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Research Article

The Role of Sowing Times and Seedling Ages in the N, P, and K Absorption and Presence in Hybrid Rice

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Abstract

An agricultural study was carried out at the Agronomy Farm, during the Kharif seasons of 2021 and 2022. The aim of this study was to investigate how the availability and uptake of nitrogen (N), phosphorous (P), and potassium (K) content in hybrid rice in the Kokan region are influenced by the date of sowing and the age of seedlings. With 48 treatment combinations and three replications, the experiment used a split-split plot design. Four unique sowing periods—S1 (4–10 June), S2 (18–24 June), S3 (2–8 July), and S4 (16–22 July)—were the focus of the main plot treatments. Four different rice hybrids were used as supplementary plot interventions. *i.e.* Ambemohar, Indrawani, Kalbhat, and Dumra were the four rice hybrids used in the study. Three seedling stages were included in the sub-sub plot design: 15 days following planting (A1), 30 days following sowing (A2), and 45 days following sowing (A3). Clay loam with a moderate pH and a high amount of organic carbon made up the soil in the experimental area. The study's main objective was to evaluate the levels of and uptake by rice hybrids of nitrogen, phosphorus, and potassium. The 23rd meteorological week's work, which ran from June 4 to June 10, saw a significant increase in the nitrogen (N) content of grains (1.139% and 1.128%), phosphorus (P) content of grains (0.231% and 0.225%), and potassium (K) content of grains (0.341% and 0.335%) and straw (1.338% and 1.331%). In comparison to the other hybrids under study, Sahyadri 3 (H2) showed improved N, P, and K content (%) and uptake in grains, straw, and overall uptake (kg/ha). The treatment using 15-day-old seedlings (A1) revealed significantly greater N content (1.128% and 1.107%), P content (0.216% and 0.213%), K content (0.338% and 0.328%), and C content (0.098% and 0.095%) in grains and straw, respectively. As compared to the A2 (30 days after sowing) and A3 (45 days after sowing) seedlings stages in both years, the total intake of N (128.46 kg/ha and 111.38 kg/ha), P (23.50 kg/ha and 20.22 kg/ha), and K (130.49 kg/ha and 110.02 kg/ha) was greater in the A1 medication.

Keywords: NPK Availability and Uptake; Sowing time; Hybrids; Age of Seedling

Introduction

Around 163.1 million hectares are cultivated for rice globally, producing an estimated 722.56 million tonnes with average productivity of 4.4 tonnes ha-1. After China, India ranks as the world's second-largest producer and consumer of rice. [3] India will grow 108.50 million tonnes of rice on 44.11 million hectares of land in 2015 [2]. 15.51 lakh hectares of rice are grown in the state of Maharashtra, generating 29,465,000 tonnes of rice. However, India (2.13 tonnes ha-1) and Maharashtra (1.68 tonnes ha-1) produce much less rice on exceeds the global average of 4.4 tonnes per year. With an area of 4.20 lakh hectares and an annual production of 10.73 lakh tonnes of rice and an average productivity of 2.40 tonnes ha-1, the Konkan region of Maharashtra makes a significant contribution to the rice industry [3]. Maharashtra has several important rice-growing regions, including on the west coast, and Bhandara and Chandrapur in the east. Minor agricultural regions can also be found in the Western Ghat of Pune [3]. For the rural people in India's Konkan region, which is located on the Arabian Sea coast, rice-based agriculture is of utmost importance. Around 80% of the rice harvests in this area are grown on lowlands, which stretch

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700 km along the west coast and are 40–60 km wide. However, unpredictable weather patterns including delayed monsoons, high and persistent rainfall, sporadic dry spells, and major rains during harvesting times cause rice yields to vary considerably. It is necessary to increase rice production in order to meet the demands of the growing population and attain self-sufficiency in the production of food grains. The emphasis must shift to raising rice productivity per unit of land because there are few options to expand rice farming areas.

As a result, hybrid rice becomes a practical and simple genetic strategy to increase rice output. When grown using good management techniques, these hybrid cultivars perform well and offer improved yield prospects. In situations where traditional varieties have reached yield saturation and conventional methods are no longer able to generate further production advances, the cultivation of hybrid rice is advocated. It is critical to increase present rice production levels in order to attain national food grain self-sufficiency given the compelling need to meet the growing population demands on agricultural land. The emphasis is on increasing rice productivity per unit of land because there is little opportunity for expanding the area used for rice cultivation [9]. In this situation, hybrid rice shines out as a practical and simple genetic strategy to increase rice output. These hybrid types perform best when grown using good management techniques, offering a better possibility for greater yields. Not every variety will do equally well when transplanted using overly developed seedlings. To get superior yields in these circumstances, the selection of an appropriate variety becomes essential [13]. The sowing window is of utmost importance in influencing crop output. The planting timing is the only factor that affects how well a genotype performs. Planting delays often result in lower yields, and these losses cannot be made up for with other strategies. Grain yields have been demonstrated to be much greater at the ideal sowing periods.

Materials and Procedures

A study titled "Evaluation of Different Rice Hybrids for Sustainable Production via Agronomic Adjustments in High Rainfall Conditions of Aurangabad " was carried out in plot 74 of the "C" block during the Kharif seasons of 2021 and 2022. The experimental plot's soil had a clay loam texture, high levels of potassium (271.89 kg ha-1), and medium levels of both phosphorus (10.81 kg ha-1) and accessible nitrogen (270.22 kg ha-1). A large amount of organic carbon (1.2%) and a pH of 6.15 were present in the soil. A split-split plot design was used to organize the field experiment, which consisted of 48 treatment combinations that were reproduced three times. The main plot treatments covered four different sowing periods: the 23rd meteorological week (June 4–10, S1), the 25th meteorological week (June 18–24, S2), the 27th meteorological week (July 2–8, S3), and the 29th meteorological week (July 16–22, S4). Four rice hybrids, namely Ambemohar, Indrawani, Kalbhat, and Dumra, were the subject of the sub-plot treatments. Three seedling stages—A1 at 15 days after planting, A2 at 30 days after sowing, and A3 at 45 days after sowing—were included in these sub-plot treatments. For the transplanting procedure, seedlings from the nursery beds that were 15, 30, and 45 days old were removed and the same day as the transplant while maintaining a 20 by 15 centimetre of space. The different cultivation chores, such as applying fertilizer, controlling weeds and plants, harvesting, and threshing, were completed according to the established schedules. The three main nutrients, nitrogen, phosphorus, and potassium, were examined both before and after the crop was harvested. With the aid of tried-and-true techniques for soil and plant analysis, the NPK content of rice grain and straw was ascertained.

Impact of Planting Intervals

The 23rd meteorological week (4th to 10th June) saw a significant increase in the nitrogen (N) content of grain (1.139% and 1.128%), phosphorus (P) content of grain (0.231% and 0.225%), potassium (K) content of grain (0.341% and 0.335%), and straw (1.338% and 1.331%) following sowing. In addition, this sowing period saw the highest overall uptake of N (165.76 kg/ha and 144.87 kg/ha), P (30.92 kg/ha and 26.71 kg/ha), and K (172.01 kg/ha and 149.41 kg/ha). The 25th, 27th, and 29th meteorological weeks—observed in both 2021 and 2022—were followed by this pattern in descending order. [6,10]. Crops sown during the 23rd meteorological week had the highest nitrogen, phosphorus, and potassium uptake levels, followed by those sown during the 25th, 27th, and 29th meteorological weeks, in that decreasing order over the course of the two study years. Because grain and straw yield as well as their nutrient content affect nutrient uptake, the significant improvement in these elements' nutritious content as well as enhanced grain and straw yield significantly increased nutrient uptake. [10,11] However, because of the changes in sowing timings, it was discovered that the availability of nitrogen, phosphate, and potassium in the soil after harvest was statistically insignificant.

The Effectiveness of Hybrids

Both innate genetic factors and acquired properties of cultivars within particular climatic circumstances affect the nutritional contents and their depletion. However, due to its genetic establishment and as demonstrated by numerous testing carried out in India and around the world, any constituent's content remains unaltered. However, minor improvements can be made by changing agronomic management practices, such as choosing hybrids that respond well to additional inputs and adjusting planting schedules. These modifications may alter the anatomical physiology of the plants and improve their behavior, especially their effective uptake and utilization of nutrients. Ambemohar, which outperformed Indrawani, Kalbhat, and Dumra in descending order of significance, had the highest nitrogen (N) content and uptake among the hybrids that had been tested. [7,12]. This might be explained by Ambemohar's superior capacity for absorbing nitrogen, phosphate (P), and potassium (K), as well as by the fact that it produces more biological yield than the other hybrids. In both study years, Ambemohar showed noticeably greater levels of phosphorus content, elimination by grain and straw, and total uptake. Ambemohar significantly outperformed Indrawani, Kalbhat, and Dumra in terms of total phosphorus removal, doing so by 6.21%, 10.29%, and 16.77% more, respectively. The potassium (K) content and uptake in grain, straw, and total uptake were all noticeably greater in Sahyadri 3 (H2) [5]. In terms of total K intake, Ambemohar outperformed the other hybrids by 4.34%, 7.81%, and 14.14%

Table 1: Influence of Rice Grain Potassium Uptake (kg/ha) in 2022 due to Planting Schedule and Seedling Age.

Medication	2022			
	S_1: 23rd MW	S_2: 25th MW	S_3: 27th MW	S_4: 29th MW
$A_{1:}$ 15 DAS	29.29	24.50	18.32	7.66
$A_{2:}$ 30 DAS	25.34	21.34	14.48	5.41
$A_{3:}$ 45 DAS	22.28	18.71	13.09	4.60
S.E.±	0.48			
C.D. at 5%	1.35			

Table 2: Nitrogen, Phosphorus and Potassium content (%) by grain and straw as influenced by different treatments during *Kharif* 2021 and 2022.

Treatment	N content Grain (%)		N content Straw (%)		P content Grain (%)		P content Straw (%)		K content Grain (%)		K content Straw (%)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
A. Sowing times (S):												
S_1: 23rd MW (4th to 10th June)	1.139	1.128	0.640	0.631	0.231	0.225	0.103	0.102	0.341	0.335	1.338	1.331
S_2: 25th MW (18th to 24th June)	1.114	1.121	0.614	0.602	0.215	0.214	0.098	0.094	0.328	0.323	1.282	1.265
S_3: 27th MW (2nd to 8th July)	1.096	1.062	0.580	0.579	0.195	0.193	0.092	0.088	0.305	0.302	1.194	1.188
$S_{4:}$ 29th MW (16th to 22th July)	1.069	1.050	0.533	0.519	0.180	0.179	0.073	0.068	0.291	0.286	1.026	0.952
S.Em. ±	0.003	0.002	0.005	0.006	0.003	0.002	0.001	0.001	0.003	0.003	0.014	0.010
C.D. at 5 %	0.010	0.007	0.018	0.021	0.009	0.005	0.005	0.004	0.012	0.011	0.047	0.035
B. Hybrids (H):												
HH_1: Kalbhat	1.095	1.080	0.590	0.578	0.204	0.200	0.091	0.087	0.314	0.309	1.204	1.175
H_2H_2: Ambemohar	1.121	1.101	0.605	0.600	0.212	0.209	0.094	0.092	0.321	0.318	1.229	1.208
H_3: Dumra	1.096	1.079	0.579	0.566	0.199	0.198	0.090	0.086	0.312	0.307	1.197	1.169
H_4: Indrawani	1.106	1.100	0.593	0.587	0.205	0.204	0.091	0.088	0.318	0.312	1.209	1.185
S.Em. ±	0.008	0.008	0.007	0.009	0.004	0.003	0.001	0.002	0.002	0.003	0.012	0.011
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C. Age of seedlings (A):												
A_1: 15 DAS (Days after sowing)	1.128	1.107	0.618	0.615	0.216	0.213	0.098	0.095	0.338	0.328	1.247	1.226
A_2: 30 DAS (Days after sowing)	1.104	1.090	0.594	0.582	0.204	0.203	0.091	0.087	0.315	0.310	1.211	1.178
A_3: 45 DAS (Days after sowing)	1.082	1.073	0.564	0.551	0.195	0.193	0.085	0.082	0.296	0.297	1.172	1.148
S.Em. ±	0.006	0.005	0.006	0.007	0.003	0.002	0.001	0.001	0.002	0.002	0.008	0.010
C.D. at 5%	0.018	0.015	0.016	0.020	0.008	0.006	0.004	0.003	0.007	0.007	0.024	0.028
Interaction effect												
	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
H x A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x H x A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x H	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
General mean	**1.104**	**1.090**	**0.592**	**0.583**	**0.205**	**0.203**	**0.091**	**0.088**	**0.316**	**0.312**	**1.210**	**1.184**

Table 3: Nitrogen Phosphorus and Potassium uptake by grain and straw (kg/ha)) as influenced by different treatments during *Kharif* 2021 and 2022.

Treatment	N uptake Grain (kg/ha)		N uptake Straw (kg/ha))		P uptake Grain (kg/ha))		P uptake Straw (kg/ha))		K uptake Grain (kg/ha))		K uptake Straw (kg/ha)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
A. Sowing times (S):												
S_1: 23rdMW (4th to 10th June)	100.11	86.12	65.65	58.76	20.32	17.22	10.60	9.49	35.01	25.64	137.00	123.78
S_2: 25th MW (18th to 24th June)	90.95	74.48	57.77	50.65	17.66	14.30	9.20	7.92	30.87	21.52	120.71	106.51
S_3: 27th MW (2nd to 8th July)	59.77	53.75	39.94	34.87	10.63	9.78	6.33	5.28	20.97	15.30	82.00	71.25
$S_{4:}$ 29th MW (16th to 22th July)	28.38	21.59	20.21	17.45	4.80	3.70	2.75	2.27	11.07	5.89	38.86	31.83
S.Em. ±	0.91	0.81	0.50	0.74	0.37	0.20	0.10	0.10	0.45	0.31	1.01	0.87
C.D. at 5 %	3.13	2.79	1.72	2.57	1.27	0.68	0.33	0.34	1.55	1.07	3.49	3.01
B. Hybrids (H):												
HH_1: Kalbhat	68.54	57.92	45.47	39.69	13.03	11.03	7.12	6.06	24.28	16.86	93.66	81.55
H_2H_2: Ambemohar	74.88	62.79	49.29	43.98	14.66	12.22	7.76	6.87	26.00	18.35	100.80	89.52
H_3: Dumra	64.65	54.03	41.64	36.68	12.08	10.18	6.60	5.60	22.42	15.50	86.82	76.74
H_4: Indrawani	71.15	61.19	47.18	41.38	13.64	11.37	7.31	6.33	25.22	17.63	97.28	85.55
S.Em. ±	1.22	1.17	1.05	0.90	0.31	0.27	0.14	0.14	0.46	0.32	1.57	1.43
C.D. at 5%	3.56	3.42	3.07	2.64	0.91	0.80	0.42	0.40	1.33	0.93	4.59	4.20
C. Age of seedlings (A):												
A_1: 15 DAS (Days after sowing)	77.93	66.66	50.52	44.72	15.35	13.18	8.15	7.04	27.64	19.94	102.85	90.07
A_2: 30 DAS (Days after sowing)	69.20	57.97	46.21	39.64	13.17	11.02	7.25	6.08	24.36	16.64	95.26	81.64
A_3: 45 DAS (Days after sowing)	62.27	52.32	40.95	36.94	11.54	9.55	6.26	5.60	21.44	14.67	85.81	78.31
S.Em. ±	1.45	0.91	0.82	0.66	0.36	0.22	0.15	0.12	0.39	0.24	1.43	1.10
C.D. at 5%	4.09	2.58	2.31	1.88	1.01	0.63	0.43	0.33	1.11	0.68	4.05	3.10
Interaction effect												
S x H	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x A	NS	NS	NS	Sig	NS	Sig	NS	NS	NS	Sig	NS	NS
H x A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x H x A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
General mean	**69.80**	**58.98**	**45.89**	**40.43**	**13.35**	**11.25**	**7.22**	**6.24**	**24.48**	**17.09**	**94.64**	**83.34**

Table 4: Total uptake and avaibility of nitrogen, phosphorus and potassium (kg/ha)) as influenced by different treatments during *Kharif* 2021 and 2022.

Treatment	Total N uptake (kg/ha)		Total P uptake Straw (kg/ha))		Total K uptake Grain (kg/ha))		Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
A. Sowing times (S):												
S_1: 23rd MW (4th to 10th June)	165.76	144.87	30.92	26.71	172.01	149.41	271.13	259.53	11.41	10.91	290.16	283.32
S_2: 25th MW (18th to 24th June)	148.72	125.13	26.86	22.21	151.58	128.03	260.16	252.07	10.76	10.60	279.06	269.49
S_3: 27th MW (2nd to 8th July)	99.71	88.61	16.96	15.06	102.97	86.54	252.58	243.97	9.97	9.93	258.11	252.13
$S_{4:}$ 29th MW (16th to 22th July)	48.59	39.04	7.55	5.97	49.93	37.72	245.00	237.69	9.57	9.56	247.35	238.28
S.Em. ±	1.14	0.50	0.39	0.18	1.39	0.80	1.15	1.21	0.09	0.10	1.07	1.40
C.D. at 5 %	3.95	1.73	1.35	0.62	4.80	2.77	NS	NS	NS	NS	NS	NS
B. Hybrids (H):												
HH_1: Kalbhat	114.01	97.81	20.16	17.08	117.94	98.41	260.43	251.42	10.62	10.49	272.02	263.96
H_2H_2: Ambemohar	124.17	106.77	22.42	19.09	126.80	107.87	249.10	239.11	9.72	9.44	261.16	251.33
H_3: Dumra	106.29	90.71	18.68	15.87	109.24	92.24	264.13	255.18	11.00	10.73	274.60	268.15
H_4: Indrawani	118.32	102.57	21.03	17.91	122.50	103.18	255.22	247.55	10.36	10.34	266.90	259.79
S.Em. ±	1.50	1.65	0.32	0.32	1.94	1.67	2.07	1.41	0.13	0.10	1.21	1.54
C.D. at 5%	4.37	4.81	0.97	0.94	5.65	4.90	NS	NS	NS	NS	NS	NS
C. Age of seedlings (A):												
A_1: 15 DAS (Days after sowing)	128.46	111.38	23.50	20.22	130.49	110.02	250.74	242.19	9.65	9.63	256.53	251.81
A_2: 30 DAS (Days after sowing)	115.41	97.61	20.42	17.09	119.62	98.28	257.55	248.80	10.36	10.20	267.76	260.63
A_3: 45 DAS (Days after sowing)	103.22	89.26	17.80	15.15	107.25	92.98	263.37	253.95	11.26	10.93	281.72	269.97
S.Em. ±	1.72	1.11	0.39	0.25	1.74	1.10	2.00	1.44	0.11	0.10	1.44	1.45
C.D. at 5%	4.85	3.14	1.11	0.71	4.91	3.09	NS	NS	NS	NS	NS	NS
Interaction effect												
S x H	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x A	NS	Sig	NS	Sig	NS	NS	NS	NS	NS	NS	NS	NS
H x A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x H x A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
General mean	**115.70**	**99.41**	**20.57**	**17.49**	**119.12**	**100.43**	**257.22**	**248.31**	**10.43**	**10.25**	**268.67**	**260.81**

in the corresponding years. This result was influenced by increased grain and straw yields as well as increased nutritional concentration in grains. Ambemohar's increased uptake and removal of nutrients from the soil's accessible pool caused a rise in photosynthesis-related physiological expression, which in turn increased the amount of dry matter partitioning into stems and leaves [7,12]. Comparing several rice hybrids in the years 2021 and 2022, it was discovered that the amounts of nitrogen, phosphorus, and potassium in the soil following crop harvest were statistically negligible [7,12].

Effect of Seedling Age

The age of seedlings and their ability to draw nutrients from the soil were significant determinants of the nitrogen, phosphorous, and potassium levels in both grains and straw, as well as their overall intake (Tables 2, 3, & 4). With the exception of potassium (K), which followed the reverse pattern and was present in higher concentration in straw than in grains, the nutritional content (N and P%) was higher in grains as compared to straw. Using various seedling ages resulted in statistically negligible fluctuations in N, P, and K content in both grains and straw over the course of the two study years. Accordingly, the use of seedlings that were 15 days old (A1) led to considerably increased N, P, and K uptake in grains and straw, as well as their overall uptake, as compared to older seedlings that were 30 days old (A2) and 45 days old (A3) during their respective years [8]. It should be noted that the greater removal of K by straw is mostly attributable to the nutrient's luxury use throughout the crop cycles, particularly more so than in grains. After crop harvest, the primary nutrients nitrogen, phosphorus, and potassium in the soil (as shown in Table 1) did not show any statistically significant differences in relation to the different seedling ages in the years 2021 and 2022, respectively [4].

Effect of Interaction

Regarding the grain intake by rice in 2022 (as shown in Table 1), the treatment combination S1A1 that was taken. into account both planting time and seedling age showed significantly better potassium straw uptake by rice (in kg per hectare). This particular therapy combination worked much better than the other treatment combinations.

Author Statements

Conflict of Interest

The authors have no conflicts of interest to declare.

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