Research article

EFFECTS OF VARIETIES AND FERTILIZER LEVELS ON YIELD AND ECONOMICS OF HYBRID RICE AT HARDINATH, NEPAL

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ABSTRACT

Hybrid rice has the potential to increase rice yield. Fertilizer requirement is higher to achieve higher productivity in hybrid rice. A field experiment was carried out to evaluate the performance of hybrid rice varieties at different levels of fertilizer management. The experiment was conducted at research farm of National Rice Research Program (NRRP), Hardinath, Dhanusha, Nepal during rainy season of 2018. The experimental plot was laid out in a strip plot design with three replications. The treatment consisted of combination of six registered hybrid rice namely Arize 6444, ArizeTejgold, Gorakhnath 509, Shanti, Sudha, US 312 and two high yielding checks viz., Sabitri and Hardinath 1; and three levels of fertilizer management viz., Farmers practices(60-40-0 N, P_2O_5, k_2O kg ha^{-1}), National recommended Dose (100-30-30 N, P_2O_5, k_2O kg ha^{-1}) and 125% of National recommended Dose (125-40-40 N, P_20_5, k_20 kg ha^{-1}). The result of research revealed that rice hybrid Sudha produced the highest grain yield (5659 kg ha^{-1}) followed by US 312 (5153 kg ha^{-1}).All the hybrids produced significantly higher yield than improved check varieties. The yield increment in rice hybrids ranged from 17.7 to 42.0% and 54.9 to 119.9% over Sabitri and Hardinath1 respectively. Higher gross return(Nrs 190.78 thousand ha^{-1}), net return(Nrs 100.77 thousand ha^{-1}) and benefit cost ratio of (2.11) was obtained in rice hybrid Sudha followed by US 312, Shanti and Arize Tejgold. Similarly, higher gross return (NRs. 178.59 thousand ha^{-1}), net return (84.59 thousand ha^{-1}) and benefit cost ratio (1.9) were found higher in 25% more fertilizer applied dose than National recommendation dose. Therefore, all tested hybrid rice can produce higher grain yield and 25% higher dose of fertilizer was better than national recommended dose for achieving higher yield and net income.

Keywords: Yield, hybrid rice, benefit cost ratio

INTRODUCTION

Rice (*Oryza sativa* L.) is the first most important staple crop both in terms of area and production in Nepal. It was grown in 1,491,744 ha with total production of 5,610,011 tonnesand productivity of 3.76 t ha^{-1} in the cropping season 2019/20. It contributes 20% to the agricultural gross domestic product (AGDP) and more than 7% in gross domestic product (GDP), (MoALD, 2020).

The productivity growth of rice in Nepal in the last 54 years was 1.5% and has not kept up with the population growth rate, and it do not produce enough rice to meet the demand of the people (Joshi and Upadhya, 2020). The rice import has been increased to 950 thousand tonnes in 2020(MoALD, 2020). Recently fifty exotic F1 hybrid varieties of rice has been introduced from India and China and registered in Nepal for the cultivation. Hybrid rice varieties US 312, Gorakhnath 509, Arize 6444, Arize Tej Gold, Garima and Hj G5 have covered large areas in Nepal (Sah and Joshi, 2020). The two hybrid rice Hardinath hybrid 1 F1 and Hardinath hybrid 3 F1 have been released in Nepal (SQCC, 2021) The hybrid rice has shown the yield advantages of 20 to 30 % higher over high yielding inbred rice varieties (Virmani, 1996).

The yield potential of hybrid rice is higher than modern high yielding improved varieties of rice.The fertilizer recommendation is higher in hybrid rice than high yielding conventional bred rice (Sah and Joshi, 2020). In Nepalese context, we do not have enough information regarding the yield advantages of hybrid rice over the modern improved inbred rice varieties. The present investigation was carried out to determine the growth, productivity and economics of hybrid rice varieties in comparision with conventional bred high yielding varieties at different levels of fertilizer management.

MATERIALS AND METHODS

The experiment was conducted at National Rice Research Program Hardinath, Dhanusha, Nepal, from June to October, 2018. Geographically, the station is located at 93 meter above mean sea level and lies at the 26°, 49' North latitude and 86°, 57' East longitutde.

Soil physico-chemical properties and climate of the experimental site

The physico-chemical properties of the soil of the experimental site were recorded by obtaining the composite soil samples from of 0-15 cm depth. The soil texture of experimental plots was silty loam with slightly acidic pH(6.31). The soil was low in total nitrogen %, available potassium, and medium in available Phosphorus. The average maximum temperature of 38.1^{0}C was recorded in the second week of July and average minimum temperature of 18.8^{0}C was recorded during fourth week of October. The total rainfall of 972.2 mm was received during the entire period of experimentation.

Experimental detail

The experiment was carried out in strip plot design with 24 treatments and three replications. The horizontal factors consisted of eight rice varieities which includes six hybrid rice varieties (Arize 6444, Arize Tej Gold, Gorakhnath 509, Shanti , Sudha, US312) and two conventionally bred high yielding varieties(Sabitri and Hardinath1). The vertical factors included three fertilizer management practices (Farmers practices 60- 40- 0 N, P2O5, K2O, kg ha-1 National Recommended dose- 100- 30- 30 N, P2O5, K2O kg ha-1, 125% of National Recommended dose 125- 38-38 N, P2O5, K2O kg ha-1)

The individual plot size was 3 m x 3.6 m. The 22 days old seedling at the rate of two seedling per spot was transplanted on 17th July,2018 in puddled field at the spacing of 20 cm x 20 cm. There were fifteen rows in each plot. The standard practices were followed for all agronomic operation during whole growing cycle of the crop..

The data on yield attributes , yield, and economics were collected, analyzed for analysis of varience, using MSTAT-C and mean comparisions were done using LSD and DMRT at 0.05 level of significance.

RESULTS AND DISCUSSION

Number of effective tillers

The mean number of effective tillers per square meter was (244) and it ranged from 188.60 to 269.60 (Table 1). The number of effective tillers were significantly influenced both varieties and fertilizer management practices. The highest number of effective tillers per square meter was recorded for hybrid Sudha (269.60) which was significantly higher than improved varieties Sabitri and Hardinath1, whereas statistically similar to other hybrids. The least number of effective tillers per square meter was recorded for Hardianth1, which was significantly lower than all tested hybrid but statistically at par with Sabitri.The higher number of effective tillers per square meter in hybrid as compared with inbred rice is because of heterosis effect in hybrid rice. Siddiquee et al.,2002 also reported higher number of effective tillers in hybrid rice as compared with inbred rice.

Increasing the fertilizer levels significantly increased the number of effective tillers per square meter. The highest number of effective tillers square meter was (258) recorded in 125 % recommendation dose application, which was significantly higher than NRD and farmers practices. The lowest effective tillers per square meter were (228) recorded for farmer's fertilizer management practices. Higher number of effective tiller with higher dose of fertilizer is obvius as it helps in tiller survival and better growth of crop.Meena, Singh and Shivay(2003) also reported higher effective tillers in rice with higher dose of N level.

Grains per panicle

The average number of grains per panicle was (123.40) in the experiment and it ranged from 107.70 to 128.60 (Table 1). The grain per panicle significantly differed among the varieties and fertilizer management practices. The highest number of grains per panicle was (128.60) recorded in hybrid Shanti which was significantly higher than the number of grains per panicle recorded in improved varieties Sabitri and Hardinath1 but statistically at par among the other hybrids in the experiment. The number of grains per panicle in hybrids, Arize 6444 and US 312 were also similar with Sabitri. The lowest number of grains per panicle was recorded Hardinath1, which was lower than other varieties tested in the experiment. In general higher grain per panicle was observerd in hybrid rice varieties compared with conventional bred high yielding varieties.Mrityunjay (2001) also reported higher number of grain per panicle in hybrid rice varieties.

Thousand grain weight

The average thousand grain weight 18.09 g and it ranged from 17.33 to 23.00 g (Table 1) among all the tested varieties of experiments. TGW significantly differed among the tested varieties and fertilizer management practices. The highest TGW was for improved varieties Sabitri (23.00 g) which were significantly higher than other tested varieties. Thousand grain weight is generally genetic makeup of the varieties although it is also influenced by environmental factors like soil fertility, soil moisture content during grainfilling period. In the present experiment TGW differed among the varieties . Siddiquee et al. (2002) also observed non significant differences in TGW among hybrid and conventional bred rice. The increasing fertilizer level increased the TGW. The highest TGW was in 125% of NRD which was statistically similar in NRD but significantly higher than Farmers dose. It is obvious the higher level of fertilizer application increases the size of individual grain as the nutirient play vital roles in growth and development.

Table 1. Yield attributes of rice as influenced by varieties and fertilizer management practices at Hardinath, Dhanusha, Nepal in 2018

Treatments	ETM $^{-2}$	GPP	Sterility (%)	TGW (g)
Varieties				
Arize 6444	266.00^{a}	124.90^{ab}	9.75^{bc}	16.70^{cd}
ArizeTejgold	254.40^{a}	128.4^{20a}	9.04^{bc}	16.36^{d}
Gorakhnath 509	252.40^{a}	128.30^{a}	5.96^{c}	16.46^{cd}
Shanti	245.40^{ab}	128.60^{a}	8.58^{bc}	16.28^{d}
Sudha	269.60^{a}	126.90^{a}	10.95^{b}	17.33^{c}
US 312	258.10^{a}	125.00^{ab}	9.89^{bc}	17.07^{cd}
Sabitri	217.60^{bc}	117.80^{b}	8.95^{bc}	23.00^{a}
Hardinath 1	188.60^{c}	107.70^{c}	15.53^{a}	21.55^{b}
SEm (±)	8.08	3.71	1.91	0.40
LSD (0.05)	17.32	7.90	4.10	0.87
CV (%)	4.10	3.70	23.80	2.80
Fertilizer Managements				
FP	228.30^{c}	118.00^{b}	10.20	17.83^{b}
NRD	245.20^{b}	124.00^{ab}	9.97	17.98^{ab}
125 % NRD	258.50^{a}	127.70^{a}	9.29	18.44^{a}
SEm (±)	2.22	2.35	0.64	0.16
LSD (0.05)	6.16	6.53	Ns	0.46
CV (%)	1.10	2.30	8.00	1.80
Grand Mean	244.00	123.40	9.84	18.09

FP: Farmers Practice (60:40:0 N, P_2O_5, K_2O kg ha $^{-1}$), NRD: National Recommendation Dose (100:30:30 N, P_2O_5, K_2O kg ha^{-1}) and 125% NRD (125:40:40 N, P_2O_5, K_2O kg ha^{-1}). Ns: not significant , Means followed by the same letters(s) in the same column are not significantly different at 5 % probability level by Duncan Multiple Range Test.

Grain yield

Table 2. Grain yield straw yield and harvest index rice as influenced by varieties and fertilizer management practices at Hardinath, Dhanusha, Nepal in 2018

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Varieties			
Arize 6444	4733^{b}	5730^{b}	45.05^{b}
ArizeTejgold	4899^{b}	5904^{ab}	45.21^{b}
Gorakhnath 509	4722^{b}	5628^{b}	45.39^{b}
Shanti	4928^{b}	6018^{ab}	44.83^{b}
Sudha	5695^{a}	6399^{a}	47.06^{a}
US 312	5153^{ab}	6108^{ab}	45.54^{ab}
Sabitri	4010^{c}	4999^{c}	43.99^{b}
Hardinath -1	2589^{d}	3623^{d}	39.71^{c}
SEm (±)	264.70	231.70	0.74
LSD (0.05)	567.80	496.90	1.58
CV (%)	7.10	5.10	2.00
Fertilizer Managements			
FP	3680^{c}	4666^{b}	42.96^{b}
NRD	4619^{b}	5646^{b}	44.82^{a}
125 % NRD	5475^{a}	6342^{a}	46.00^{a}
SEm (±)	308.30	277.30	0.60
LSD (=0.05)	255.90	770.00	1.68
CV (%)	8.20	6.10	1.70
Grand Mean	4591.00	5551.00	44.60

Note: FP: Farmers Practice (60:40:0 N, P_2O_5, K_2O kg ha^{-1}),National Recommendation Dose (100:30:30 N, P_2O_5, K_2O kg ha^{-1}) and 125% NRD (125:40:40 N, P_2O_5, K_2O kg ha^{-1}). Means followed by the same letters(s) in the same column are non-significantly different at 5 % probability level by Duncan Multiple Range Test.

The mean grain yield was 4591 kg ha^{-1} in the experiment and ranged from 2589 to 5695 kg ha $^{-1}$ (Table 2) among different varieties. The highest grain yield was obtained from the hybrid Sudha (5695 kg ha^{-1}), which was statistically similar with grain yield obtained from hybrid US 312 (5153 kg ha^{-1}) but higher than all other tested varieties on the experiment. The lowest grain yield (2589 kg ha^{-1}) was obtained from Hardinath 1 which was significantly lower than all other tested varieties. Similarly Sabitri produced (4010 kg ha-^{1}) significantly higher grain yield than Hardinath1. Both Sabitri and Hardinath 1 produced significantly lower grain yields than all other hybrid rice tested in the experiment. The higher grain yield in Hybrid rice was because of more number of effective tillers per square meter and more grain per panicle(Table 1) and higher harvest index (Table 2). Higher yield of the hybrid rice is due to the heterosis effect when compared with the inbred. Yuan et al. (2005) reported that indica hybrid showed yield increase of 38.46% against an improved inbred variety in Jiangsu province of China. Mishra (2003) reported 18% to 44.9% yield advantage of 17 released indica hybrids over standard check from on farm evaluation experiment in India.

The fertilizer management practices also influenced grain yield on the experiment. The increasing fertilizer dose significantly increased grain yield. The highest yield was obtained with the application of 125 % NRD, which was higher than NRD and FP. The NRD also produced significantly higher grain yield than the farmer's practices.

Straw yield

The highest value of straw yield 6377 kg ha^{-1} was recorded for hybrid Sudha (Table 2), which was significantly higher than hybrid Arize 6444 and Gorakhnath 509, Sabitri and Hardinath1 but statistically at par with rest of other hybrids .Among hybrid lowest straw yield was recorded for Gorakhnath 509. Both improved varieties Sabitri and Hardinath 1 had significantly lower straw yield than hybrids. Hardinath 1 also had significantly lower straw yield than sabitri. Application of 125 % NRD resulted in significantly higher straw yield than NRD and farmers practices.

Harvest index

The mean harvest index was 44.6 %. Harvest index significantly differed among varieties and fertilizer management practices. The harvest index was the highest (47.06 %) in the rice hybrid Sudha (Table 2). This harvest index was significantly superior than all other varieties except US 312 (HI 45.54 %).Significantly lower harvest index was observed in Hardinath 1 than other varieties including Sabitri. The harvest index was the highest (46 %) in 125 % NRD followed by NRD (44.82 %), these harvest index were statistically similar but significantly superior than farmers practices (42.96 %).

Yield increment of hybrid rice over improved varieties

Table 3. Grain yield increment (%) of hybrid rice over the improved rice varieties at Hardinath, Nepal, 2018

Treatments	Yield increment over the improved varieties		
Varieties	**Grain yield (kg ha^{-1})**	**Yield increase over Improved varieties Sabitri (%)**	**Yield increase over improved varieties Hardinath (%)**
Arize 6444	4733	18.03	82.81
ArizeTej gold	4899	22.17	89.22
Gorakhnath 509	4722	17.76	82.39
Shanti	4928	22.89	90.34
Sudha	5695	42.02	119.97
US 312	5153	28.50	99.03
Sabitri	4010	0.00	54.89
Hardianth	2589	-35.44	0.00

The highest grain yield incrementwas observed in hybrid rice Sudha (42.09 and 119.97%) followed by US 312(28.5 and 99.03%) over both high yielding varieties (HYV). Sabitri and Hardinath1 respectively(Table 3).The yield increment over high yielding varieties Sabitri and Hardinath 1 ranged from 17.76–28.50% and 82.81–119.97% respectively among the rice hybrids. The yield of HYV Sabitri was 54.89% higher than high yielding Hardinath1.

The higher grain yield of hybrid rice is because of heterosis effect which has been found to increase spikelet number per penicle, more panicle per unit area. Yuan(1994), and Virmani(1994) have reported 15-20% yield advantage of hybrid rice over conventional bred best check varieties.

Table 4. Economic analysis of rice as influenced by varieties and fertilizer management practices at Hardinath, Nepal, 2018

Treatments	Total Cost production (NRs ha^{-1}'000)	Gross return (NRs.ha^{-1} '000)	Net return (NRs. '000 ha^{-1})	B:C ratio
Varieties				
Arize 6444	90.75	155.60^{b}	64.85^{b}	1.71^{b}
Arizetejgold	90.01	164.12^{b}	74.11^{b}	1.81^{b}
Gorakhnath 509	87.41	155.03^{b}	67.62^{b}	1.76^{b}
Shanti	89.88	165.09.^{b}	75.21^{b}	1.83^{ab}
Sudha	90.01	190.78^{a}	100.77^{a}	2.11^{a}
US 312	90.54	172.63^{ab}	82.08^{ab}	1.89^{ab}
Sabitri	84.44	117.17^{c}	32.73^{c}	1.39^{c}
Hardianth 1	84.86	75.43^{d}	-9.43^{d}	0.87^{d}
SEm (±)		9517.80	8698.30	0.10
LSD (=0.05)		20413.60	20800.90	0.23
CV (%)		7.81	19.50	8.00
Fertilizer Management				
FP	85.44	120.50^{c}	35.068^{b}	1.39^{b}
NRD	86.57	149.90^{b}	63.326^{b}	1.72.^{a}
25 % NRD	93.45	178.04^{a}	84.590^{a}	1.90^{a}
SEm (±)		9713.30	9713.3	0.11
LSD (=0.05)		26967.5	26967.5	0.31
CV (%)		8.2	19.5	8.2
Grand mean	88491.00	149486	60995	1.67

Note: FP: Farmers Practice (60:40:0 N, P_2O_5, K_2O kg ha^{-1}),National Recommendation Dose (100:30:30 N, P_2O_5, K_2O kg ha^{-1}) and 125% NRD (125:40:40 N, P_2O_5, K_2O kg ha^{-1}). Means followed by the same letters(s) in the same column are non-significantly different at 5 % probability level by Duncan Multiple Range Test.

Economic analysis

The cost of cultivation was higher in Hybrids than in improved varieties Sabitri and Hardinath1 but gross return, net return and B: C ratio were higher in Hybrids (Table 4). Likewise, based on the fertilizer management practice, highest B:C ratio of 1.90 was obtained from 125% NRD followed by NRD with B/C ratio of (1.72) but both 125 % NRD and NRD were statistically similar. Lower B:C ratio (1.39) was observed in farmer practice (Table 4). The higher cost of cultivation among the hybrids as compared with HYV Sabitri and Hardinath 1 was because of higher cost of seed of Hybrid but higher gross return and net return andB:C ratio among the Hybrids was because of higher yield of Hybrids as compared inbred varieties.Khushk et al. (2011) reported that majority of farmers were focusing to cultivate hybrid rice, because of it gives better yield, result highlighted that the cost of production of hybrid rice were little bit high. Major reasons of high cost were higher seed prices, slightly higher land management costs. Salam (2012) observed that per hectare total cost of hybrid rice production was about 4% higher compared to that of inbred rice production. It revealed that per hectare total return received was US $ 1226 from inbred rice production while it was US $ 1443 ha^{-1} from hybrid rice.

CONCLUSION

All the hybrids rice varieties tested in the experiment produced higher yield as compared with high yielding modern inbred rice varieties. Higher fertilizer was required to achieve higher yield in hybrid. Therefore, among the tested hybrid rice varieties Sudha and US 312 can be grown with 125% fertilizer dose of national recommended dose.

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