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Effect of NPK Fertilizer Doses on Production and Productivity of Local Rice (*Oryza sativa* L.) Cultivars of Nagaland under Upland Rainfed Condition

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ABSTRACT: An experiment was carried out during *kharif* season of 2019 and 2020 in the Agronomy Research farm of SASRD, Medziphema campus, Nagaland. The treatments consisted of factorial combination of four local rice cultivars *viz.*, Gwabilo ssu, Hoikha, Ronga shea, Semvu shea and an improved dwarf variety Sahbhagi dhan (check) 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 result of the study showed that the application of 60:30:30 NPK kg ha^{-1} enhanced the growth and yield of all the four local rice cultivars. While a higher dose of 90:45:45 NPK kg ha^{-1} resulted in better performance of the improved dwarf variety both in terms of growth and yield being more by nature. The highest value for grain yield, harvest index and benefit cost ratio was recorded with the improved variety Sahbhagi dhan which was statistically at par with the local cultivar Semvu shea. While the highest production efficiency as well as nutrient uptake was 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 equally efficient with the improved variety Sahbhagi dhan @ 60:30:30 NPK kg ha^{-1} proving its superiority over the other local cultivars and its capability to perform as good as the improved check variety with adequate nutrient management and care.

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

INTRODUCTION

Among the cereals of great social and economic importance in the world, highlights the rice (*Oryza sativa* L.), which is an energy source for two-thirds of the world population, providing about 20% of energy and 15% of the protein that human needs. It has shaped the culture, diets and economy of thousands and millions of people. For more than half of the humanity "rice is life". Although, the national food security heavily depends on rice and wheat (78 per cent), rice alone contributes to 43 per cent of food grain production and 46 per cent of cereal production in the country (Raj *et al*., 2016). 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, 2016-17) accounting 21.49% of total rice production in the world (Anonymous, 2016a). 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, 2015). 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, 2016$_b$), which is below the average national productivity. In Nagaland, the farmers grow traditional rice varieties available (856 rice land races reported by the Directorate of Agriculture, Govt. of Nagaland) with them without application of fertilizers. The majority of these people belong to what governments usually call "ethnic minorities" or "tribal people". Today, however, many of these peoples prefer to be called indigenous peoples. 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. Also, the findings of the proposed work will provide a new vista in the breeders to utilize those fertilizer responsive local cultivars for further breeding works to develop cultivars suitable for Nagaland.

MATERIALS AND METHODS

The investigation was initiated during *kharif* season of 2019 and 2020 at the experimental 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 experimental farm lies in humid sub-tropical region with an average rainfall ranging from 2000-2500 mm annually. 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*., V1-Gwabilo ssu, V2-Hoikha, V3-Ronga shea, V4-Semvu shea and one improved dwarf variety V5-Sahbhagi dhan 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. Five hills in each plot were randomly selected and tagged for recording plant height (cm), number of tillers per m^2, number of green leaves per plant, crop growth rate, relative growth rate and leaf area index. 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. Observation on days to 50% flowering and days to maturity were also recorded. Available soil nutrient status after harvest and plant nutrient uptake (NPK) was recorded. The production efficiency of the crop was also evaluated. Data collected was subjected to analysis of variance. The significant difference was tested by 'f' test and difference between mean by CD at 5% level Panse and Sukhatme (1985).

RESULTS AND DISCUSSIONS

A. Growth Characters

The maximum plant height 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 with the interaction V_4F_3 showing the best interaction effect at all growth stages except at 30 DAS. While in case of number of tillers m^{-2} variety V_5 (Sahbhagi dhan) recorded the highest value during both the year, with fertilizer dose F_3 (90:45:45 kg ha^{-1} NPK) and treatment interaction T_{20} (Sahbhagi dhan + 90:45:45 NPK kg ha^{-1}) giving the highest value for both the years. This may be attributed to the genetic makeup of the variety having a potential to produce more tillers even under drought conditions which proved instrumental in showing effective variation. These results are in agreement with Sarkar *et al*. (2013) and 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) were recorded in Sahbhagi dhan whereas lower effectivity of tillers (7.4 %) was observed in local check Khandagiri. In case of cropgrowth rate and relative growth rate significant variation was recorded at 60 DAS with cultivar V_4 (Semvu shea) giving the highest value with the fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}). This could be attributed to the increase in vegetative growth owing to higher dose of nitrogen application which activates the growth hormones resulting in formation of more vegetative parts of the plant. This finding were in conformity with Gosh (2015) who revealed that crop receiving 75 % RDF and vermicompost 25 % produced higher CGR than that of other treatments throughout the growth periods except tillering to PI, when it produced comparable CGR to that of 50 % RDF through FYM or vermicompost 50 %. Leaf area index (LAI) was found to be significantly higher with V_4 (Semvu shea) with a fertilizer dose of F_3 (90:45:45 NPK kg ha^{-1}). This is mainly due to the fact that nitrogen is the major factor influencing leaf growth as it affects average leaf size, number of leaves per tiller and number of tillers per hill. Hashem *et al*. (2016) also reported that application of nitrogen in the form of urea (46.5%N) @ 90 kg N ha-1 and K @ 40 kg $ha-^{1}$ revealed higher value of leaf area index in comparison to nitrogen levels 0, 110 and 165 kg N ha^{-1}.

B. Yield and Yield Attributing Characters

The highest number of panicles m^{-2} (117.16) was recorded with V_5 (Sahbhagi dhan), While 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. While, the other yield attributing components such as grain filled percent (85.42 %) and test weight (21.35 g) were recorded to be highest with the improved check variety Sahbhagi dhan. This could be due to higher spikelet fertility owing to reduced no of unfilled spikelet than the local check. This finding is in corroboration with the findings of C.R.R.I (2014). The number of grains per panicle was also found to be significantly highest (233.21) in the check variety Sahbhagi dhan. Also Samant *et al*. (2015) reported that Sahbhagi dhan showed higher germination (48.4 %), effective tillers $plant^{-1}$ (13.2), length of panicle (22.6 cm), filled grains $panicle^{-1}$ (125.3) with spikelet fertility (93.65 %) and 1000 grain weight (22.3 g) than Khandagiri.

Highest grain yield (2790.27 kg ha^{-1}) was obtained from the check variety Sahbhagi dhan under fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}). This could be owing to higher production of tillers, spikelet fertility and filled grain percent as compared to the other local cultivars. Also due to its dwarf stature it could resist lodging even under development of heavy yield attributing characters during reproductive stage and management practices could be more effectively carried out in case of this variety. This finding was in conformity with Raman *et al*. (2012) who reported a high ranking for Sahbhagi Dhan and also a consistently higher yield than IR64 and MTU1010 (popular high-yielding but drought-susceptible varieties) across irrigated and drought-stress environments.

Table 1: Effect of cultivars and fertilizer doses on growth, yield attributes and production efficiency of rice at different growth stages.

Treatments / Cultivars	Plant height (cm)	No. of tillers (m^2)	CGR (g m^{-2} day^{-2})	RGR (g g^{-1} day^{-1})	LAI	Length of panicle (cm)	Weight of panicle (g)	Number of grains $panicle^{-1}$	Filled grain percent (%)	Test weight (g)	Grain yield (kg ha^{-1})	Harvest index (%)	Production efficiency		
													NUE	PUE	KUE
V_1- Gwabilo ssu	150.41	136.54	7.68	0.045	1.27	27.71	4.48	180.75	80.33	20.21	1421.84	25.69	41.08	76.61	76.61
V_2- Hoikha	140.15	137.54	11.21	0.049	1.30	27.52	4.89	200.78	82.30	20.68	1540.86	27.45	44.21	85.21	85.21
V_3- Ronga shea	154.39	137.21	15.03	0.045	1.29	27.47	4.74	211.95	82.34	20.32	1634.74	26.17	46.72	95.12	95.11
V_4- Semvu shea	156.19	142.63	15.13	0.051	1.34	28.53	5.31	226.09	84.23	21.28	2638.19	35.15	58.06	115.71	115.69
V_5- Sahbhagi dhan	136.22	156.46	14.11	0.050	1.25	27.24	5.17	219.61	85.42	21.35	2790.27	37.76	47.02	99.61	99.61
SEm±	3.26	0.49	0.43	0.001	0.004	0.38	0.19	4.95	0.78	0.16	29.38	0.21	0.37	0.37	0.37
CD (P=0.05)	10.56	1.60	1.40	0.003	0.012	1.24	0.56	15.99	2.35	0.52	95.02	0.68	1.21	1.21	1.21
Fertilizer doses (NPK kg ha^{-1})															
F_0- Control	133.05	141.30	11.66	0.045	1.28	26.18	3.44	192.25	81.27	20.12	1440.87	28.28	34.51	70.86	70.86
F_1- 30:15:15	141.09	141.03	12.56	0.045	1.30	26.86	4.76	206.62	82.37	20.35	2130.83	32.91	41.95	91.90	91.87
F_2- 60:30:30	152.54	142.63	12.59	0.048	1.28	27.80	5.38	217.99	83.32	20.71	2189.95	34.73	53.81	114.51	114.51
F_3- 90:45:45	163.20	143.33	14.21	0.049	1.30	27.00	4.89	213.49	83.84	20.75	2259.07	35.69	51.18	97.71	97.71
SEm±	2.92	0.44	0.38	0.001	0.004	0.34	0.17	4.42	0.69	0.14	26.28	0.18	0.34	0.33	0.33
CD (P=0.05)	9.44	1.43	1.25	0.004	NS	NS	0.54	NS	2.25	0.47	84.98	0.61	1.08	1.08	1.08

Table 2: Interaction effect of cultivars and fertilizer doses on growth, yield attributes and production efficiency of rice at different growth stages.

Treatments V x F	Plant height (cm)	No. of tillers (m^2)	CGR (g m^{-2} day^{-2})	RGR (g g^{-1} day^{-1})	LAI	Length of panicle (cm)	Weight of panicle (g)	Number of grains $panicle^{-1}$	Filled grain percent (%)	Test weight (g)	Grain yield (kg ha^{-1})	Harvest index (%)	Production efficiency		
													NUE	PUE	KUE
T_1 (V_1F_0)	139.96	139.17	6.56	0.059	1.29	27.72	5.97	133.89	77.53	19.94	1001.50	24.64	33.54	67.23	67.23
T_2 (V_1F_1)	154.88	134.33	7.31	0.038	1.31	25.87	4.48	199.32	85.32	21.53	1641.67	25.17	50.32	95.45	95.45
T_3 (V_1F_2)	155.26	139.49	8.15	0.040	1.25	26.33	4.82	163.18	81.28	19.41	1575.92	26.28	59.03	101.05	101.05
T_4 (V_1F_3)	178.89	136.44	8.42	0.050	1.23	27.30	5.61	226.61	86.44	21.41	1468.25	26.68	37.20	54.43	54.43
T_5 (V_2F_0)	174.67	138.00	9.31	0.039	1.29	25.43	4.07	219.05	79.60	20.22	1127.77	24.61	34.02	87.03	87.03
T_6 (V_2F_1)	99.33	136.87	12.43	0.061	1.24	28.55	4.27	180.56	79.08	20.48	1782.86	25.39	30.15	47.17	47.17
T_7 (V_2F_2)	166.59	135.33	8.38	0.051	1.25	27.50	5.65	197.42	86.57	22.54	1552.77	26.31	40.35	58.38	58.38
T_8 (V_2F_3)	100.08	138.71	7.01	0.052	1.29	26.84	3.93	206.13	80.43	19.44	1700.00	28.39	23.74	106.87	106.87
T_9 (V_3F_0)	154.77	138.42	9.97	0.045	1.29	25.63	3.69	193.70	85.62	18.77	1153.78	23.93	40.23	80.44	80.44
T_{10}(V_3F_1)	156.64	135.21	10.28	0.046	1.30	27.43	4.71	201.45	87.85	20.06	1685.18	29.15	48.03	86.27	86.27
T_{11}(V_3F_2)	180.71	139.55	11.92	0.042	1.29	28.54	5.88	245.78	89.46	20.98	1866.67	28.32	38.78	80.33	80.33
T_{12}(V_3F_3)	159.27	136.21	11.62	0.048	1.29	28.09	4.52	199.86	80.92	20.71	1833.33	28.38	37.13	64.21	64.21
T_{13}(V_4F_0)	167.88	138.66	12.84	0.045	1.32	26.76	4.37	210.27	81.16	21.02	1606.48	35.42	34.96	66.17	66.17
T_{14}(V_4F_1)	107.06	143.65	14.69	0.047	1.32	26.16	4.24	201.08	83.43	20.12	2914.81	36.32	57.55	105.12	105.12
T_{15}(V_4F_2)	160.48	145.78	14.28	0.043	1.30	29.53	8.04	267.03	89.85	22.57	3250.00	38.53	86.97	166.56	166.56
T_{16}(V_4F_3)	182.16	141.45	19.15	0.062	1.41	29.38	6.86	221.31	80.93	21.33	2698.15	35.64	55.32	44.35	44.35
T_{17}(V_5F_0)	93.29	151.50	10.80	0.052	1.22	25.20	4.61	179.18	79.35	18.87	2314.82	37.09	38.22	79.35	79.35
T_{18}(V_5F_1)	147.34	155.23	12.67	0.047	1.31	26.63	4.58	198.85	84.07	20.07	2629.62	36.24	43.78	86.98	86.98
T_{19}(V_5F_2)	152.98	158.31	12.76	0.047	1.29	27.51	4.44	158.33	86.38	22.54	2966.67	36.73	64.32	123.41	123.41
T_{20}(V_5F_3)	146.54	162.00	14.67	0.055	1.30	27.67	5.44	252.78	91.62	23.22	3333.33	41.56	70.61	125.82	125.82
SEm±	6.53	0.99	0.86	0.003	0.009	0.78	0.38	9.89	1.56	0.32	58.76	0.42	0.75	0.75	0.75
CD (P=0.05)	21.11	3.20	2.81	0.009	0.020	2.48	1.21	31.99	4.78	1.05	1190.03	1.36	2.44	2.43	2.43

Table 3: Effect of cultivars and fertilizer doses on soil nutrient status after harvest (kg ha^{-1}) and plant nutrient uptake (kg ha^{-1}).

Treatments	Soil nutrient status after harvest					Plant nutrient uptake (kg ha^{-1})		
Cultivars	**Soil pH**	**Soil Organic Carbon (%)**	**Available nitrogen (kg ha^{-1})**	**Available phosphorus (kg ha^{-1})**	**Available potassium (kg ha^{-1})**	**Nitrogen uptake (kg ha^{-1})**	**Phosphorus uptake (kg ha^{-1})**	**Potassium uptake (kg ha^{-1})**
V_1- Gwabilo ssu	4.60	1.28	173.08	15.96	281.93	42.63	7.06	21.06
V_2- Hoikha	4.51	1.28	180.07	20.63	282.63	43.82	8.04	21.14
V_3- Ronga shea	4.87	1.51	178.78	19.53	298.89	44.72	8.06	21.14
V_4- Semvu shea	4.63	1.72	182.32	22.70	311.50	46.49	9.38	28.55
V_5- Sahbhagi dhan	4.63	1.50	185.60	23.04	345.50	44.99	8.80	24.11
SEm±	0.02	0.02	5.28	0.37	6.22	0.66	0.12	0.58
CD (P=0.05)	0.06	0.07	17.10	1.15	20.10	2.14	0.36	1.88
Fertilizer doses (NPK kg ha^{-1})								
F_0- Control	4.63	1.38	171.42	18.77	299.35	43.36	7.43	22.40
F_1- 30:15:15	4.65	1.39	176.00	20.57	298.88	44.79	8.07	21.22
F_2- 60:30:30	4.69	1.44	184.82	20.92	296.77	45.12	8.63	22.27
F_3- 90:45:45	4.64	1.50	188.66	21.22	335.39	4.89	213.49	83.84
SEm±	0.02	0.02	4.73	0.33	5.56	0.17	4.42	0.69
CD (P=0.05)	NS	0.06	NS	NS	17.98	0.54	NS	2.25

Table 4: Interaction effect of cultivars and fertilizer doses on soil nutrient status after harvest (kg ha^{-1}) and plant nutrient uptake (kg ha^{-1}).

Treatments	Soil nutrient status after harvest					Plant nutrient uptake (kg ha^{-1})		
V×F	**Soil pH**	**Soil Organic Carbon (%)**	**Available nitrogen (kg ha^{-1})**	**Available phosphorus (kg ha^{-1})**	**Available potassium (kg ha^{-1})**	**Nitrogen uptake (kg ha^{-1})**	**Phosphorus uptake (kg ha^{-1})**	**Potassium uptake (kg ha^{-1})**
T_1 (V_1F_0)	4.64	1.55	148.52	12.58	245.62	43.37	5.95	20.22
T_2 (V_1F_1)	4.37	1.19	176.85	14.83	294.55	45.89	7.41	29.86
T_3 (V_1F_2)	4.73	1.31	186.05	18.26	348.05	44.87	7.50	29.92
T_4 (V_1F_3)	4.59	1.06	180.91	18.18	242.28	45.83	9.40	21.57
T_5 (V_2F_0)	4.37	1.12	168.03	21.23	287.69	45.45	9.48	28.19
T_6 (V_2F_1)	4.74	1.43	188.24	19.68	306.59	43.69	8.54	20.11
T_7 (V_2F_2)	4.40	1.48	173.67	18.27	305.73	43.38	7.87	10.52
T_8 (V_2F_3)	4.66	1.24	196.75	23.70	227.71	44.43	9.37	30.22
T_9 (V_3F_0)	4.79	1.47	162.86	23.32	278.96	40.25	5.24	21.54
T_{10}(V_3F_1)	4.91	1.52	165.57	20.88	224.56	46.80	6.54	12.56
T_{11}(V_3F_2)	4.99	1.41	165.45	22.56	348.42	45.71	9.71	25.43
T_{12}(V_3F_3)	4.77	1.66	185.99	20.81	328.82	43.55	8.46	20.23
T_{13}(V_4F_0)	4.35	1.30	186.12	19.46	288.93	44.23	6.34	26.21
T_{14}(V_4F_1)	4.53	1.65	174.91	17.41	339.02	44.23	8.21	28.72
T_{15}(V_4F_2)	4.96	1.50	185.16	18.68	335.63	42.72	8.81	30.22
T_{16}(V_4F_3)	4.64	2.13	228.12	25.87	367.23	48.49	10.92	30.33
T_{17}(V_5F_0)	4.33	1.56	162.49	21.21	347.17	40.15	9.28	18.46
T_{18}(V_5F_1)	4.69	1.53	151.53	21.07	363.24	45.31	7.90	20.16
T_{19}(V_5F_2)	4.96	1.54	164.35	22.66	271.22	46.23	8.55	20.17
T_{20}(V_5F_3)	4.52	2.02	233.13	27.75	396.57	47.65	9.74	25.25
SEm±	0.04	0.04	10.57	0.74	12.43	1.32	0.24	1.16
CD (P=0.05)	0.13	0.14	34.21	2.27	40.21	3.95	0.72	3.76

Table 5: Economic analysis of different treatments.

Treatments	Cost of cultivation (₹ ha^{-1})	Gross income (₹ ha^{-1})		Net income (₹ ha^{-1})		Benefit cost ratio	
		2015	2016	2015	2016	2015	2016
T_1 (V_1F_0)	21,700	8,034.15	17,655.60	-13665.85	-4044.40	-0.62	-0.18
T_2 (V_1F_1)	25,100	38,496.30	24,317.15	13396.30	-782.85	0.53	-0.03
T_3 (V_1F_2)	26,000	42,414.20	26,402.40	16414.20	402.40	0.63	0.02
T_4 (V_1F_3)	26,900	32,340.65	30,354.20	5440.65	3454.20	0.20	0.13
T_5 (V_2F_0)	21,700	16,962.40	20,960.20	-4737.60	-739.80	-0.22	-0.03
T_6 (V_2F_1)	25,100	44,554.70	31,790.30	19454.70	6690.30	0.78	0.27
T_7 (V_2F_2)	26,000	35,237.66	35,027.30	9237.66	9027.30	0.36	0.35
T_8 (V_2F_3)	26,900	43,161.80	31,563.90	16261.80	4663.90	0.60	0.17
T_9 (V_3F_0)	21,700	19,433.70	27,268.90	-2266.30	5568.90	-0.10	0.26
T_{10}(V_3F_1)	25,100	43,777.50	32,332.11	18677.50	7232.11	0.74	0.29
T_{11}(V_3F_2)	26,000	37,770.26	30,582.00	11770.26	4582.00	0.45	0.18
T_{12}(V_3F_3)	26,900	39,235.82	41,875.00	12335.82	14975.00	0.45	0.56
T_{13}(V_4F_0)	21,700	16,572.05	22,193.70	-5127.95	493.70	-0.24	0.02
T_{14}(V_4F_1)	25,100	44,902.40	31,887.90	19802.40	6787.90	0.78	0.27
T_{15}(V_4F_2)	26,000	49,444.30	50,916.30	24777.70	24916.30	0.90	0.96
T_{16}(V_4F_3)	26,900	47,889.20	48,578.10	20989.20	21678.10	0.78	0.81
T_{17}(V_5F_0)	21940	23,777.80	27,381.30	1837.80	5441.30	0.08	0.25
T_{18}(V_5F_1)	25340	30,799.00	26,765.70	5459.00	1425.70	0.22	0.06
T_{19}(V_5F_2)	26240	36,828.07	43,632.40	10588.07	17392.40	0.40	0.66
T_{20}(V_5F_3)	27140	77,020.6	68,226.00	39126.60	41086.00	1.44	1.51
SEm±	21,700	8,034.15	17,655.60	-13665.85	-4044.40	-0.62	-0.18
CD (P=0.05)	25,100	38,496.30	24,317.15	13396.30	-782.85	0.53	-0.03

Production Efficiency. Production efficiency was found to be highest with treatment interaction V_4F_2 (cultivar Semvu shea + 60:30:30 NPK kg ha^{-1}) which was followed by variety Sahbhagi dhan under fertilizer dose F_3 (90:45:45 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 Reddy and Kumar (2010) at Warangal (A.P.) and Sree Rekha and Pradeep (2012) at Adilabad (A.P.) in rice. Khiriya (2001) also reported a decrease in agronomic efficiency and P recovery with increasing levels of P application in fenugreek.

Fertility Status after Harvest. From the experimental data analysis, the total nitrogen availability during both the year as well as the pooled data showed significant under different cultivars while in case of fertilizer dose, significant variation was recorded only during the first year of experiment. The highest value was obtained from variety V_5 (Sahbhagi dhan) under fertilizer dose F_3 (90:45:45 kg ha^{-1}) and interaction V_5 F_3. The probable cause of high available nitrogen could be due to less utilisation during the crop growth stages, poor soil physical structure, lack of organic manures and microbial activities in the soil. The present findings was in agreement with Masthana *et al.* (2005), who reported the application of 100 percent NPK significantly improved the soil available N. Therefore, application of 100 % NPK result in increased in available NPK in soil as compared to control.

Nutrient Uptake by Plants. The uptake of N, P and K increased with increasing level of fertilizer application. The steady increase in N uptake during rice growing season indicated a rapid absorption of N by the crop. The highest nitrogen, phosphorus and potassium uptake during both the year of experiment was recorded with cultivar V_4 (Semvu shea). Different fertilizer doses could not show any significant difference in its uptake. Fertilizer dose F_3 (90:45:45 NPK kg ha^{-1}) however gave the highest for the entire three nutrient element. In case of interaction effect V_4F_3 (cultivar Semvu shea + 90:45:45 NPK kg ha^{-1}) gave the highest value over all the other treatments under experiment. The rice crop absorbs N continuously up to maturity and the delayed N application at flowering stage expectedly results in relatively higher N accumulation in foliage including lower leaves, contributing to higher growth leading to larger cytokynine production. Cytokynine in turn release senescence of the whole plant causing more dry matter production to adequately meet the needs arising on account of larger sink in the crop.

C. Economics

Effect of nutrient management levels was more pronounced on benefit: cost ratio than hybrids. Gross returns of rice cultivars were attributed mainly to grain yield. These results may be similar to the findings of Bhowmick and Nayak (2000) and 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. Yadav *et al*. (2007) as well as Kumar and Yadav (2008) reported from Kanpur that increases in fertilizer level increase the economic parameters significantly in rice.

CONCLUSIONS

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} and was also found to be significantly at par with the released check variety under experiment. 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. However, the improved dwarf variety Sahbhagi dhan was recorded to perform better with higher dose of fertilizer i.e., 90:45:45 NPK kg ha^{-1} resulting in highest yield and highest benefit cost ratio. The highest production efficiency in terms of nutrient uptake was however recorded with cultivar Semvu shea. Hence, from the experimental findings it can be stated that with the application of correct dose of fertilizer cultivar Semvu shea of Phek district has the capability to perform as good as the released check variety whose yield was found to be significantly at par with the released variety.

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