#7604 GRAIN YIELD OF TWO PRE-RELEASE RICE VARIETIES INCREASED MARGINALLY WITH HIGHER PLANT DENSITY AND NITROGEN RATE

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ABSTRACT

The application of precision agriculture (PA) through the optimization of plant population and management of fertilizer nitrogen (N) can increase yield. Current rice *(Oryza sativa*) plant population and N management guidelines in Kenya were developed from research conducted about three decades. These management guidelines might still be robust and could be applied to recently released as well as close-to-release varieties. However, the yield potential of new and pipeline varieties might not be maximized under existing sowing density and N rate. A study was conducted to investigate the effect plant population and N rate on two pre-release rice varieties, namely 08FAN10 and CSR36. Field experiments were carried out in Ahero and Mwea rice research stations. Treatments were laid out in a randomized complete block design with split-split plot arrangement where three N rates (0, 75 and 125 kg N/ha) formed the main plots, varieties were assigned to the sub-plots while three plant densities (1, 2 and 3 plants per hill, PPH) were allocated to the sub-sub plots. Nitrogen was applied in the form of urea in two equal splits at 21 and 45 day after transplanting (DAT). Data were collected on crop growth, yield and N traits, and subjected to analysis of variance using GenStat 14th edition. Treatment means were compared and separated the least significant difference at 5% probability level. Variety 08FAN10 out-yielded CSR36 by 47% in Mwea only while the addition of fertilizer nitrogen significantly improved grain yield compared with control but there were no marked yield differences between 75 and 125 kg N/ha. The effects of plant density were marginal with only a 20% increase in grain yield under 3PPH compared with 1PPH in Mwea only but without differences between 2 and 3PPH. Number of productive tillers numbers were significantly affected by N rate and variety but there were no differences between the three plant densities. In addition, grain yield was a function of the number of reproductive tillers (R^2 = 0.49) in Ahero only. Both two-way and three-way treatment interactions were not significant for grain yield in both sites.

INTRODUCTION

Since being introduced to Kenya in 1907, rice has become the third most important cereal crop after maize and wheat (IRRI, 2018). Kenya's annual rice production is estimated at 112,800 metric tons against a consumption demand of 538,000 metric tons (IRRI, 2018). These deficits demonstrate the need to increase rice production in the Country. Current farmers' yields are estimated on 4.25 t/ha against a yield potential of 7 t/ha (Atera *et al*., 2018). This large yield gap stems from lack of improved varieties, poor agronomic practices and water shortages as well as high cost of inputs and machinery (Atera *et al*., 2018)). Current rice agronomic practices were developed about three decades ago despite significant advances in rice breeding both locally and globally. Whilst these practices might be robust with modern varieties, the yield potential of these new and pre-release genotypes might not be maximized. Plant density and N rate are important precision agriculture tools in rice production (Dong *et al*., 2012). Counce and Wels (1990) reported that at an adequate plant population density with a high level of N, rice crops have shown to produce more tillers, hence a high number of panicles which results to greater grain yield. The objective of this study was to evaluate the effect of fertilizer N rate and plant density on the yield of two pre-release rice varieties in Kenya.

MATERIALS AND METHODS

Field experiments were carried out in Ahero and Mwea irrigation schemes in Kenya. Treatments comprised two pre-release varieties (08 FAN 10 and CSR 36), three plant population densities and three nitrogen rates (0, 75, and 125 kg N/ha). The treatments were laid out in a randomized complete block design with split split plot arrangement and replicated three times in Mwea and four times in Ahero. Seedlings were transplanted after 21 days at a spacing of 20 cm by 20 cm. Fertilizer N was sourced from urea (46% N) and applied in two equal portions at 21 and 45 days after transplanting. One, two and three seedling number per hill were planted to create different plant population densities, designated as 1PPH, 2PPH and 3PPH. Data was collected on crop phenology, crop growth traits and yield components, and subjected to analysis of variance using GenStat 14th edition software at 5% significance level.

RESULTS AND DISCUSSION

Variety 08 FAN 10 out-yielded CSR 36 by 30% in both sites. Addition of fertilizer N significantly increased grain yield of rice in both sites compared with control (Table 1). In Ahero the effect of nitrogen rates on the grain yield was highly significant at $p<0.05$. Nitrogen is the most essential macro nutrient for plant growth; hence the increase in its application, leads to increment in yields (Dong *et al*., 2012). There was significant effect of nitrogen rates to the number of productive tillers in both sites at $p<0.05$. Tillering is essential in determining the overall grain yield in rice (Ling, 2000). This can be attributed to the important role nitrogen plays in cell division in plants (Rajput *et al*., 1988).

Varietal effect on grain yield and the number of productive tillers was significant at $p<0.05$ in the both sites. Higher yields were recorded in Ahero as compared to Mwea. This could be due to the fact the temperature conditions for Ahero are relatively higher than Mwea. Ying *et al*., (1998) reported that rice production is correlated to air temperature and amount of nitrogen applied, where rice grown in hotter places tend to have a faster crop growth rate than the ones grown in cooler ones.

The effect of plant per hill on grain yield was highly significant in Mwea at $p<0.05$ but not significant in Ahero. Likewise, the effect of plants per hill on productive tillers number was not significant at $p<0.05$ in the two sites. There was a marginal increase in grain yield in the two sites due to the effect of plant per hill although not significant. Nitrogen rate and variety interaction had a significant effect on grain yield at $p<0.05$ in Mwea and a highly significant effect in Ahero. Nitrogen and variety interaction was not significant on productive tiller number in the two sites. This can be attributed to the fact that the natural endowments of crop cultivars to optimally utilize available nutrients and subsequently partition its photosynthates for dry matter accumulation do vary (Mani *et al*., 2018).

Nitrogen rate and plant per hill interaction effect was not significant on grain yield and productive tiller number at $p<0.05$ as shown in table below. Variety, plant per hill interaction was only significant on the productive tillers in Ahero and not significant on grain yield and productive tillers in Mwea. Nitrogen rate, variety and plants per hill interactions at $p<0.05$ were not significant in the two sites as shown in Table 1. The analysis of variance did not show any significant effect on grain yield and productive tillers numbers.

CONCLUSIONS

Results of the present study imply that, irrespective of rice variety, higher N rates increase grain yield but an economically optimal rate requires further investigation. The possibility of modern pre-release varieties to withstand higher seedling densities without compromising on grain yield offers the opportunity to reduce weed competition in rice fields. Further fine tuning of plant population and N rate in modern varieties through the application of PA technologies will contribute to the reduction of rice yield gaps.

Table 1. Grain yield and number of productive tillers per m^2 of two pre-release rice varieties grown under three N rates and three plant densities in Mwea and Ahero.

Treatment	Mwea		Ahero	
	Yield (t/ha)	Tillers/m^2	Yield (t/ha)	Tillers/m^2
Variety				
08 FAN 10	3.92a	11a	7.08a	12a
CSR 36	2.12b	11a	6.42b	11b
P value	<0.001	0.015	0.017	0.016
N rate				
0 kg N/ha	2.15b	10b	5.82b	11b
75 kg N/ha	3.37a	11a	7.28a	11b
125 kg N/ha	3.54a	11a	7.15a	12a
P value	0.015	0.015	<0.001	0.019
Plants per hill (PPH)				
1 PPH	2.65b	11a	6.69a	12a
2 PPH	3.08a	11a	6.74a	11b
3 PPH	3.33a	11a	6.81a	11b
P-value	0.017	0.381	0.942	0.393
Interactions				
N rate × variety	0.030	0.637	<0.001	0.091
N rate × plants per hill	0.255	0.653	0.859	0.534
Variety × plants per hill	0.794	0.491	0.865	0.031
N rate × variety × plants per hill	0.878	0.680	0.665	0.325

Means followed by the same letter are not significantly different

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