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Influence of Different Methods of Sowing, Mulching and Precision Nitrogen Management on Growth and Yield of Aerobic Rice

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Abstract

A field experiment entitled 'Influence of different methods of sowing, mulching and precision nitrogen management on growth and yield of aerobic rice' was conducted during *kharif* 2021-22 and 2022-23 at Agronomy Field Unit, ZARS, GKVK, Bengaluru. The experiment was laid out in a split-split plot design consisting methods of sowing (S_1 - Raised bed and S_2 - Flat bed) as main plot treatments with polythene mulching (M_0 - without mulching and M_1 - with mulching) as sub plots treatment and five nitrogen managements (N_1-Nutrient expert, N_2-Site specific nutrient management (SSNM), N_3-Green seeker, N_4-Nano urea and N_5-RDN) as sub-sub plot treatments. Irrigation was provided through drip throughout the crop duration. Experiment consisted of twenty treatment combinations and replicated thrice. The results of pooled data revealed that raised bed had higher plant height (19.18 and 93.11 cm at 30 and 90 DAS, respectively), leaf area (3182 cm^2 at 90 DAS), number of panicles $plant^{-1}$ (23.73), grain yield (5831 kg ha^{-1}) and straw yield (7181 kg ha^{-1}) over flat bed. The polythene mulching treatment outperformed over without mulching by recording higher plant height (19.81 and 95.78 cm at 30 and 90 DAS, respectively), leaf area (3238 cm^2 at 90 DAS), number of panicles $plant^{-1}$ (24.39), grain yield (5999 kg ha^{-1}) and straw yield (7364 kg ha^{-1}). Among the nitrogen management practices, following the recommendations of nutrient expert recorded higher plant height (20.35 and 97.99 cm at 30 and 90 DAS, respectively), leaf area (3316 cm^2 at 90 DAS), number of panicles $plant^{-1}$ (25.53), grain yield (6235 kg ha^{-1}) and straw yield (7620 kg ha^{-1}) over other practices. The results of the treatment SSNM in respect of plant height (19.15 and 95.53 cm at 30 and 90 DAS, respectively), leaf area (3224 cm^2 at 90 DAS), number of panicles $plant^{-1}$ (24.75), grain yield (6014 kg ha^{-1}) and straw yield (7461 kg ha^{-1}) were found on par with nutrient expert. Sustainable aerobic rice production can be achieved by the adoption of raised bed with polythene mulching and nitrogen management through nutrient expert which also benefit farmers with higher yield, economics and conserve resources.

Keywords : Polythene mulching, Aerobic rice, Precision nitrogen management, Green seeker

Rice, a vital cereal crop globally, is a cornerstone of sustenance for two-thirds of the world's population. In 2004, the United Nations recognized its pivotal role, designating it as the 'International Year of Rice'. This acknowledgement stems from rice's status as a staple food for half the world's populace, significantly contributing to the fight against poverty and malnutrition. It provides around 700 calories per day for approximately three billion people, particularly in developing nations (Sangeetha and Baskar, 2015).

Asia bears the responsibility for 90 per cent of paddy production and consumption worldwide, with India being the second-largest producer and consumer. India alone cultivates rice across 464 lakh hectares, yielding 129.47 million tons and average productivity of 2798 kg ha^{-1} (Anonymous, 2022). In Karnataka, rice covers roughly 13.97 lakh hectares, producing 43.18 lakh tons with a productivity of 3089 kg ha^{-1} (Anonymous, 2022).

Looking forward to 2025, the global population is projected to reach 8.1 billion. To ensure self-sufficiency in rice production, an annual increase of 2-3 per cent is needed, utilizing existing land and water resources. Traditional rice cultivation, characterized by continuous standing water until maturity, consumes 30 to 45 per cent of the Earth's freshwater resources (Humphreys *et al*., 2010). However, traditional methods face challenges due to water scarcity. Water-saving techniques like continuously saturated soil cultivation, the system of rice intensification (SRI), and alternate wetting and drying systems are believed to still demand significant water consumption (Geethalakshmi *et al.,* 2011).

In contrast, the aerobic rice system shines as a water-saving production method. It involves cultivating rice under unpuddled and unsaturated soil with supplementary irrigation, effectively reducing seepage, percolation and evaporation compared to conventional irrigation. Although it involves numerous drying and wetting cycles, it holds promise. Superior irrigation management techniques, coupled with suitable rice genotypes, could further enhance the yield and water use efficiency of aerobic rice. Drip irrigation, with precise water and nutrient application, is a feasible method for this approach (Hanson and May, 2007).

Implementing changes in land configuration, particularly through the adoption of the raised bed method, offers potential water-saving benefits up to 50 per cent reduction in irrigation water consumption and labour requirements, along with reduced pest and disease pressure (Ockerby and Fukai, 2001).

Mulching is another promising practice for soil protection, particularly in preventing soil moisture evaporation. Mulch prevents direct exposure of soil particles to raindrops, reduces the velocity of water flow over the soil, minimizes runoff losses and prevents soil erosion. Mulch also plays a crucial role in maintaining optimal soil temperature, promoting healthy plant growth, acting as a natural weed suppressant and preventing nutrient losses.

In case of the aerobic system, the alternating moist and dry soil conditions may stimulate nitrification-denitrification processes, leading to nitrogen loss through N_2 and N_2O. Even with high nitrogen applications, grain filling in aerobic rice may be limited by a low contribution of post-anthesis assimilates (Zhang *et al*., 2009). Additionally, the shallow root system in aerobic rice due to the absence of transplanting results in relatively low nitrogen uptake.

In southern India, rice yields fall short of their potential due to inadequate and inappropriate fertilizer use. Farmer's insufficient knowledge of nutrient management leads to unbalanced fertilizer applications, striving for maximum economic yields with new rice hybrids. Soil fertility variations across fields necessitate individualized fertilizer requirements and generic state recommendations often prove unsatisfactory. Therefore, the present investigation was undertaken to study the different methods of sowing, mulching and precision nitrogen management on growth and yield of aerobic rice

MATERIAL AND METHODS

A field experiment was carried out during *kharif* 2021-22 and 2022-23 at the Agronomy Field Unit, ZARS, GKVK, Bengaluru. The site is situated in the Agro-climatic Zone V: Eastern Dry Zone of Karnataka at 13° 05' North latitude and 77° 34' East longitude with an altitude of 924 m above mean sea level. The experiment consisted of twenty treatment combinations replicated three times, assigning two methods of sowing as main plot treatment (S_1 - Raised bed and S_2 - Flat bed) with two sub plots of polythene mulching (M_0 - Without mulching and M_1 - With mulching) and five sub-sub plot of nitrogen management (N_1 -Nutrient Expert, N_2 - Site Specific Nutrient Management (SSNM), N_3 - Green Seeker, N_4 - Nano urea and N_5 - RDN) was laid out in a split-split plot design.

The mulching material used for the experiment was a black polythene plastic sheet of 25 microns with 50 per cent coverage each which was covered during the crop as per treatments. Seed priming was done by soaking KRH-4 seeds in clean water for six hours and storing them in the gunny bag for three hours. The primed seeds were again treated with *Azospirullum* @ 4 g kg^{-1} of seeds. The KRH-4 seeds were sown on 16th August 2021 and 20th August 2022 and seeds were sown manually by following the seed rate of 5 kg ha^{-1} with a spacing of 25 cm × 25 cm. Irrigation was provided through drip lines laid between two crop rows. The drip lines were laid under the mulch in the treatments receiving polyethene mulch. The irrigation was scheduled at three days intervals up to harvest through a drip system. Nutrients were applied as per the treatments in the form of urea, single super phosphate and muriate of potash to supply nitrogen, phosphorus, and potassium, respectively as per the treatments and FYM of 10 t ha^{-1} was common for all the treatments. N_1-Nutrient Expert is a software developed by IPNI and CIMMYT, Mexico, for optimizing nutrient management in rice. N_2-SSNM, Nutrients required to achieve target yield (8 t ha^{-1}) were calculated by using the formulae given by Biradar and Aladakatti (2007) and Jnanesha (2012).

$$NR = \text{Uptake per quintal} \times T$$

Where,

NR = Nutrient required to achieve target yield in kg ha^{-1}

Uptake = Nutrient uptake by the crop per tonne grain yield in the respective crop and location

T = Target yield (ha^{-1})

N3 - Green Seeker is an optical sensor that emits and measures reflected light at two different wavelengths. NDVI values range from 0 to 1. If NDVI values are below 0.3, apply 25 kg ha^{-1} nitrogen. If values are between 0.3 and 0.5, apply 20 kg ha^{-1} nitrogen. If it is not in the range, no nitrogen is applied and values are more than 0.6, there is no need to apply additional nitrogen. N_4 - Treatment receiving nano urea spray, 50 per cent of nitrogen and 100 per cent of recommended P and K were applied as basal dose. At 15, 30, 45 and 60 DAS nano urea spray was taken up @ 4 ml l^{-1} of water. N_5 - RDN the 50 per cent of nitrogen and total amount of phosphorus and potassium were applied at sowing time and the remaining 50 per cent of nitrogen was applied as top dressing at 30 and 60 DAS in two equal splits. Timely weeding, plant protection and intercultivation operations were carried out.

Biometric observations on growth parameters were recorded randomly on selected five plants at 30, 60, 90 DAS and at harvest in the net plot. Data related to yield was recorded at the time of harvest of the crop. The data recorded on various parameters were subjected to Fisher's method of analysis of variance and interpretation of the data was made as given by Gomez and Gomez (1984). The level of significance used in the 'F' and't' test was P = 0.05. Whenever, the F-test was significant for comparison amongst the treatments, an appropriate value of critical differences (CD) was worked out. Otherwise, against CD values abbreviation 'NS' (Non-significant) is indicated.

RESULTS AND DISCUSSION

Plant height

Pooled data revealed that numerically higher plant height (19.18 cm) was recorded at 30 DAS in plants grown on raised bed but, at 90 DAS it varied significantly by recording higher plant height (93.11 cm at 90 DAS) than flat bed (Table 1 and 2). These outcomes may be due to the reason that plants grown on raised bed experience less resistance over flat bed, lead to improved growth observed. The results are in line with Fanish and Ragavan (2018).

When compared to without mulching, with polythene mulching recorded significantly higher plant height at all the growth stages in both the years with 19.81 and 95.78 cm at 30 and 90 DAS, respectively, over without mulching.

TABLE 1

Plant height of aerobic rice at 30 DAS as influenced by different sowing methods, mulching and precision nitrogen management

Treatment	Plant height (cm) at 30 DAS								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_1: Raised bed	18.68	19.72	19.20	18.07	20.26	19.17	18.38	19.99	19.18
S_2: Flat bed	17.24	19.90	18.57	17.27	19.36	18.31	17.25	19.63	18.44
Mean	17.96	19.81		17.67	19.81		17.82	19.81	
SMS x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
	NS	0.12	-	NS	0.46	-	NS	0.29	-
	**	0.24	0.95	**	0.08	0.30	**	0.13	0.50
	NS	0.34	-	NS	0.11	-	NS	0.18	-
Nitrogen Management (N)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N_1: NE	19.40	22.38	20.89	18.69	20.94	19.81	19.05	21.66	20.35
N_2: SSNM	18.62	19.58	19.10	18.26	20.14	19.20	18.44	19.86	19.15
N_3: GreenSeeker	18.31	19.21	18.76	18.19	19.75	18.97	18.25	19.48	18.87
N_4: Nano urea	16.85	18.73	17.79	16.37	19.80	18.08	16.61	19.27	17.94
N_5: RDN	16.61	19.15	17.88	16.85	18.42	17.63	16.73	18.78	17.76
NN x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
	*	0.74	2.12	*	0.46	1.32	**	0.47	1.36
	NS	1.04	-	NS	0.65	-	NS	0.67	-
Nitrogen Management (N)	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
N_1: NE	21.99	19.79	20.89	21.04	18.59	19.81	21.52	19.19	20.35
N_2: SSNM	19.26	18.94	19.10	19.44	18.97	19.20	19.35	18.96	19.15
N_3: GreenSeeker	18.56	18.96	18.76	19.63	18.31	18.97	19.09	18.64	18.87
N_4: Nano urea	17.80	17.78	17.79	18.27	17.90	18.08	18.04	17.84	17.94
N_5: RDN	18.40	17.36	17.88	17.45	17.81	17.63	17.93	17.58	17.76
N x S	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
	NS	1.04	-	NS	0.65	-	NS	0.67	-
Sowing methods (S) and Nitrogen Management (N)	M_0	M_1	M_0	M_1	M_0	M_1			
S_1N_1	20.85	17.96	19.74	17.64	20.29	17.80			
S_1N_2	20.15	17.09	18.95	17.57	19.55	17.33			
S_1N_3	18.76	17.85	18.37	18.02	18.57	17.94			
S_1N_4	17.10	16.60	16.47	16.26	16.79	16.43			
S_1N_5	16.54	16.68	16.83	16.86	16.69	16.77			
S_2N_1	23.13	21.62	22.34	19.53	22.74	20.58			
S_2N_2	18.37	20.79	19.92	20.36	19.15	20.58			
S_2N_3	18.35	20.07	20.90	18.60	19.62	19.34			
S_2N_4	18.50	18.97	20.07	19.53	19.29	19.25			

Continued....

Table 1 Continued....

Treatment	Plant height (cm) at 30 DAS								
	Mulching (M)								
	2021			2022			Pooled		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_2N_5	20.26	18.04	18.07	18.76	19.17	18.40			
S x M x N	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	1.47	-	NS	0.92	-	NS	0.94	-	

S_1 = Raised bed; S_2 = Flat bed; M_0= Without polythene mulching; M_1= With polythene mulching; N_1 =Nutrient Expert (NE); N_2 = Site specific nutrient management (SSNM); N_3 = GreenSeeker; N_4 = Nano urea; N_5 = Recommended dose of nitrogen (RDN); NS = Non-Significant

TABLE 2

Plant height of aerobic rice at 90 DAS influenced by different sowing methods, mulching and precision nitrogen management

Treatment	Plant height (cm) at 90 DAS								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_1: Raised bed	89.45	96.82	93.13	89.25	96.93	93.09	89.35	96.88	93.11
S_2: Flat bed	90.71	94.48	92.59	88.85	94.87	91.86	89.78	94.68	92.23
Mean	90.08	95.65		89.05	95.90		89.56	95.78	
SMS x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
**	0.03	0.17	**	0.06	0.38	**	0.05	0.27	
**	0.49	1.93	**	0.25	0.98	**	0.37	1.45	
NS	0.70	-	NS	0.35	-	NS	0.52	-	
Nitrogen Management (N)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N_1: NE	94.68	101.25	97.97	93.99	102.03	98.01	94.34	101.64	97.99
N_2: SSNM	93.26	97.82	95.54	92.23	98.80	95.51	92.74	98.31	95.53
N_3: GreenSeeker	90.71	94.35	92.53	89.35	94.97	92.16	90.03	94.66	92.34
N_4: Nano urea	89.12	94.29	91.71	87.47	93.39	90.43	88.30	93.84	91.07
N_5: RDN	82.62	90.53	86.58	82.22	90.34	86.28	82.42	90.43	86.43
NN x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
**	2.14	6.18	**	1.98	5.69	**	2.04	5.88	
NS	3.03	-	NS	2.79	-	NS	2.89	-	
Nitrogen Management (N)	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
N_1: NE	98.68	97.25	97.97	98.45	97.57	98.01	98.57	97.41	97.99
N_2: SSNM	95.61	95.46	95.54	96.22	94.81	95.51	95.92	95.14	95.53
N_3: GreenSeeker	91.69	93.36	92.53	91.51	92.81	92.16	91.60	93.09	92.34
N_4: Nano urea	91.61	91.81	91.71	91.76	89.10	90.43	91.68	90.45	91.07
N_5: RDN	88.08	85.08	86.58	87.51	85.04	86.28	87.80	85.06	86.43

Continued....

Table 2 Continued....

Treatment	Plant height (cm) at 90 DAS								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N x S	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ± CD @ 5%	
NS	3.03	-	NS	2.79	-	NS	2.89	-	
Sowing methods (S) and Nitrogen Management (N)	M_0	M_1	M_0	M_1	M_0	M_1			
S_1N_1	95.23	94.13	93.39	94.60	94.31	94.36			
S_1N_2	91.95	94.57	92.49	91.96	92.22	93.26			
S_1N_3	88.06	93.36	87.72	90.98	87.89	92.17			
S_1N_4	88.89	89.36	89.12	85.82	89.00	87.59			
S_1N_5	83.12	82.13	83.52	80.91	83.32	81.52			
S_2N_1	102.13	100.38	103.52	100.54	102.82	100.46			
S_2N_2	99.28	96.36	99.94	97.65	99.61	97.01			
S_2N_3	95.33	93.37	95.30	94.64	95.31	94.00			
S_2N_4	94.33	94.26	94.40	92.37	94.36	93.32			
S_2N_5	93.04	88.03	91.51	89.17	92.27	88.60			
S x M x N	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ± CD @ 5%	
NS	4.29	-	NS	3.95	-	NS	4.08	-	

S_1 = Raised bed; S_2 = Flat bed; M_0= Without polythene mulching; M_1= With polythene mulching; N_1 =Nutrient Expert (NE); N_2 = Site specific nutrient management (SSNM); N_3 = GreenSeeker; N_4 = Nano urea; N_5 = Recommended dose of nitrogen (RDN); NS = Non-Significant

The pooled data of 2021 and 2022 showcased that among five different precision nitrogen management practices, Nutrient Expert guided N management (N_1) recorded significantly taller plants of 20.35 and 97.99 cm at 30 and 90 DAS, respectively and which was showed on par results with Site Specific Nutrient Management (SSNM-N_2) with a targeted yield of 8 t ha^{-1} (19.15 and 95.53 cm at 30 and 90 DAS, respectively) and Green Seeker (N_3) guided nitrogen management showed on par results (92.34 cm at 90 DAS) with Nutrient Expert and SSNM. Shorter plants height (17.94 and 91.07 cm; 17.76 and 86.43 cm at 30 and 90 DAS, respectively) was recorded in the nano urea and RDN treatments. Interaction of methods of sowing, mulching and precision nitrogen management was non-significant on plant height at all the growth stages of aerobic rice.

Such a variation in plant height was caused by the interaction of numerous factors. Primarily due to irrigating the crop at the right time, which resulted in continuous availability of required moisture near the root zone which resulted in higher nutrient uptake and increased cell division and elongation and stimulated vegetative growth. The split dose application of nutrients will help crops to take up the nutrients in required time with sufficient quantity. Better nutrition, optimum moisture and solar energy utilization during plant growth was possible by practicing raised bed, polythene mulching and nitrogen management through Nutrient Expert has resulted in taller plants (Shukla *et al*., 2004).

Leaf Area Plant^{-1}

The pooled data on leaf area plant^{-1} was influenced by methods of sowing, mulching and precision nitrogen management. Data revealed that leaf area plant^{-1} increased in aerobic rice up to 90 DAS, then gradually reduced towards maturity (Table 3 to 4).

TABLE 3

Leaf area plant^{-1} of aerobic rice at 30 DAS influenced by different sowing methods, mulching and precision nitrogen management

Treatment	Leaf area plant^{-1} (cm^2) at 30 DAS								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_1: Raised bed	72.08	70.93	71.50	72.14	72.79	72.46	72.11	71.86	71.98
S_2: Flat bed	70.26	72.46	71.36	74.44	71.30	72.87	72.35	71.88	72.12
Mean	71.17	71.69		73.29	72.04		72.23	71.87	
SMS x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	0.76	-	NS	0.42	-	NS	0.17	-	
NS	0.50	-	NS	0.69	-	NS	0.13	-	
NS	0.70	-	NS	0.98	-	NS	0.18	-	
Nitrogen Management (N)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N_1: NE	73.95	71.90	72.93	72.68	73.93	73.31	73.32	72.92	73.12
N_2: SSNM	68.03	66.11	67.07	73.68	75.09	74.39	70.86	70.60	70.73
N_3: GreenSeeker	73.65	72.97	73.31	68.48	69.98	69.23	71.07	71.48	71.27
N_4: Nano urea	67.98	76.03	72.01	75.62	70.27	72.95	71.80	73.15	72.48
N_5: RDN	72.24	71.46	71.85	75.97	70.95	73.46	74.11	71.20	72.65
NN x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	1.61	-	NS	1.72	-	NS	0.83	-	
NS	2.27	-	NS	2.43	-	NS	1.17	-	
Nitrogen Management (N)	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
N_1: NE	73.07	72.79	72.93	75.09	71.53	73.31	74.08	72.16	73.12
N_2: SSNM	66.53	67.61	67.07	75.24	73.53	74.39	70.88	70.57	70.73
N_3: GreenSeeker	74.11	72.52	73.31	70.35	68.12	69.23	72.23	70.32	71.27
N_4: Nano urea	71.26	72.75	72.01	71.54	74.36	72.95	71.40	73.55	72.48
N_5: RDN	72.55	71.14	71.85	70.11	76.81	73.46	71.33	73.98	72.65
N x S	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	2.27	-	NS	2.43	-	NS	1.17	-	
Sowing methods (S) and Nitrogen Management (N)	M_0	M_1	M_0	M_1	M_0	M_1			
S_1N_1	75.10	72.81	72.65	72.72	73.87	72.76			
S_1N_2	69.45	66.61	72.03	75.34	70.74	70.97			
S_1N_3	75.91	71.39	69.48	67.48	72.70	69.43			
S_1N_4	66.28	69.69	73.80	77.44	70.04	73.56			
S_1N_5	73.65	70.83	72.74	79.21	73.20	75.02			
S_2N_1	71.04	72.76	77.53	70.33	74.28	71.55			
S_2N_2	63.60	68.61	78.45	71.73	71.03	70.17			
S_2N_3	72.30	73.65	71.21	68.75	71.75	71.20			
S_2N_4	76.24	75.82	69.27	71.28	72.76	73.55			

Continued....

Table 3 Continued....

Treatment	Leaf area plant^{-1} (cm^2) at 30 DAS								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_2N_5	71.46	71.46	67.48	74.42	69.47	72.94			
S x M x N	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ± CD @ 5%	
NS	3.22	-	NS	3.44	-	NS	1.65	-	

S_1 = Raised bed; S_2 = Flat bed; M_0= Without polythene mulching M_1= With polythene mulching; N_1 =Nutrient Expert (NE); N_2 = Site specific nutrient management (SSNM); N_3 = GreenSeeker; N_4 = Nano urea; N_5 = Recommended dose of nitrogen (RDN); NS = Non-Significant

Table 4

Leaf area plant^{-1} of aerobic rice at 90 DAS influenced by different sowing methods, mulching and precision nitrogen management

Treatment	Leaf area plant^{-1} (cm^2) at 30 DAS								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_1: Raised bed	3042	3198	3120	3162	3325	3243	3102	3262	3182
S_2: Flat bed	2894	3153	3023	3008	3277	3143	2951	3215	3083
Mean	2968	3176		3085	3301		3027	3238	
SMS x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
**	5	30	**	5	31	**	5	31	
**	18	71	**	19	73	**	18	72	
NS	25	-	NS	26	-	NS	26	-	
Nitrogen Management (N)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N_1: NE	3113	3389	3251	3236	3523	3380	3175	3456	3316
N_2: SSNM	3075	3247	3161	3197	3375	3286	3136	3311	3224
N_3: GreenSeeker	2945	3141	3043	3062	3265	3164	3004	3203	3103
N_4: Nano urea	2884	3072	2978	2998	3193	3096	2941	3133	3037
N_5: RDN	2821	3028	2924	2932	3147	3040	2877	3088	2982
NN x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
**	51	148	**	66	191	**	59	170	
NS	73	-	NS	94	-	NS	83	-	
Nitrogen Management (N)	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
N_1: NE	3265	3238	3251	3394	3366	3380	3329	3302	3316
N_2: SSNM	3189	3133	3161	3315	3257	3286	3252	3195	3224
N_3: GreenSeeker	3096	2991	3043	3218	3109	3164	3157	3050	3103
N_4: Nano urea	3048	2908	2978	3168	3023	3096	3108	2966	3037

Continued....

Table 4 Continued....

Treatment	Leaf area plant^{-1} (cm^2) at 30 DAS								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N_5: RDN	3003	2845	2924	3122	2958	3040	3063	2902	2982
N x S	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	73	-	NS	94	-	NS	83	-	
Sowing methods (S) and Nitrogen Management (N)	M_0	M_1	M_0	M_1	M_0	M_1			
S_1N_1	3107	3119	3230	3243	3169	3181			
S_1N_2	3094	3056	3217	3177	3156	3117			
S_1N_3	3036	2854	3156	2967	3096	2911			
S_1N_4	3008	2760	3127	2869	3068	2815			
S_1N_5	2963	2678	3080	2784	3022	2731			
S_2N_1	3422	3356	3558	3489	3490	3423			
S_2N_2	3283	3210	3413	3337	3348	3274			
S_2N_3	3155	3127	3280	3251	3218	3189			
S_2N_4	3087	3056	3209	3177	3148	3117			
S_2N_5	3043	3012	3164	3131	3103	3072			
S x M x N	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	103	-	NS	133	-	NS	118	-	

S_1 = Raised bed; S_2 = Flat bed; M_0= Without polythene mulching; M_1= With polythene mulching; N_1 =Nutrient Expert (NE); N_2 = Site specific nutrient management (SSNM); N_3 = GreenSeeker; N_4 = Nano urea; N_5 = Recommended dose of nitrogen (RDN); NS = Non-Significant

At 30 DAS, flat bed (72.12 cm^2), without polythene mulching (72.23 cm^2) and nitrogen management through Nutrient expert (73.12 cm^2) recorded numerically superior leaf area plant^{-1} over other treatments.

Methods of sowing had a direct effect on leaf area plant^{-1} of aerobic rice. Treatment with raised bed recorded significantly higher leaf area plant^{-1} at all the stages of crop growth except at 30 DAS. Higher leaf area plant^{-1} of 3182 cm^2 at 90 DAS, in raised bed which exceeded over flatbed.

Polythene mulch recorded significantly higher leaf area plant^{-1} 90 DAS (3238 cm^2) over without mulching treatment. The results are in line with Ehsanullah *et al.* (2014) and Iqbal and Ali (2014). Kulkarni *et al.* (1998) showed that the increased reflectivity index of polythene mulches gave more solar energy to the lower layers of the crop, which was not the case with no mulch treatments. As a result, even the lower levels of the crop were photosynthetically more active under polythene mulch treatments than the crop under no mulch. This led to increased leaf area.

Among different nitrogen management practices, application of optimum level of nitrogen based on the crop demand through Nutrient Expert recorded significantly higher leaf area plant^{-1} at all the growth stages (3316 cm^2 plant^{-1} at 90 DAS) which showed statistically on par results with SSNM (3224 cm^2 at 90 DAS). Application of RDN and nano urea foliar spray recorded lower leaf area trough out the crop growth period. Nitrogen promotes the growth of leaves and stems in rice plants. Adequate nitrogen supply enhances the leaf area, allowing for increased photosynthetic activity and improved overall plant growth.

Number of Panicles Plant^{-1}

The pooled data on number of panicles plant^{-1} varied significantly due to different treatments at harvest (Table 5).

Pooled data revealed that raised bed recorded 23.73 panicles plant^{-1} which outperformed flatbed and polythene mulching recorded higher panicles plant^{-1} of 24.39 when compared to without mulching.

Treatment receiving nitrogen management through Nutrient Expert recorded 25.53 and SSNM recorded 24.75 panicles plant^{-1} which was found on par with the best treatment. Lower number of panicles plant^{-1} (22.31 and 19.91) was recorded in nano urea and RDN, respectively. The formation of greater yield attributes may have been aided by significantly higher growth characteristics such as LAI, tillers m^{-2}, dry matter accumulation, higher chlorophyll content and PAR

TABLE 5

Number of panicles plant^{-1} of aerobic rice at harvest influenced by different sowing methods, mulching and precision nitrogen management

Treatment	Number of panicles plant^{-1}								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_1: Raised bed	22.55	25.04	23.79	22.63	24.70	23.67	22.59	24.87	23.73
S_2: Flat bed	20.87	24.13	22.50	21.65	23.69	22.67	21.26	23.91	22.59
Mean	21.71	24.59		22.14	24.19		21.93	24.39	
SMS x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
*	0.10	0.59	*	0.16	0.98	*	0.13	0.79	
**	0.18	0.70	**	0.29	1.13	**	0.23	0.91	
NS	0.25	-	NS	0.41	-	NS	0.33	-	
Nitrogen Management (N)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N_1: NE	24.16	27.40	25.78	24.13	26.43	25.28	24.14	26.92	25.53
N_2: SSNM	23.26	26.80	25.03	23.72	25.24	24.48	23.49	26.02	24.75
N_3: GreenSeeker	21.33	25.32	23.32	21.94	24.54	23.24	21.64	24.93	23.28
N_4: Nano urea	20.75	22.98	21.86	21.76	23.73	22.75	21.26	23.36	22.31
N_5: RDN	19.05	20.42	19.74	19.15	21.03	20.09	19.10	20.73	19.91
NN x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
**	0.49	1.42	**	0.59	1.70	**	0.53	1.52	
NS	0.70	-	NS	0.83	-	NS	0.75	-	
Nitrogen Management (N)	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
N_1: NE	26.02	25.54	25.78	25.56	24.99	25.28	25.79	25.27	25.53
N_2: SSNM	25.54	24.52	25.03	24.84	24.11	24.48	25.19	24.32	24.75
N_3: GreenSeeker	23.83	22.82	23.32	23.38	23.10	23.24	23.61	22.96	23.28
N_4: Nano urea	22.72	21.00	21.86	23.35	22.14	22.75	23.04	21.57	22.31
N_5: RDN	20.85	18.63	19.74	21.18	18.99	20.09	21.02	18.81	19.91
N x S	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	0.70	-	NS	0.83	-	NS	0.75	-	

Continued....

Table 5 Continued....

Treatment	Number of panicles plant^{-1} — Mulching (M)								
	2021			2022			Pooled		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
Sowing methods (S) and Nitrogen Management (N)	M_0	M_1	M_0	M_1	M_0	M_1			
S_1N_1	24.43	23.89	24.27	23.99	24.35	23.94			
S_1N_2	24.24	22.28	24.24	23.20	24.24	22.74			
S_1N_3	22.14	20.52	22.04	21.85	22.09	21.18			
S_1N_4	22.21	19.29	22.97	20.56	22.59	19.92			
S_1N_5	19.73	18.38	19.64	18.66	19.68	18.52			
S_2N_1	27.62	27.19	26.86	26.00	27.24	26.59			
S_2N_2	26.84	26.77	25.45	25.03	26.14	25.90			
S_2N_3	25.52	25.12	24.73	24.35	25.12	24.73			
S_2N_4	23.24	22.72	23.74	23.73	23.49	23.22			
S_2N_5	21.97	18.88	22.73	19.33	22.35	19.10			
S x M x N	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	0.98	-	NS	1.18	-	NS	1.06	-	

S_1 = Raised bed; S_2 = Flat bed; M_0= Without polythene mulching; M_1= With polythene mulching; N_1 =Nutrient Expert (NE); N_2 = Site specific nutrient management (SSNM); N_3 = GreenSeeker; N_4 = Nano urea; N_5 = Recommended dose of nitrogen (RDN); NS = Non-Significant

interception. Additionally, greater uptake and availability of nitrogen, a substrate for the synthesis of the organic molecules that make up protoplasm and chlorophyll (Sen *et al*., 2011) has led to more number of panicles plant^{-1}.

Different methods of sowing, mulching and precision nitrogen management did not have a significant interaction effect on number of panicles plant^{-1} in aerobic rice.

Grain and Straw Yield (kg ha^{-1})

Grain yield and straw yield measured after harvest in both the years (2021 and 2022) varied significantly by methods of sowing, mulching and precision nitrogen management and is presented in the Table 6 and 7.

In the year 2021, the treatment with raised bed recorded significantly higher grain and straw yield (6458 and 7410 kg ha^{-1}) over the flat bed (6200 and 7077 kg ha^{-1}). Similar trend was also observed in the second year (2022) where the earlier one recorded an average grain and straw yield of 5205 and 6952 kg ha^{-1}.

The pooled data showed that raised bed recorded higher grain and straw yield (5831 and 7181 kg ha^{-1}) over flat bed and the results were similar to Uphoff *et al.* (2011) and Zhang *et al.* (2009). Raised bed facilitated better initial growth which later led to overall improvement in yield paraments and finally yield.

The treatment with polythene mulching performed better in both the years with a significant yield difference of higher grain and straw yield in the year 2021 (6655 and 7611 kg ha^{-1}, respectively) and 2022 (5343 and 7118 kg ha^{-1}, respectively) over without mulching which recorded 6003 and 6876 kg ha^{-1} of grain and straw yield, respectively in the year 2021 and 4915 and 6660 kg ha^{-1}, respectively in 2022. The results agreed with Jabran *et al*., 2015 and Xu *et al*., 2007. Along with moisture conservation, enhanced nutrient availability, effective weed control, the higher

TABLE 6

Grain yield of aerobic rice influenced by different sowing methods, mulching and precision nitrogen management

Treatment	Grain yield (kg ha^{-1})								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_1: Raised bed	6194	6722	6458	5012	5397	5205	5603	6059	5831
S_2: Flat bed	5812	6588	6200	4817	5289	5053	5314	5938	5626
Mean	6003	6655		4915	5343		5459	5999	
SMS x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ± CD @ 5%	
**	4.71	28.69	*	11.24	68.37	**	4.09	24.88	
**	90.13	353.90	**	40.93	160.73	**	30.56	119.97	
NS	127.46	-	NS	57.89	-	NS	43.21	-	
Nitrogen Management (N)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N_1: NE	6644	7189	6916	5300	5809	5554	5972	6499	6235
N_2: SSNM	6277	7015	6646	5214	5550	5382	5745	6282	6014
N_3: GreenSeeker	5803	6859	6331	4721	5397	5059	5262	6128	5695
N_4: Nano urea	5714	6430	6072	4694	5163	4928	5204	5796	5500
N_5: RDN	5578	5783	5681	4645	4796	4720	5111	5290	5201
NN x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ± CD @ 5%	
**	158.65	457.03	**	141.98	408.98	**	139.96	403.17	
NS	224.37	-	NS	200.78	-	NS	197.93	-	
Nitrogen Management (N)	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
N_1: NE	6994	6838	6916	5615	5494	5554	6305	6166	6235
N_2: SSNM	6814	6477	6646	5487	5277	5382	6150	5877	6014
N_3: GreenSeeker	6476	6186	6331	5148	4970	5059	5812	5578	5695
N_4: Nano urea	6235	5909	6072	4982	4875	4928	5608	5392	5500
N_5: RDN	5772	5590	5681	4792	4648	4720	5282	5119	5201
N x S	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD@5%
NS	224.37	-	NS	200.78	-	NS	197.93	-	
Sowing methods (S) and Nitrogen Management (N)	M_0	M_1	M_0	M_1	M_0	M_1			
S_1N_1	6738	6550	5354	5246	6046	5898			
S_1N_2	6580	5974	5322	5105	5951	5539			
S_1N_3	6016	5590	4871	4570	5443	5080			
S_1N_4	5950	5479	4793	4595	5371	5037			
S_1N_5	5690	5467	4721	4568	5206	5017			
S_2N_1	7251	7127	5876	5741	6563	6434			
S_2N_2	7049	6981	5651	5449	6350	6215			
S_2N_3	6936	6782	5425	5369	6180	6075			

Continued....

Table 6 Continued....

Treatment	Grain yield (kg ha^{-1})								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_2N_4	6520	6340	5170	5155	5845	5747			
S_2N_5	5854	5713	4863	4729	5358	5221			
S x M x N	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	317.31	-	NS	283.95	-	NS	279.91	-	

S_1 = Raised bed; S_2 = Flat bed; M_0= Without polythene mulching M_1= With polythene mulching; N_1 =Nutrient Expert (NE); N_2 = Site specific nutrient management (SSNM); N_3 = GreenSeeker; N_4 = Nano urea; N_5 = Recommended dose of nitrogen (RDN); NS = Non-Significant

Table 7

Straw yield of aerobic rice influenced by different sowing methods, mulching and precision nitrogen management

Treatment	Straw yield (kg ha^{-1})								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_1: Raised bed	7138	7682	7410	6819	7085	6952	6979	7383	7181
S_2: Flat bed	6615	7540	7077	6501	7151	6826	6558	7345	6951
Mean	6876	7611		6660	7118		6768	7364	
SMS x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
**	19.15	116.50	**	0.66	4.04	**	9.87	60.03	
**	80.67	316.76	**	64.14	251.86	**	60.63	238.08	
NS	114.09	-	NS	90.71	-	NS	85.75	-	
Nitrogen Management (N)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N_1: NE	7647	8083	7865	7120	7629	7375	7383	7856	7620
N_2: SSNM	7277	8016	7646	7073	7477	7275	7175	7746	7461
N_3: GreenSeeker	6774	7877	7325	6586	7313	6950	6680	7595	7138
N_4: Nano urea	6596	7469	7033	6364	7051	6708	6480	7260	6870
N_5: RDN	6088	6610	6349	6157	6118	6138	6122	6364	6243
NN x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
**	163.10	469.85	**	176.96	509.76	**	117.41	338.23	
NS	230.66	-	NS	250.26	-	NS	166.05	-	
Nitrogen Management (N)	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
N_1: NE	7925	7804	7865	7408	7341	7375	7667	7573	7620
N_2: SSNM	7844	7449	7646	7310	7239	7275	7577	7344	7461
N_3: GreenSeeker	7492	7159	7325	7077	6823	6950	7284	6991	7138

Continued....

Table 7 Continued....

Treatment	Straw yield (kg ha^{-1}) Mulching (M) 2021 M$_0$	2021 M$_1$	2021 Mean	2022 M$_0$	2022 M$_1$	2022 Mean	Pooled M$_0$	Pooled M$_1$	Pooled Mean
N$_4$: Nano urea	7195	6870	7033	6848	6567	6708	7022	6719	6870
N$_5$: RDN	6593	6105	6349	6118	6157	6138	6356	6131	6243
N x S	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	230.66	-	NS	250.26	-	NS	166.05	-	
Sowing methods (S) and Nitrogen Management (N)	M$_0$	M$_1$	M$_0$	M$_1$	M$_0$	M$_1$			
S$_1$N$_1$	7700	7594	7142	7099	7421	7346			
S$_1$N$_2$	7594	6960	7133	7013	7363	6986			
S$_1$N$_3$	7099	6449	6799	6373	6949	6411			
S$_1$N$_4$	6845	6347	6621	6107	6733	6227			
S$_1$N$_5$	6453	5723	6402	5912	6427	5817			
S$_2$N$_1$	8151	8015	7675	7584	7913	7799			
S$_2$N$_2$	8094	7937	7487	7466	7791	7702			
S$_2$N$_3$	7885	7869	7354	7272	7620	7571			
S$_2$N$_4$	7546	7393	7075	7027	7310	7210			
S$_2$N$_5$	6734	6487	5834	6403	6284	6445			
S x M x N	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	326.21	-	NS	353.92	-	NS	234.83	-	

S$_1$ = Raised bed; S$_2$ = Flat bed; M$_0$= Without polythene mulching M$_1$= With polythene mulching; N$_1$ =Nutrient Expert (NE); N$_2$ = Site specific nutrient management (SSNM); N$_3$ = GreenSeeker; N$_4$ = Nano urea; N$_5$ = Recommended dose of nitrogen (RDN); NS = Non-Significant

response of physiological parameters may be the additional gain for increasing in grain yield in the polythene mulching treatment, which had been proved with the research of Lu *et al.* (2000).

Precision nitrogen management had significant effect on grain and straw yield of aerobic rice in both the years. Treatment N$_1$ recorded higher grain and straw yield (6916 and 7865 kg ha^{-1}) which showed on par results with N$_2$ (6646 and 7646 kg ha^{-1}). The grain (6331 kg ha^{-1}) and straw yield of 7325 kg ha^{-1} was recorded in treatment receiving GreenSeeker guided nitrogen management which was found as the next best treatment. Nano urea foliar application (6072 and 7033 kg ha^{-1} of grain and straw yield, respectively) and RDN (5681 and 6349 kg ha^{-1} of grain an straw yield, respectively) recorded lower grain and straw yield.

Similar results were recorded in the year 2022, higher grain and straw yield of aerobic rice recorded in N$_1$ (5554 and 7375 kg ha^{-1}) and was found to be on par with SSNM (5382 and 7275 kg ha^{-1}). GreenSeeker (5059 and 6950 kg ha^{-1}) recorded next best results. Nano urea (4928 and 6708 kg ha^{-1}) and RDN (4720 and 6138 kg ha^{-1}) recorded lower grain and straw yield.

The pooled data revealed that 19 and 22 per cent of grain and straw yield increment was possible by adopting precision nitrogen management technique like Nutrient Expert and SSNM. Nitrogen significantly influences the development of grains in rice. It plays a crucial role in the formation of the panicle, where the rice grains are produced. Proper nitrogen management can contribute to increased grain yield and quality. These results are in conformity with findings of other researchers (Dobermann *et al*., 2002;

Biradar *et al.* (2006) and Maheshwari *et al.,* 2009). Singh *et al.* (2009) compared SSNM in rice and wheat with farmer's fertilizer practice and found that average increase in rice and wheat yield was achieved by SSNM as Nutrient Expert. Wang *et al*. (2001) found that the performance of SSNM has consistently improved grain yield by about 10-15 per cent compared to the farmers' fertilizer practice.

Harvest Index

Pooled data of harvest index of aerobic rice as influenced by method of sowing, mulching and precision nitrogen management did not vary significantly and is presented in the Table 8.

The average of two years data showed that raised bed was advantageous over flat bed and the same recorded numerically higher harvest index of 0.45.

On comparison to without mulching, polythene mulching recorded higher growth parameters, yield attributes and higher yield. But with respect to harvest index no significant difference was recorded. Similar results were also recorded by Harunur *et al.* (2009).

Results of two years study (2021 and 2022) proved nutrient management do not have a significant effect on harvest index and the trend was reverse when compared to all other parameters. Treatment N_5 - RDN recorded numerically higher harvest index (0.46) and

TABLE 8

Harvest index of aerobic rice influenced by different sowing methods, mulching and precision nitrogen management

Treatment	Harvest index								
	Mulching (M)								
	2021			2022			Pooled		
Sowing methods (S)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
S_1: Raised bed	0.47	0.47	0.47	0.44	0.45	0.44	0.45	0.46	0.45
S_2: Flat bed	0.47	0.47	0.47	0.44	0.44	0.44	0.46	0.45	0.45
Mean	0.47	0.47		0.44	0.44		0.45	0.45	
SMS x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	0.001	-	NS	0.002	-	NS	0.001	-	
NS	0.005	-	NS	0.003	-	NS	0.004	-	
NS	0.007	-	NS	0.004	-	NS	0.005	-	
Nitrogen Management (N)	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N_1: NE	0.47	0.47	0.47	0.43	0.44	0.44	0.45	0.46	0.45
N_2: SSNM	0.46	0.47	0.47	0.44	0.43	0.44	0.45	0.45	0.45
N_3: GreenSeeker	0.46	0.47	0.46	0.43	0.44	0.44	0.45	0.45	0.45
N_4: Nano urea	0.46	0.46	0.46	0.45	0.44	0.45	0.46	0.45	0.46
N_5: RDN	0.48	0.47	0.47	0.44	0.45	0.45	0.46	0.46	0.46
NN x M	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	0.008	-	NS	0.010	-	NS	0.007	-	
NS	0.011	-	NS	0.014	-	NS	0.010	-	
Nitrogen Management (N)	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
N_1: NE	0.47	0.47	0.47	0.44	0.44	0.44	0.45	0.45	0.45

Continued....

Table 8 Continued....

Treatment	Harvest index								
	Mulching (M)								
	2021			2022			Pooled		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
N_2: SSNM	0.47	0.47	0.47	0.44	0.43	0.44	0.45	0.45	0.45
N_3: GreenSeeker	0.46	0.46	0.46	0.44	0.44	0.44	0.45	0.45	0.45
N_4: Nano urea	0.46	0.46	0.46	0.44	0.45	0.45	0.45	0.46	0.46
N_5: RDN	0.47	0.48	0.47	0.45	0.44	0.45	0.46	0.46	0.46
N x S	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	0.011	-	NS	0.014	-	NS	0.010	-	
Sowing methods (S) and Nitrogen Management (N)	M_0	M_1	M_0	M_1	M_0	M_1			
S_1N_1	0.47	0.47	0.43	0.43	0.45	0.45			
S_1N_2	0.47	0.46	0.44	0.44	0.45	0.45			
S_1N_3	0.46	0.46	0.43	0.43	0.45	0.45			
S_1N_4	0.46	0.46	0.45	0.46	0.46	0.46			
S_1N_5	0.47	0.49	0.43	0.45	0.45	0.47			
S_2N_1	0.47	0.47	0.44	0.44	0.46	0.45			
S_2N_2	0.47	0.47	0.44	0.43	0.45	0.45			
S_2N_3	0.47	0.46	0.44	0.44	0.46	0.45			
S_2N_4	0.46	0.46	0.44	0.44	0.45	0.45			
S_2N_5	0.46	0.47	0.47	0.43	0.47	0.45			
S x M x N	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%	F-test	S Em ±	CD @ 5%
NS	0.016	-	NS	0.020	-	NS	0.015	-	

S_1 = Raised bed; S_2 = Flat bed; M_0= Without polythene mulching; M_1= With polythene mulching; N_1 =Nutrient Expert (NE); N_2 = Site specific nutrient management (SSNM); N_3 = GreenSeeker; N_4 = Nano urea; N_5 = Recommended dose of nitrogen (RDN); NS = Non-Significant

nano urea (0.46). Lower harvest index was recorded in the Nutrient Expert, SSNM and Green Seeker treatments. Similar results were reported by Bhavya and Basavaraja (2021) and Theerthana *et al*. (2022).

Different methods of sowing, mulching and precision nitrogen management did not have significant interaction effect on harvest index of aerobic rice.

The outcomes of present study showed that the growth, yield and yield components of aerobic rice were significantly influenced by different treatments. Therefore, according to present study, it is concluding that the combination raised bed, polythene mulching and nitrogen management through Nutrient Expert recorded higher growth, yield and yield attributing components.

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