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Productivity and Economics of Local Rice (*Oryza sativa* L.) Cultivars in Relation to Different Doses of N, P and K under Upland Rainfed Condition of Nagaland

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ABSTRACT

An experiment was carried out during *kharif* season of 2015 and 2016 in the Agronomy Research farm of SASRD, Medziphema campus, Nagaland to study the effect of different levels of N, P and K on productivity and economics of upland rice cultivars. The treatments consisted of factorial combination of four local rice cultivars viz.,Gwabilo ssu, Hoikha, Ronga shea and Semvu sheawith four fertilizer doses viz., F_0- 0:0:0 NPK kg ha^{-1}: F_1- 30:15:15 NPK kg ha^{-1}: F_2-60:30:30 NPK kg ha^{-1} and F_3- 90:45:45 NPK kg ha^{-1} laid out in a Randomized Block Design with 3 replications. The result of the study showed that application @ 60:30:30 NPK kg ha^{-1} enhanced the overall productivity of all the four local rice cultivars. While a higher dose @ 90:45:45 NPK kg ha^{-1} resulted in lodging and ultimate loss of yield of the rice cultivars. However the highest value for grain yield, harvest index and benefit cost ratio was recorded with the local cultivar Semvu shea. The highest production efficiency as well as nutrient uptake was also recorded for cultivar Semvu shea. Hence from the experiment it can be concluded that the local cultivar Semvu shea with a fertilizer dose of 60:30:30 NPK kg ha^{-1} is comparatively more responsive in terms of nutrient uptake and thus resulting in higher productivity and benefit cost ratio.

Keywords: Local rice cultivars, Yield, Nutrient uptake, Production efficiency, Economics.

INTRODUCTION

Rice is the most important food crop of the developing world and the staple food for more than 70% of the Indian populace. The slogan 'Rice is life' is most appropriate for India as this crop plays a pivotal role in our national food security and is a means of livelihood for millions of rural household. In the global context India stands first in area with 43.39 m ha, second in production with 108.86 million tonnes and an average productivity of 2.40 t ha^{-1} (Anonymous 2016a) accounting 21.49% of total rice production in the world (Anonymous 2016b). At the current rate of population growth (1.55%) in India, the rice requirements by 2020 would be around 120-150 million tonnes. In North Eastern Region of India, rice is the principal food crop occupying 3.52 million ha with a production of 6.57 million t and a productivity of 2.05 t ha^{-1}(Anonymous 2016-17). While in Nagaland rice is grown in an area of about 1,95,240 ha with a production of 4,54,190 t and productivity of only 2.33 t ha^{-1}(Anonymous 2015),which is below the average national productivity. In Nagaland, the farmers grow

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traditional rice varieties available (856 rice land races reported by the Directorate of Agriculture, Govt. of Nagaland) with them without application of fertilizers. It is a general fear of the farmers that the application of fertilizer will deteriorate the quality of the soil as well as the quality of the product will be inferior from the original product with fertilizer. It is proposed that the investigation will demonstrate the differences of their beliefs and will help the farming community to increase the productivity level of rice.

MATERIALS AND METHODS

The investigation was initiated during *kharif* season of 2015 and 2016 on semi-arid, rainfed, sandy loam soil at the experiment farm of Department of Agronomy, SASRD, Nagaland University, Medziphema campus. The research farm was situated at an altitude of 310 m above sea level with the geographical location of $25^0$45'43''N latitude and $95^0$53'04'' E longitudes. The soil of the experiment field was sandy loam in texture well drained and with acidic reaction (pH 4.5). The organic carbon content of the soil was high (1.26) whereas the available nitrogen, available phosphorus and available potassium were found to be medium. The treatments comprised of four local rice cultivars viz., Gwabilo ssu, Hoikha, Ronga shea and Semvu shea with four fertilizer doses viz., F_0- 0:0:0 NPK kg ha^{-1}: F_1- 30:15:15 NPK kg ha^{-1}: F_2-60:30:30 NPK kg ha^{-1} and F_3- 90:45:45 NPK kg ha^{-1} laid out in a Randomized Block Design with 3 replications. The plot size was kept as 4 × 3 meter. Five hills in each plot were randomly selected and tagged for recording plant height (cm) and number of tillers per m^2. The other quantitative indices viz., number of panicles (m^{-2}), length of panicle (cm), weight of panicle (g), number of grains per panicle, filled grain percentage (%), test weight (g), grain yield, straw yield and harvest index. The production efficiency of the crop was also evaluated. Data collected were subjected to analysis of variance. The significant difference was tested by 'f' test and difference between mean by CD at 5% level (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Growth characters

The maximum plant height (Table 1) was obtained from V_4 (cultivar Semvu shea) at all the stages, while among the fertilizer doses F_3 (90:45:45 NPK kg ha^{-1}) gave the best result. This findings were in conformity with Pal and Mahunta(2010) who ascribed that growth of kharif rice (*Oryza sativa* L.) as influenced by three fertility levels (40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}, 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1} and 15 t FYM + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}) which revealed that for almost all the fertility levels 60 kg N

Table 1.Effect of cultivars and fertilizer doses on plant hight (cm) and number of tillers at different growth stages of rice.

Treatments Cultivars (V)	Plant height (cm) at different growth stages of rice				No.of tillers
	30 DAS	60 DAS	90 DAS	Harvest	90 DAS
V_1- Gwabilo ssu	49.61	96.66	124.75	150.41	136.54
V_2- Hoikha	50.28	95.51	123.52	140.15	137.54
V_3- Ronga shea	49.12	94.67	134.39	154.39	137.21
V_4- Semvu shea	54.10	101.01	142.39	156..19	142.63
SEm±	1.37	2.63	1.80	3.26	0.49
CD (p=0.05)	4.44	8.49	5.82	10.56	1.60
Fertilizer doses (NPK kg ha^{-1})					
F_0- Control	46.99	87.61	121.16	133.05	141.30
F_{1-} 30:15:15	47.78	90.56	123.03	141.09	141.03
F_2- 60:30:30	48.50	95.28	127.81	152.54	142.63
F_3- 90:45:45	54.46	103.69	138.39	163.20	143.33
SEm±	1.23	2.35	1.61	2.92	0.44
(p=0.05)	3.97	7.59	5.21	9.44	1.43

Table 2. Interaction effects of cultivars and fertilizer doses on plant height (cm) and number of tillers at different growth stages of rice.

Treatments	Plant height (cm) at different growth stages of rice				No. of tillers
V × F	30 DAS	60 DAS	90 DAS	Harvest	90 DAS
T_1 (V_1F_0)	47.65	89.19	121.91	139.96	139.17
T_2 (V_1F_1)	53.06	100.00	121.85	154.88	134.33
T_3 (V_1F_2)	44.87	102.51	126.26	155.26	139.49
T_4 (V_1F_3)	52.85	108.45	124.81	178.89	136.44
T_5 (V_2F_0)	47.50	104.72	132.41	174.67	138.00
T_6 (V_2F_1)	36.70	119.30	119.93	99.33	136.87
T_7 (V_2F_2)	49.48	109.43	130.64	166.59	135.33
T_8 (V_2F_3)	38.75	83.03	123.97	100.08	138.71
T_9 (V_3F_0)	56.20	78.88	105.74	154.77	138.42
T_{10} (V_3F_1)	46.71	111.29	128.32	156.64	135.21
T_{11} (V_3F_2)	57.57	122.37	144.93	180.71	139.55
T_{12} (V_3F_3)	50.66	108.27	125.92	159.27	136.21
T_{13} (V_4F_0)	59.28	119.85	132.12	167.88	138.66
T_{14} (V_4F_1)	42.47	93.10	125.06	107.06	143.65
T_{15} (V_4F_2)	57.09	110.38	132.71	160.48	145.78
T_{16} (V_4F_3)	66.61	124.26	154.22	182.16	141.45
SEm±	2.75	5.25	3.60	6.53	0.99
CD (P=0.05)	8.88	16.98	11.64	21.11	3.20

+ 30 kg P_2O_5 + 30 kg K_2O ha^{-1} revealed higher plant growth attributes such as plant height and number of green leaves. Also these findings are in close agreement with those reported by Metwally (2015). While also in case of number of tillers m^{-2} cultivar V_4 (Semvu shea) recorded the highest value (Table 1) with fertilizer dose F_2(60:30:30 kg ha^{-1} NPK) and treatment interaction T_{15}(Semvu shea + 60:30:30 NPK kg ha^{-1}) (Table 2). This may be attributed to the positive response of the cultivar to the adequate nutrient supply which proved instrumental in showing effective variation. These results are in agreement with Sarkaret al. (2013), Mondal et al. (2005) who also reported that higher tillers $plant^{-1}$ (19.3), effective tillers $plant^{-1}$ (13.2), 1000 grain weight (22.3 g) in coarse rice cultivar attributing to their genetic variability, varietal difference and environmental adaptability.

Yield and yield attributing characters

The variations on number of panicles due to cultivars and fertilizers were found to be non-significant (Tables 3, 4). However the highest number of panicles

Table 3. Effect of cultivars and fertilizer doses on yield attributes of rice.

Treatments Cultivars (V)	Number of panicles m^{-2}	Length of panicle (cm)	Weight of panicle (g)	Number of grains $panicle^{-1}$	Filled grain percent (%)	Test weight (g)
V_1-Gwabilo ssu	111.16	27.71	4.48	180.75	80.33	20.21
V_2-Hoikha	111.83	27.52	4.89	200.78	82.30	20.68
V_3-Ronga shea	112.67	27.47	4.74	211.95	82.34	20.32
V_4-Semvu shea	114.33	28.53	5.31	226.09	84.23	21.28
SEm±	1.53	0.38	0.19	4.95	0.78	0.16
CD (p=0.05)	NS	1.24	0.56	15.99	2.35	0.52
Fertilizer doses (NPK kg ha^{-1})						
F_0-Control	111.19	26.18	3.44	192.25	81.27	20.12
F_1-30:15:15	109.97	26.86	4.76	206.62	82.37	20.35
F_2-60:30:30	110.23	27.80	5.38	217.99	83.32	20.71
F_3-90:45:45	111.57	27.00	4.89	213.49	83.84	20.75
SEm±	1.37	0.34	0.17	4.42	0.69	0.47
CD (p=0.05)	NS	NS	0.54	NS	2.25	0.47

Table 4. Interaction effect of cultivars and fertilizer doses on yield attributes of rice.

Treatments V × F	Number of panicles m^{-2}	Length of panicle (cm)	Weight of panicle (g)	Number of grains $panicle^{-1}$	Filled grain percent (%)	Test weight (g)
T_1 (V_1F_0)	107.33	27.72	5.97	133.89	77.53	19.94
T_2 (V_1F_1)	108.67	25.87	4.48	199.32	85.32	21.53
T_3 (V_1F_2)	109.33	26.33	4.82	163.18	81.28	19.41
T_4 (V_1F_3)	111.33	27.30	5.61	226.61	86.44	21.41
T_5 (V_2F_0)	105.33	25.43	4.07	219.05	79.60	20.22
T_6 (V_2F_1)	112.00	28.55	4.27	180.56	79.08	20.48
T_7 (V_2F_2)	120.00	27.50	5.65	197.42	86.57	22.54
T_8 (V_2F_3)	114.66	26.84	3.93	206.13	80.43	19.44
T_9 (V_3F_0)	109.33	25.63	3.69	193.70	85.62	18.77
T_{10} (V_3F_1)	115.33	27.43	4.71	201.45	87.85	20.06
T_{11} (V_3F_2)	116.87	28.54	5.88	245.78	89.46	20.98
T_{12} (V_3F_3)	109.34	28.09	4.52	199.86	80.92	20.71
T_{13} (V_4F_0)	106.67	26.76	4.37	210.27	81.16	21.02
T_{14} (V_4F_1)	113.33	26.16	4.24	201.08	83.43	20.12
T_{15} (V_4F_2)	120.00	29.53	8.04	267.03	89.85	22.57
T_{16} (V_4F_3)	112.00	29.38	6.86	221.31	80.93	21.33
SEm ±	3.07	0.78	0.38	9.89	1.56	0.32
CD (p=0.5)	9.92	2.48	1.21	31.99	4.78	1.05

m^{-2} (114.33) was recorded with cultivar V_4 (Semvu shea). This could be attributed mainly to the stimulation effect of nitrogen on effective tillers formation. These findings are consistent with those reported by Metwally (2015).). While also the longest panicle length (28.53cm),panicle weight (5.31 cm) and number of grains per panicle (226.09)was recorded in cultivar V_4 (Semvu shea) with a fertilizer dose of F_2 (60:30:30 NPK kg ha^{-1}). This could be because of the genetic variations among the different cultivars as genetic variations play a key role in development of yield attributing components. This finding is in conformity with Sarawateet al. (2007) who carried out an experiment to study the comparative performance of rice cultivars PhuleRadha, a short slender, medium duration rice cultivar with KJT-4 and Zinia 63 under various nutrients sources and reported that that Phule Radha was superior in terms of yield contributing characters such as panicle length, number of spikelets $panicle^{-1}$ resulting in significantly higher grain yield than KJT-4 and Zinia 63. This result was also in conformity with Ikramullah and Ranjan (2001), who reported that application of different graded level of fertilizers had significant impact on yield and yield components of rice crop.The other yield attributing components such as grain filled percent (84.23%) and test weight (21.28g) were also recorded to be highest with the same rice cultivar. This could be due to higher spikelet fertility owing to reduced no of unfilled spikelet. This finding is in corroboration with the findings of C.R.R.I (2014). Dekhane et al. (2014) also reported that application of 125% of RDF significantly recorded higher panicle length (22.1 cm), grains $panicle^{-1}$ (128), 1000 grain weight (20.9 g) and grain yield (5.18 t ha^{-1}), straw yield (5.79 t ha^{-1}), tillers $plant^{-1}$ 9.7 and 11.7 at 45 DAT and harvest. Highest grain yield (2638.19kg ha^{-1}) was thus obtained from the cultivar Semvu shea under fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}). The treatment interaction also showed highest value (3250.00 kg ha^{-1}) for V_4F_2(cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}). This could be owing to higher production of tillers, spikelet fertility and filled grain percent as compared to the other cultivars. Straw yield was found to be non-significant. Similar finding was supported by Girish et al. (2006) who reported a better grain yield (4.51 kg ha^{-1}), number of tillers (350), test weight (25.2 g), sterility percent (36.7 %) and harvest index (39.6 %) from coarse rice under aerobic conditions in eastern India.

Production efficiency

Production efficiency in terms of nitrogen, phosphorus and potassium response was recorded to be highest

Table 5. Effect of cultivars and fertilizer doses on yield and production efficiency of rice.

Treatments Cultivars (V)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	NUE (kg ha^{-1})	PUE (kg ha^{-1})	KUE (kg ha^{-1})
V_1-Gwabilo ssu	1421.84	4140.51	25.69	41.08	76.61	76.61
V_2-Hoikha	1540.86	4368.53	27.45	44.21	85.21	85.21
V_3-Ronga shea	1634.74	4286.66	26.17	46.72	95.12	95.11
V_4-Semvu shea	2638.19	4868.54	35.15	58.06	115.71	115.69
SEm±	29.38	233.42	0.21	0.37	0.37	0.37
CD (p=0.05)	95.02	754.85	0.68	1.21	1.21	1.21
Fertilizer doses (NPK kg ha^{-1})						
F_0-Control	1440.87	4260.18	28.28	34.51	70.86	70.86
F_1-30:15:15	2130.83	4594.44	32.91	41.93	91.90	91.87
F_2-60:30:30	2189.95	4766.66	34.73	53.81	114.51	114.51
F_3-90:45:45	2259.07	4937.96	35.69	51.18	97.71	97.71
SEm ±	26.28	208.77	0.18	0.34	0.33	0.33
CD (p=0.5)	84.98	NS	0.61	1.08	1.08	1.08

in cultivar V_4 Semvu shea during both the year with fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}) (Tables 5, 6), which was followed by cultivarRonga shea under fertilizer dose F_2 (60:30:30 NPK kg ha^{-1}). The higher value for production efficiency could be a result of positive response of the rice cultivar to the particular fertilizer dose resulting in higher yield. Thus clearly indicating that higher dose of fertilizer is not directly proportional to the use efficiency by the crop but the fine tuning of the right crop variety and adequate dose as per the crop requirement that influences the crop yield. Similar results were observed by Kumaret al. (2012) at Warangal (A.P.) , Sree Rekha and Pradeep (2012) at Adilabad (A.P.) in rice.

Economics

Economics of the rice crop was significantly influenced by different treatments (Table 7). Cost of cultivation of test cultivars were exactly same, however varied slightly as different nutrient management levels incurred.Cultivar Semvu shea earned maximum net returns followed by cultivar Ronga shea (Table

Table 6. Interaction effects of cultivars and fertilizer doses on yield and production efficiency of rice.

Treatments V × F	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	NUE (kg ha^{-1})	PUE (kg ha^{-1})	KUE (kg ha^{-1})
$T_1(V_1F_0)$	1001.50	3462.96	24.64	33.54	67.23	67.23
$T_2(V_1F_1)$	1641.67	4877.77	25.17	50.32	95.45	95.45
$T_3(V_1F_2)$	1575.92	5925.18	26.28	59.03	101.05	101.05
$T_4(V_1F_3)$	1468.25	4914.81	26.68	37.20	54.43	54.43
$T_5(V_2F_0)$	1127.77	4106.48	24.61	34.02	87.03	87.03
$T_6(V_2F_1)$	1782.86	4083.33	25.39	30.15	47.17	47.17
$T_7(V_2F_2)$	1552.77	4671.95	26.31	40.35	58.38	58.38
$T_8(V_2F_3)$	1700.00	5300.93	28.39	23.74	106.87	106.87
$T_9(V_3F_0)$	1153.78	4740.74	23.93	40.23	80.44	80.44
$T_{10}(V_3F_1)$	1685.18	5208.33	29.15	48.03	86.27	86.27
$T_{11}(V_3F_2)$	1866.67	4886.57	28.32	38.78	80.33	80.33
$T_{12}(V_3F_3)$	1833.33	4949.07	28.38	37.13	64.21	64.21
$T_{13}(V_4F_0)$	1606.48	3540.74	35.42	34.96	66.17	66.17
$T_{14}(V_4F_1)$	2914.81	5218.52	36.32	57.55	105.12	105.12
$T_{15}(V_4F_2)$	3250.00	4951.38	38.53	86.97	166.56	166.56
$T_{16}(V_4F_3)$	2698.15	5305.55	35.64	55.32	44.35	44.35
SDm ±	58.76	466.84	0.42	0.75	0.75	0.75
CD (p=0.05)	1190.03	NS	1.36	2.44	2.43	2.43

Table 7. Effect of varieties and treatments oncost of cultivation and Gross return Rs ha^{-1}). FYM (0.5% N)-Rs 500 t^{-1}, Urea (46% N)- Rs 10 kg^{-1}, SSP (16% P_2O_5) -Rs 15 kg^{-1}, MOP (60% K_2O) - Rs 25 kg^{-1}.

Interactions	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Benefit cost ratio
$T_1(V_1F_0)$	21,700	15022.50	-66.77.50	-0.31
$T_2(V_1F_1)$	25,100	24625.05	-474.95	-0.02
$T_3(V_1F_2)$	26,000	23638.80	-2361.20	-0.09
$T_4(V_1F_3)$	26,900	22023.75	-4876.25	-0.18
$T_5(V_2F_0)$	21,700	16916.55	-4783.45	-0.22
$T_6(V_2F_1)$	25,100	26742.90	1642.90	0.07
$T_7(V_2F_2)$	26,000	23291.55	-2780.45	-0.11
$T_8(V_2F_3)$	26,900	25500.00	-1400.00	-0.05
$T_9(V^3F_0)$	21,700	17306.70	-4393.30	-0.20
$T_{10}(V_3F_1)$	25,100	25277.70	177.70	0.001
$T_{11}(V_3F_2)$	26,000	28000.00	2000.00	0.08
$T_{12}(V_3F_3)$	26,000	27499.95	599.95	0.02
$T_{13}(V_4F_0)$	21,700	24097.20	2397.20	0.11
$T_{14}(V_4F_1)$	25,100	43797.15	18697.15	0.74
$T_{15}(V_4F_2)$	26,000	48750.00	22750.00	0.88
$T_{16}(V_4F_3)$	26,900	40472.25	13572.25	0.50

7). While a depletion in net return was recorded from cultivars Gwabilo ssu and Hoikha (Table 7). In case of nutrient management level, F_2 (60:30:30 NPK kg ha^{-1}) earned significantly highest profit (Table 7) followed by F_3 (90:45:45 NPK kg ha^{-1}). It is obvious from table that cultivar Semvu shea attained significantly highest benefit: cost ratio followed by cultivar Ronga shea while significantly lowest was attained by cultivars Gwabilo ssu and Hoikha (Table 7). The benefit: Cost ratio showed significant improvement with optimum level of nutrient management.These results may be similar to the findings of Bhowmick and Nayak (2000), Singh and Singh (2008). Net returns and benefit: Cost ratio was also worked out significantly highest at F_3 (90:45:45 NPK kg ha^{-1}) attributed mainly due to higher gross return under this treatment. Though cost of cultivation was also highest at F_3 (90:45:45 NPK kg ha^{-1}) than lower nutrient management levels, while margin of difference was found much higher in case of gross return which could not only compensated the higher cost but increased the net returns and benefit: Cost ratio at higher nutrient management levels.

CONCLUSION

Among the local rice cultivars under experiment, cultivar Semvu shea recorded a comparatively higher yield with fertilizer dose @ 60:30:30 NPK kg ha^{-1}. While application of higher dose of fertilizer @ 90:45:45 NPK kg ha^{-1} resulted in excess vegetative growth and subsequent lodging and reduction in yield of the cultivars.Hence, it can be stated that application of adequate dose of fertilizer, cultivar Semvu shea of Phek district proved its superiority in case of productivity and economics in comparison to other cultivars under experiment.

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