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Biometric observations of upland rice (*Oryza sativa* L.) as influenced by NK ratios and time of sowing

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Abstract
An experiment was conducted at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala Agricultural University, Kerala, India. The treatments were laid out in factorial randomized block design. Different NK ratios (60:30, 120:60, 120:90, 140:70 and 140:105) and two time of sowing (one week after the commencement of SW monsoon, 2019 and two weeks after the commencement of SW monsoon, 2019) were studied and evaluated statistically on growth characters like plant height (30 DAS, 60 DAS and at harvest), number of tillers m^{-2} (60 DAS) leaf area index (60 DAS) and dry matter production (60 DAS and at harvest). The results revealed that there is significant difference in biometric observations. The treatment l_6 (140:105 kg ha^{-1} of NK at 2:1.5 ratio) recorded the maximum plant height (99.23 cm), highest number of tillers m^{-2} (378.83) and dry matter production (5073 kg ha^{-1}). Regarding time of sowing, s_1 (sowing one week after the commencement of S-W monsoon, 2019) produced the tallest plants (96.77 cm), highest number of tillers m^{-2} (345.00) and dry matter production (4618 kg ha^{-1}). Among the treatment combinations, l_6s_1 (140:105 kg ha^{-1} of NK at 2:1.5 ratio and time of sowing one week after the commencement of S-W monsoon, 2019) produced the tallest plants (101.70 cm), highest number of tillers m^{-2} (415.67) and the maximum dry matter production (5256 kg ha^{-1}).

Keywords: Upland rice, nitrogen, potassium, time of sowing

Introduction
Rice is one of the chief grains of the world. Rice provides food for more than half of the world's population. Rice provides 21 per cent of global human per capita energy and 15 per cent of per capita protein. Nutrient management is an important factor which influences upland rice production. Suitable nutrient management practices must be adopted to overcome the constraint of low productivity in upland rice. Studies indicated that upland rice responded well to higher levels of N and K. An adequate supply of N is associated with higher photosynthetic activity, vegetative growth and yield of upland rice. K is essential for photosynthetic activity and helps in inducing drought tolerance, disease resistance and production of stiff stalks and stem. In addition, increased K levels enhance water use efficiency, root growth and water absorption, especially under upland condition. The present recommended doses of N and K as per Package of Practices are 60 and 30 kg ha^{-1} (KAU 2016) [7]. It is observed that there is higher uptake of N and K at rates exceeding the recommended dose leading to depletion of N and K reserves of soil. Kumar (2016) [6] reported that N and K applied at 120 kg ha^{-1} and 60 kg ha^{-1} recorded higher growth characters.
One of the critical aspects of direct seeding of rice is time of sowing. Planting time is the major factor that determines the productivity of the crop. Optimum planting time is important for realizing higher yields. Early or delay in sowing leads to lower production in upland rice. It is therefore necessary to standardize time of sowing. Optimum sowing time has to be standardized for realizing higher yields of upland rice, for every agro- ecological situation for success of upland rice.

Materials and methods
The field trial was conducted during Kharif 2019 at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India. The variety used for the study was Aiswarya (PTB 52). The experiment was laid out in factorial randomized block design consists of 12 treatment

combinations and 3 replications. The soil was sandy clay loam in texture and low in available N (252 kg ha^{-1}), high in available P (30.20 kg ha^{-1}) and medium available K (220 kg ha^{-1}). The treatments comprised of 6 levels of N and K in 2:1 and 2:1.5 ratios (l_1:60: 30 (control-1), l_2: PGPR MIX- I : 6 kg + FYM 5 t ha^{-1} (control-2), l_3 : 120: 60, l_4 :120: 90, l_5 : 140: 70 and l_6 :140:105) and 2 time of sowing (s_1: sowing one week after the commencement of S-W monsoon, 2019 and s_2: sowing two weeks after the commencement of S-W monsoon, 2019). Before the start of experiment, farm yard manure was applied uniformly to all the plots at the rate of 5 t ha^{-1}. A uniform dose of P_2O_5 (30 kg ha^{-1}) was applied to all the plots (entire quantity as basal). The first sowing was done on 13/06/2019 and second sowing on 21/06/2019. The crop was harvested on the following dates of 14/10/2019 and 21/10/2019 respectively. The growth characters like plant height (30 DAS, 60 DAS and harvest), number of tillers m^{-2} (60 DAS) leaf area index (60 DAS) and dry matter production (60 DAS, harvest) was recorded at the respective growth stages.

Results and Discussion

The results revealed that the NK ratios, time of sowing and their interactions were significantly influenced the biometric observations like plant height, number of tillers m^{-2} and dry matter production (Tables 1, 2 and Fig 1, 2). The treatment l_6 (140:105 kg ha^{-1} of NK at 2:1.5 ratio) recorded the tallest plants (99.23 cm), highest number of tillers m^{-2} (378.83) and dry matter production (5073 kg ha^{-1}). Regarding time of sowing, s_1 (sowing one week after the commencement of S-W monsoon, 2019) produced the tallest plants (96.77 cm), highest number of tillers m^{-2} (345.00) and dry matter production (4618 kg ha^{-1}). Among the treatment combinations, l_6s_1 (140:105 kg ha^{-1} of NK at 2:1.5 ratio and time of sowing one week after the commencement of S-W monsoon, 2019) produced the tallest plants (101.70 cm), highest number of tillers m^{-2} (415.67) and the maximum dry matter production (5256 kg ha^{-1}). The leaf area index was not significantly influenced by the treatments.

This is mainly attributable to higher doses of nitrogen and potassium (l_6) over other treatments. Nitrogen is one of the major nutrients needed for the plant growth. It is essential for the synthesis of proteins, a constituent of protoplasm which is considered as physiological basis of life. N is important for chloroplast synthesis. The increased plant height is mainly due to cell elongation, meristematic activity and increased photosynthetic rate. Favourable effect on plant height due to K application was noticed at 60 DAS and at harvest. Application of K at 105 kg ha^{-1} significantly influenced plant height (Tables 1a and 1b). Potassium strengthens the cell wall, helps in the growth of meristematic tissue, and enables the plant to withstand biotic and abiotic stresses. Ranjini (2002) [10] obtained higher plant height in upland rice at higher N and K levels up to 90 and 45 kg ha^{-1} respectively. This is in conformity with the findings of Kumar (2016) [6] and Greeshma (2019) [5] in upland rice.

Application of higher levels of N and K (140:105 kg ha^{-1}at 2:1.5 ratio) favourably influenced tillering. This might be due to more availability of N and K for crop growth. Higher levels of K improved tillering by way of favouring protein synthesis and imparting drought tolerance. Kumar (2016) [6] obtained increased tillering when N and K were applied at 120 kg and 60 kg ha $^{-1}$ respectively. Application of N and K at 100 and 50 kg ha^{-1} respectively produced the maximum tillers in rice (Mini, 2005) [8]. Greeshma (2019) [5] reported the maximum tiller number m^{-2} at the NK level of 120:90 kg ha^{-1} (2:1.5 ratio) in upland rice.

There was progressive increase in dry matter production with additional increment of N and K. Increased levels of N and K might have promoted vegetative growth in terms of height, tiller number and leaf area, there by leading to higher photosynthetic rate and better translocation of photosynthates. Anu (2001) [2] obtained similar results in upland rice at 80:45 kg ha^{-1} N and K. Kumar (2016) [6] obtained the highest dry matter production at NK applied at 120 kg and 60 kg ha^{-1}in upland rice. Greeshma (2019) [5] reported the maximum dry matter production at NK applied at 120:60 kg ha^{-1}in upland rice.

The time of sowing significantly influenced the plant height at 60 DAS and harvest. The SW monsoon commenced on 04/06/2019 with a rainfall of 58.9 mm and sowing as per treatment s_1 was done on 13/06/2019. There was an effective rainfall of 960.7 mm in 50 rainy days for treatment s_1 during the growing period. With respect to treatment s_2 (sowing two weeks after the commencement of SW monsoon), sowing was done on 21/06/2019 and there was an effective rainfall of 754.6 mm in 40 rainy days during the growing period. The treatment s_1 received an additional 206.1mm of rainfall. This might have improved moisture content of the soil and favoured the microclimate, thereby helped the plant to put forth more height. This corroborates with the findings of Bashir *et al.* (2010) [3] and Abid *et al.* (2015) [1] in rice.

Late sowing reduced tillering. The supremacy of s_1 over s_2 might be due to the longer vegetative period, better microclimate and increased moisture availability coupled with minimum abiotic stress in s_1 might have helped the plants to produce more tillers with higher availability of nutrients. This was in conformity with the findings of Rai and Kushwaha (2008) [9] in rice.

The time of sowing imparted significant difference on dry matter production both at 60 DAS and at harvest. The highest dry matter production was recorded by the treatment s_1 (sowing one week after the commencement of SW monsoon, 2019). The better utilization of resources such as moisture and nutrients coupled with favourable microclimate in s_1 might have helped the crop to tap more photosynthates there by leading to higher dry matter production. This is in conformity with the findings of Gill *et al.* (2006) [4] in direct sown rice

Table 1a: Effect of NK ratios and time of sowing on plant height, cm

Treatments	Plant height		
	30 DAS	**60 DAS**	**Harvest**
NK levels and ratios (L)			
l_1 (60:30)	45.15	82.64	92.95
l_2 (PGPR MIX I 6 kg + FYM 5 t)	45.03	82.58	92.62
l_3 (120:60)	46.90	83.79	95.62
l_4 (120:90)	47.60	86.90	96.87
l_5 (140:70)	48.74	86.92	97.63
l_6 (140:105)	49.45	89.22	99.23
SEm(±)	0.17	0.24	0.32
CD (0.05)	NS	0.722	0.966
Time of sowing			
s_1	47.57	85.96	96.77
s_2	46.72	84.73	94.87
SEm(±)	0.10	0.14	0.18
CD (0.05)	NS	0.417	0.558

Table 1b: Interaction effect of NK ratios and time of sowing on plant height, cm

Treatments	Plant height		
(l x s interaction)	30 DAS	60 DAS	At harvest
l_1s_1	45.53	83.39	93.09
l_1s_2	44.78	81.90	92.82
l_2s_1	45.30	83.48	93.10
l_2s_2	44.76	81.68	92.14
l_3s_1	47.53	83.95	95.78
l_3s_2	46.27	83.63	95.47
l_4s_1	47.63	87.74	97.43
l_4s_2	47.58	86.06	96.32
l_5s_1	49.36	87.29	99.56
l_5s_2	48.11	86.56	95.71
l_6s_1	50.05	89.90	101.70
l_6s_2	48.85	88.55	96.77
SEm(±)	0.24	0.34	0.46
CD (0.05)	NS	NS	1.367

Table 2a: Effect of NK ratios and time of sowing on dry matter production at different growth stages, kg ha^{-1}, number of tillers m^{-2} and leaf area index at 60 days after sowing

Treatments	Dry matter production		Number of tillers m^{-2}	Leaf area index
	60 DAS	Harvest		
NK levels and ratios (L)				
l_1 (60:30)	1421	3473	294.00	3.12
l_2 (PGPR MIX I + FYM)	1149	2927	286.66	3.09
l_3 (120:60)	1863	4316	311.16	3.30
l_4 (120:90)	2028	4540	338.16	3.46
l_5 (140:70)	2047	4937	361.66	3.52
l_6 (140:105)	2181	5073	378.83	3.84
SEm(±)	23	21	2.56	0.02
CD (0.05)	66.4	61.9	7.585	NS
Time of sowing				
s_1	1992	4618	345.00	3.42
s_2	1923	4369	311.83	3.35
SEm(±)	13	12	1.48	0.01
CD (0.05)	38.3	35.76	4.379	NS

Table 2b: Interaction effect of NK ratios and time of sowing on dry matter production at different growth stages, kg ha^{-1}, number of tillers m^{-2} and leaf area index at 60 days after sowing

Treatments	Dry matter production		Number of tillers m^{-2}	Leaf area index
(l x s interaction)	60 DAS	At harvest		
l_1s_1	1425	3516	300.00	3.11
l_1s_2	1416	3429	289.00	3.13
l_2s_1	1175	2956	285.67	3.04
l_2s_2	1123	2897	287.67	3.14
l_3s_1	1889	4405	320.00	3.32
l_3s_2	1837	4226	302.33	3.28
l_4s_1	2129	4678	359.33	3.52
l_4s_2	1927	4402	317.00	3.40
l_5s_1	2041	5180	389.33	3.58
l_5s_2	2052	4693	334.00	3.49
l_6s_1	2258	5256	415.67	3.95
l_6s_2	2104	4891	342.00	3.73
SEm(±)	32	30	3.63	0.03
CD (0.05)	93.9	87.6	10.726	NS

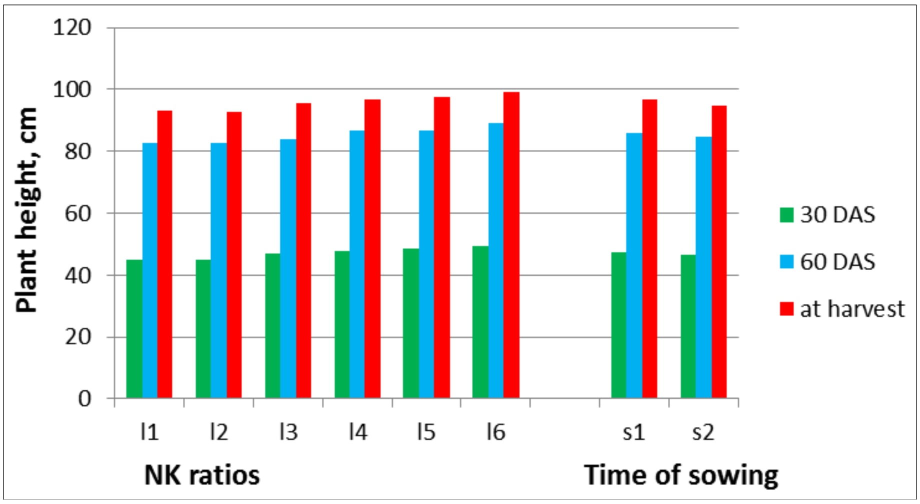

Fig 1: Effect of NK ratios and time of sowing on plant height, cm

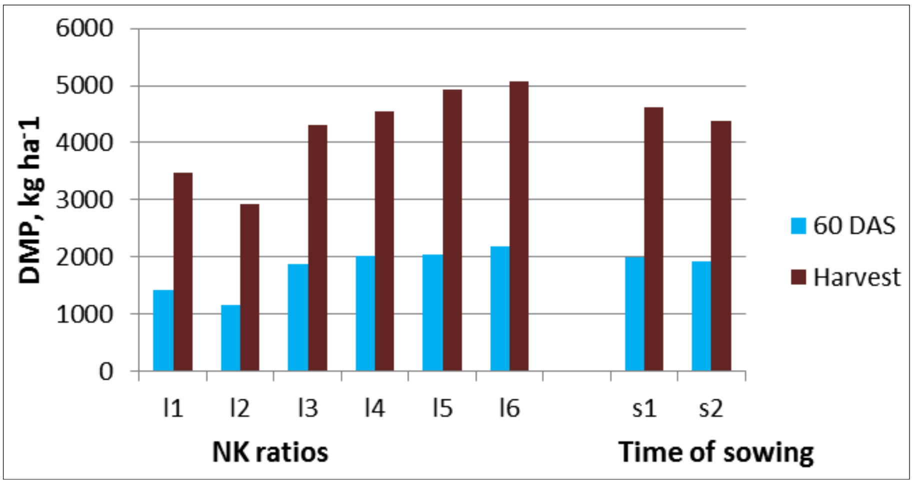

Fig 2: Effect of NK ratios and time of sowing on dry matter production, kg ha^{-1}

Conclusion

Based on the experimental results, it can be concluded that the application of 140 kg N and 105 kg K_2O ha^{-1}(2:1.5 ratio) and sowing one week after the commencement of SW monsoon resulted in higher growth characters like plant height, number of tillers m^{-2} and dry matter production.

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