatments consist of different levels of fertiliser *viz.,* Control (S_1), 75 % soil test based NPK (S_2), 100% soil test based NPK (S_3), 125 % soil test based NPK (S_4). The result revealed that daincha incorporation followed by rice wet seeding + biofertiliser recorded higher growth parameters like plant height, leaf area index, dry matter production, total number of tillers m^{-2}, yield attributes viz., productive tillers, length of panicle, weight of panicle and thousand grain weight which was on par with rice wet seeding + daincha inter cropping + biofertilizer (M_6). Among the different fertiliser levels, 125% soil test based NPK (S_4) significantly increased the growth parameters, nutrient uptake and availability of micronutrients as compared to other treatments. Grain and straw yield were significantly higher under daincha incorporation followed by rice wet seeding + biofertiliser which was on par with rice wet seeding + daincha inter cropping + biofertiliser respectively. Among the fertiliser level 125 % soil test based NPK recorded significantly higher grain and straw yield which was on par with 100 % soil test based NPK. Application of extra dose of fertiliser from the base dose of 100 % soil test based NPK does not make any yield difference. Hence 100 % of soil test based NPK is economical for producing optimum yield of rice in sodic soil which can be recommended for higher productivity of rice under sodic soil condition.

Key words: Wetseeding, Daincha incorporation, Biofertilizers, Soil test based NPK, DISSIFER

Rice (*Oryza sativa* L.) is the prime source of food for nearly half of the world's population and it is one of the most important food crop that play a key role for food security. In India, it is cultivated in an area of 43.13 Mha with a production of 100.45 mt and productivity of 2.3t ha^{-1}. Rice is one of the most important crop grown in Tamil Nadu in an area of 1.83 m ha with a production of 5.84 m t and productivity of 3.1 t ha^{-1}. Cauvery delta region is known as "Rice bowl of South India" and contributes to 60 per cent of the state's rice production, where it is cultivated mainly as transplanted crop. The productivity of rice in India is very low as compared to other rice growing countries like Australia (10.1 t ha^{-1}), USA (7.5 t ha^{-1}), Russia (5.2 t ha^{-1}) and China (4.3 t ha^{-1} Anonymous, 2015). Soil quality and yield of the crop directly depend on the nutrient status of the soil. Depletion of nutrients adversely affect the crop growth and also cause soil fertility problems (Tan *et al.*, 2005).

In India sodic soils have occupied 37.71 lakh ha and these soils are essentially located in the Indo-Gangetic plain, arid and semiarid region in Western and Central India and the peninsular region in the Southern India. Imminent water crisis, water-demanding nature of traditionally cultivated rice and increasing labour costs leads to the development of alternative management strategies to increase water productivity, system sustainability and profitability. Direct seeded rice (DSR) technique is becoming popular nowadays because of its low-input demanding nature. It improves water and environmental sustainability. This shift should substantially reduce crop water requirements and emission of greenhouse gases. The reduced emission of these gases helps in climate change adaptation and mitigation, enhanced nutrient relations, organic matter turnovers, carbon sequestration and also provides the opportunity of crop intensification. Green manuring is the best method to mitigate the sodicity problems. Green manuring involves incorporation in to the soil of any field or forage crop while green or soon after flowering, for the purpose of soil improvement and increasing plant production. Plants treated with rhizobacteria have better root and shoot growth, nutrient uptake, hydration, chlorophyll content and resistance to diseases. Stress tolerance can be

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explained by nutrient mobilisation and biocontrol of phytopathogens in the rhizosphere and by production of phytohormones and 1-aminocyclopropane-1-carboxylate deaminase. Application of required dose of fertiliser is essential for optimum growth and yield of crops. Fertilizer recommendation includes consideration of the nutrient supply by crop residues, variation in intended yield, soil chemical properties, and the growing season.

Material and Methods

Location and soil type

A field experiment was conducted during *rabi* season of 2017-2018 at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirapalli to enhance the rice yield in sodic soil through combined application of different management practices and fertiliser level. The experiment was laid out in split plot with three replications. Field experiment was conducted in Field No. A_2B at ADAC&RI, Tiruchirapalli. The farm is situated in the Cauvery Delta Zone of Tamil Nadu at 10°45'N latitude and 78°36'E longitude with an altitude of 85 m above MSL. The soil of the experimental sites was an Sandy Clay loam, with a pH of 8.9, organic carbon of 0.58 % , low available N (190 kg ha^{-1}), medium Olsen's P (13.2 kg ha^{-1}) and low available K (147 kg ha^{1})

Experimental details

The treatments included six management practices *viz*.,Rice transplanting (M_1), Rice wet seeding (M_2), Daincha incorporation followed by rice wet seeding (M_3), Rice wet seeding + daincha inter cropping (M_4), Daincha incorporation followed by rice wet seeding + biofertiliser, Azospirillum and Phosphobacteria as per recommendation (M_5), Rice wet seeding + daincha inter cropping + biofertiliser (M_6) and four levels of soil test based NPK Control (S_1), 75 % soil test based NPK (S_2), 100% soil test based NPK (S_3), 125 % soil test based NPK (S_4). The experiment was laid out in a split-plot design assigning management practices in main plot and fertiliser level in the sub-plots with three replications. The unit size of the sub-plots was 5m×4m . The rice variety TRY 3 was grown as the test crop.

Cultural practices

Field was puddled thoroughly and levelled properly with wooden plank. Individual plots were laid out with a bund of 15 cm height. Buffer channels of one meter width in between the replications and 50 cm width in between the treatments were provided. Individual plots were levelled properly. An outs of 4.5 meters were taken along the borders of the field. Irrigation channels were provided in the center and borders of the field. Daincha (*Sesbania rostrata*) collected from the campus was incorporated @ 5 t ha^{-1} in the main field and left for 15 days for decomposing. Finally, hand levelling of individual plots was done and the rice variety TNAU TRY 3 was sown using drum seeder with a seed rate of 60 kg ha^{-1}.

Good quality seeds were collected and were soaked in water for overnight and incubated in dark room for 24 hours. The pre-germinated rice seed was sown by drum seeder maintaining a row spacing of 20 cm. Meanwhile the sprouted seeds were broad casted in a well prepared raised bed nursery. After 30 days it was transplanted in the prescribed plots at a spacing of 20 cm x 10 cm @ two seedlings $hill^{-1}$. Seeds of *daincha* @ 60 kg ha^{-1} were sown in the experimental plot in between the rows of rice manually and incorporated in to the field after 60 days.

Dosage of 150: 50: 50 NPK ha^{-1} was applied as per initial soil test based analysis. After analysing the initial soil sample, the values of N, P and K is fed in to DISSIFER software and obtained the N, P, K recommendation for the field and according to the treatments, 75 per cent and 125 per cent of the recommended dosage is applied. Entire quantity of P and 25 per cent of N and K were applied at the time of sowing and remaining 75 per cent of N and K were top dressed in three equ al splits at active tillering, panicle initiation and heading stage of the crop. Azospirillum and Phosphobacteria were broadcasted to the concerned plots before sowing as per the recommendation. Irrigation management, thinning and gap filling and plant protection were done as per the recommended practice. Grain yield was recorded plot wise and expressed in kg ha^{-1}. Straw obtained from individual plot was sun dried, weighed and expressed as kg ha^{-1}.

Measurement of growth parameters and yield of Rice

Growth parameters like plant height, leaf area index were recorded at three different growth stages at 30, 60 and 90 DAS. Total number of tillers were recorded at active tillering stage and dry matter production were recorded at post harvest stage. Plant height and number of tillers m^{-2} were recorded from five randomly selected hills in each plot, excluding border hills. Leaf area was recorded from another set of five hills, excluding border hills, randomly selected in each plot. At post harvest stage leaf samples were taken, dried in an oven at 65°C for 72 h until reached a constant weight, and then the dry weight was recorded. Yield and yield component parameters (number of productive tillers m^{-2}, number of grains per panicle, weight of panicle , length of panicle) were recorded from five hills.

Economic analysis

The cost of cultivation, gross return and net return were computed (Sivaraman and Palaniappan, 1996) for each treatment considering the prevailing market rate for inputs, produce and the wages paid to the labourers at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirapalli.

Results and Discussion

Plant height

Plant height is one of the important morphological growth parameter which is influenced by external and management practices. In the present investigation, the plant height was recorded at 30, 60, 90 DAS and were presented in Table 1. Among the different management practices, significantly the tallest plants were recorded under daincha incorporation followed by rice wet seeding + biofertiliser (M_5) with the height of 48.92, 62.58 and 115.75 at 30, 60, 90 DAS respectively and was on par with the M_6, (rice wet seeding + daincha inter cropping + biofertiliser) in all stages of growth. The lowest plant height was recorded under rice transplanting (M_1) with a height of 27.9, 48.0, 60.6cm at 30, 60 and 90 DAS and was on par with rice wet seeding (M_2). In general plant height increased with the advancement of plant age which might be due to the addition of more fresh biomass inturn led to the availability of more quantity of nutrients and favoured the release of nutrients to match with nutrient uptake by crop. Similar kind of results were reported by Chanda and Sarwar (2017).With respect to fertiliser levels, the highest plant height was recorded with the application of 125 per cent soil test based NPK (43.3, 61.6, 104.4 cm) followed by 100% soil test based NPK (39.7, 57.5, 100.3 cm) at 30, 60 and 90 DAS respectively. The lowest plant height (35.7, 52.3, 90.2 cm) at 30, 60 and 90 DAS was observed in 75% soil test based NPK followed by control.Increased application of fertiliser especially nitrogen resulted in significant increase in plant height. Nitrogen is an essential element for cell division and enlargement which would have been the reason for the increase in height at different growth stages. Higher plant height due to increased N addition was reported by Islam *et al.* (2015) and Dangi (2016).

Table 1. Effect of different management practices and fertiliser levels on plant height (cm)

	30 DAS					60 DAS					90 DAS				
	S_1	S_2	S_3	S_4	MEAN	S_1	S_2	S_3	S_4	MEAN	S_1	S_2	S_3	S_4	MEAN
M_1	25.33	27.67	28.00	30.67	27.92	45.00	48.00	49.33	50.00	48.08	58.50	55.03	63.17	65.83	60.63
M_2	28.00	31.00	34.00	37.67	32.67	52.67	53.67	54.33	56.33	54.25	88.00	96.83	98.83	104.50	97.04
M_3	35.67	37.67	40.00	43.00	39.09	54.00	56.67	58.33	59.00	57.00	90.00	104.43	104.00	108.00	101.61
M_4	35.67	37.67	38.67	42.33	38.59	52.83	56.00	58.67	59.67	56.79	92.33	99.00	103.33	112.17	101.71
M_5	44.67	47.67	48.67	54.67	48.92	54.33	59.67	62.00	74.33	62.58	110.83	113.83	118.33	120.00	115.75
M_6	45.00	48.00	49.00	51.67	48.42	55.00	58.00	62.67	70.73	61.60	101.67	104.67	114.50	116.27	109.28
MEAN	35.72	38.28	39.72	43.34		52.31	55.34	57.56	61.68		90.22	95.63	100.36	104.46	
M X S	M	S	M X S	SX M		M	S	M X S	S X M		M	S	M X S	S X M	
SEd	2.17	0.79	2.75	1.95		2.43	1.41	3.86	3.46		4.70	1.97	6.29	4.83	
CD	4.83	1.61	NS	NS		5.43	2.86	NS	NS		10.47	4.00	NS	NS	

Leaf area index

With regard to various management practices, daincha incorporation followed by rice wet seeding + biofertiliser (M_5) recorded the highest LAI (2.52, 3.42 and 3.76 at 30, 60 and 90 DAS respectively) and was on par with M_6, (rice wet seeding + daincha inter cropping + biofertiliser) in all stages of growth followed by M_3, (daincha incorporation) followed by rice wet seeding and M_4, (rice wet seeding + daincha inter cropping 1.73, 2.58, 3.15) which is on par at all the growth stages. The lowest LAI of 1.17, 1.65 and 1.98 was recorded in M_1 (rice transplanting) at 30, 60 and 90 DAS of rice which was on par with the M_2, (rice wet seeding) and were presented in Table 2.

Increases in LAI due to green manuring might be due to the additional supply of nitrogen in the soil. Similar kind of results were reported by Islam *et al.* (2015). Among the various fertiliser levels, highest LAI (2.16, 2.97, and 3.36) was observed in 125 % soil test based NPK followed by 100 % soil test based NPK (1.87, 2.71, 3.10 cm) at 30, 60 and 90 DAS respectively. Higher LAI due to increased N levels were reported by Islam *et al.* (2015) and Dangi (2016). The lowest LAI of 1.49, 2.05 and 2.66 at 30, 60 and 90 DAS was recorded in control.

Dry matter production

Dry matter production at post harvest stage of the crop was influenced by different management practices and fertiliser level. Accumulation of higher dry matter production was noticed with daincha incorporation followed by rice wet seeding + biofertiliser (M_5 14.42 t ha^{-1}) and was on par with M_6, (rice wet seeding + daincha inter cropping + biofertiliser 14.40 t ha^{-1} Table 3), the lowest dry matter production was noticed with M_1 (rice transplanting 11.49 t ha^{-1}) which was on par with the M_2 (rice wet seeding 11.50 t ha^{-1}). Increased amount of dry matter production is attributed to the application of large quantity of green manure. Application of daincha leads to increase in growth parameters and attributed to the increased nitrogen content in soil from biological nitrogen fixation and nitrogen mineralised from the decomposed organic matter. This will facilitate better uptake and accumulation of nutrients by rice and thereby increase the dry matter production, Kurdali (2005).Fertiliser application showed a significant increase in dry matter production and the highest dry matter production was recorded in 125 % soil test based NPK (14.47 t ha^{-1}) addition the lowest dry matter production was recorded in 75 % soil test based NPK (12.79 t ha^{-1}) followed by control (10.85 t ha^{-1}).Lesser dry matter production was reported in transplanted rice (M_1) without fertiliser application which is on par with wet seeded rice without fertiliser application. This might be due to lesser availability of nutrients for plant growth. Application of daincha along with biofertilizer showed significant increase in yield attribues (Fawaz Kurdali, 2005).

Table 2. Effect of different management practices and fertiliser levels on leaf area index

	30 DAS					60 DAS					90 DAS				
	S_1	S_2	S_3	S_4	MEAN	S_1	S_2	S_3	S_4	MEAN	S_1	S_2	S_3	S_4	MEAN
M_1	1.07	1.09	1.17	1.37	1.17	1.43	1.67	1.68	1.81	1.65	1.83	2.03	2.03	2.03	1.98
M_2	1.03	1.19	1.32	1.43	1.24	1.33	1.63	1.68	1.80	1.61	1.93	2.10	2.43	2.71	2.29
M_3	1.33	1.63	1.83	2.13	1.73	1.90	2.53	2.82	3.07	2.58	2.74	3.05	3.24	3.58	3.15
M_4	1.29	1.57	1.79	2.07	1.68	2.87	2.50	2.81	3.07	2.57	2.67	3.03	3.27	3.55	3.13
M_5	2.04	2.51	2.57	2.97	2.52	2.87	3.10	3.67	4.03	3.42	3.40	3.65	3.83	4.17	3.76
M_6	2.17	2.44	2.54	2.97	2.53	2.87	3.07	3.63	4.01	3.40	3.37	3.65	3.80	4.13	3.74
MEAN	1.49	1.74	1.87	2.16		2.05	2.40	2.71	2.97		2.66	2.92	3.10	3.36	
M X S	M	S	M X S	S X M		M	S	M X S	S X M		M	S	M X S	S X M	
SEd	0.07	0.05	0.14	0.13		0.12	0.06	0.17	0.14		0.10	0.08	0.21	0.21	
CD	0.17	0.11	NS	NS		0.26	0.12	0.37	0.29		0.23	0.8	NS	NS	

Yield attributes

Productive tillers

Different management practices and fertiliser levels had significant influence on productive tillers m^{-2} and significantly higher values were noted in (M_5) daincha incorporation followed by rice wet seeding + biofertiliser (413) which was on par with rice wet seeding + daincha inter cropping + biofertiliser (M_6), 410 . The lowest number of productive tillers was recorded in rice transplanting (M_1), 212 which was on par with rice wet seeding (M_2), 214 .

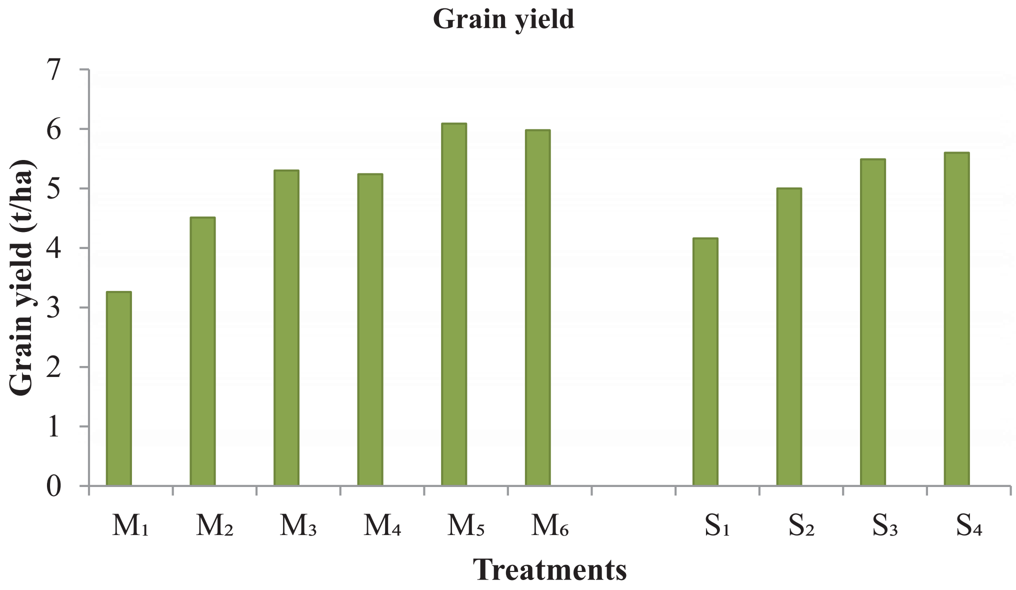
Table 3. Effect of different management practices and fertiliser levels on dry matter production (DMP t ha-1)

	DMP (t ha^{-1})				
	S_1	**S_2**	**S_3**	**S_4**	**MEAN**
M_1	9.9	10.7	12.2	12.9	11.4
M_2	9.9	10.7	12.2	12.9	11.5
M_3	10.5	12.9	13.7	14.3	12.9
M_4	10.8	12.9	13.7	14.3	12.9
M_5	11.8	14.6	15.0	16.1	14.4
M_6	11.8	14.6	15.0	16.0	14.4
MEAN	10.8	12.7	13.6	14.4	
M X S	M	S	M X S	S X M	
SEd	0.47	0.40	0.98	0.99	
CD	0.10	0.82	NS	NS	

The number of productive tillers was higher under 125 % soil test based NPK (S_4), 329 addition and was on par with by 100 % soil test based NPK (S_3), 325 lesser number of tillers was recorded in 75% soil test based NPK(S_2), 300 followed by control (S_1), 254.Application of green manure considerably modify the soil physical and chemical condition (Swarup, 1992). Increased amount of biomass resulted in more number of microbes and their activity which would have resulted in the mineralisation of nutrients and thereby it became easily available to the crop. The same result was reported by Ali (2013) and Kaur *et al.* (2017).

Grain yield and straw yield

Grain and straw yield were significantly influenced by the application of different management practices and fertiliser level. Significantly higher grain yield was recorded in daincha incorporation followed by rice wet seeding + biofertiliser (M_5 6.09 t ha^{-1}) and was on par with rice wet seeding + daincha inter cropping + biofertiliser (M_6 5.98 t ha^{-1}). The lowest grain yield of 3.2 t ha^{-1} was attained in rice transplanting (M_1) practices (Figure 1a). Significantly higher straw yield was recorded in rice wet seeding + daincha inter cropping + biofertiliser (M_6 7.56 t ha^{-1}) on par with daincha incorporation followed by rice wet seeding + biofertiliser (M_5 7.56 t ha^{-1}). The lowest straw yield of 4.68 t ha^{-1} was attained in rice transplanting (M_1 Figure 1b). Increased grain and straw yield was due to the additional supply of nitrogen through green manuring practices and also due to increase in number of grains per panicle. These findings are in line with Islam *et al.* (2015) and Swarup, (1987) and Chanda *et al*. (2017). Lesser grain and straw yield were reported in the transplanted rice without daincha and biofertilizer addition and on par with wet seeded rice without daincha and biofertilizer addition. Increasing fertiliser addition showed significant increase in grain yield and higher grain yield was recorded with the application of 125 % soil test based NPK (S_4 5.60 t ha^{-1}) which was on par with 100 % soil test based NPK (S_3 5.49 t ha^{-1}). The lowest grain yield of 4.16 t ha^{-1} was recorded in control (S_1).Higher straw yield was recorded in 125 % soil test based NPK (S_4), 6.93 t ha^{-1} which was on par with 100 % soil test based NPK (S_3 6.68 t ha^{-1}). The lowest straw yield of 5.30 t ha^{-1} was recorded in control (S_1).Grain and straw yield were significantly influenced by fertiliser levels and the increase might be due to higher sink capacity with



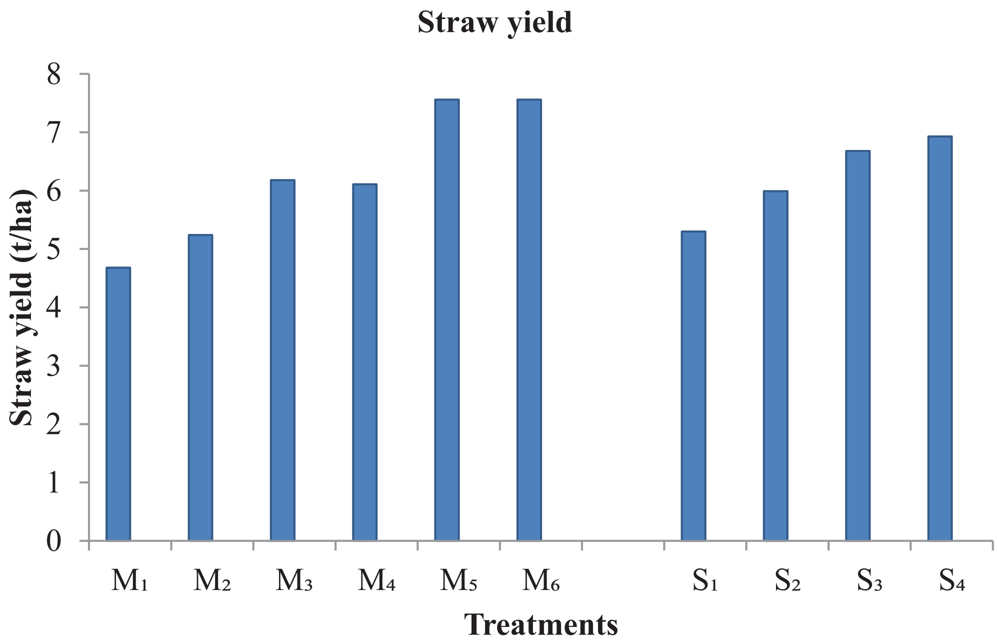


Figure 1. Influence of different management practices and fertiliser levels on grain and straw yield of rice

increased fertility and vigorous growth of the crop. Photosynthetic activity increased due to the fertiliser application especially nitrogen results in translocation of photosynthates, which promoted growth and yield attributes and produced more number of grains with higher weight that eventually increased the yield. Similar results were reported by Dangi (2016) , Islam *et al.* (2015) and Nagarajan *et al.* (2000).

Nutrient uptake

The nitrogen uptake was significantly higher at (M_5) daincha incorporation followed by rice wet seeding + biofertiliser (131.57 kg ha^{-1}) which was on par with rice wet seeding + daincha inter cropping + biofertiliser (M_6 128.66 kg ha^{-1}). The lowest nitrogen uptake was recorded rice transplanting (M_1 69.86 kg ha^{-1}) which was on par with rice wet seeding (M_2 70.53 Kg ha^{-1}).

Increased biomass resulted in increased microbiological activity and enhanced the uptake of nutrients and more over the amount of nutrients released through manure matched to the rate of utilization of nutrients and minimized nitrogen loss due to leaching and other factors due to the application of green manure. These findings are in line with Ali (2013) and Barassi *et al.* (2007). Application of biofertilizer positively influenced the nutrient uptake. This might have been due to the solubilisation of nutrients by microbes. Similar findings are also reported by Chinnusamy *et al.*(2006).

Fertiliser level showed a significant increase in nitrogen uptake at post harvest stage and the highest nitrogen uptake was recorded 125 % soil test based NPK (S_4 117.05 kg ha^{-1}) followed by 100 % soil test based NPK (S_3 110.21 kg ha^{-1}). The lowest nitrogen uptake of 74.28 kg ha^{-1} was recorded in control (S_1).

Economics

Higher cost of cultivation was incurred with daincha incorporation (M_5) followed by rice wet seeding + biofertiliser combined with 125 % soil test based NPK (Rs. 38365 ha^{-1}) which was on par with rice wet seeding + daincha inter cropping + biofertiliser (M_6) with 125 % soil test based NPK. The lesser cost of cultivation (Rs. 27425 ha^{-1}) was incurred in transplanted plot (M_1 without fertiliser).

The highest net return of Rs. 58819 ha^{-1}was recorded for daincha incorporation (M_5) followed by rice wet seeding + biofertiliser combined with 125 % soil test based NPK followed by daincha incorporation (M_5) followed by rice wet seeding + biofertiliser combined with 100 % soil test based NPK (Rs. 58573 ha^{-1}). The lowest net return of Rs.12439 ha^{-1} was recorded in transplanted plot with control (M_1without fertiliser).

Higher B:C ratio of 2.5 was recorded in daincha incorporation (M_5) followed by rice wet seeding + biofertiliser combined with 125 % soil test based NPK (M_5S_4) which was on par with daincha incorporation (M_5) followed by rice wet seeding + biofertiliser combined with 100 % soil test based NPK (M_5S_3). The lowest B:C ratio of 1.4 was recorded in transplanted plot with control (M_1 without fertiliser).

Conclusion

Among different management practices, daincha incorporation followed by rice wet seeding + biofertiliser (M_5) recorded significantly higher plant height, LAI, dry matter production, total number of tillers m^{-2}**.** Higher growth characters, physiological parameters, yield and yield attributes were obtained for 125% soil test based NPK application followed by 100 % soil test based NPK**.** Higher gross return, net return and B:C ratio were obtained in combined application of daincha incorporation followed by rice wet seeding + biofertiliser (M_5) with 125% soil test based NPK which remained on par with daincha incorporation followed by rice wet seeding + biofertiliser (M_5) with 100 % soil test based NPK. Hence 100 % of soil test based NPK is economical for producing optimum yield of rice in sodic soil which can be recommended for higher productivity of rice under sodic soil condition.

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