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Bio-Economics and Radiation Use Efficiency of Basmati, Hybrid and Coarse Rice (Oryza Sativa L.) Varieties

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ABSTRACT

A field experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad during kharif season 2013. The experiment was laid out in a randomized complete block design (RCBD) with factorial arrangement replicated thrice to assess the performance of six rice varieties (V_1 = Arize H-64, V_2 = Arize Swift, V_3 = Basmati 515, V_4= Basmati Super, V_5 = KSK 133, V_6= IRRI 6) at two fertilizer levels {F_1 = NPK 150–88–58 kg ha^{-1} (recommended for Basmati rice) and F_2 = NPK 175–100–78 kg ha^{-1} (recommended for coarse rice)}. All the dose of phosphorus and potassium were applied as a basal dose and nitrogen were applied in three split doses. The results revealed that variety V_1 recorded significantly higher grain; straw and biological yield between hybrids and fertilizer level F_2 gave significantly higher all types of yield in this rice type. In basmati types there was no significant increase in yield and yield parameters both at fertilizer and variety stage. In case of coarse rice KSK-133 gave the significantly higher grain, straw and biological yield at F_2 level but there was no significant effect of variety. In case of economics the maximum profit (78443) and marginal rate of return (2.12) was obtained from V_1 at F_2 level. The same variety gave highest profit (69550) and marginal rate of return (2.06) at F_1. After that maximum profit (67828) and marginal rate of return (1.98) was obtained from V_2 at F_2.The basmati 515 gave the highest profit (48951) and marginal rate of return (1.83) at fertilizer level F_1 after the hybrids. The variety IRRI-6 gave the minimum profit (27769) and marginal rate of return (1.46) at F_2 from all the varieties. Arize H-64 recorded significantly higher radiation use efficiency at F_2 as compared to F_1. Basmati varieties were not different significantly in RUE at any fertilizer level. In coarse rice F_2 gave significantly higher RUE as compared to F_1.

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food of nearly half of the world's population (Islam *et al.*, 2010; Atera *et al.*, 2011). Rice is the chief food for the world 2.7 billion populations, from which mostly belong to Asia (Hussain *et al.*, 2008). Asia produces and consumes a huge part (90%) of world's rice (Said *et al.*, 2003). Rice production includes 40 percent of Basmati (Fine) type and 60 percent of coarse types. Rice comes at second number amongst the staple food grain crop in Pakistan. It has been a major source of foreign exchange earnings in recent years. Pakistan grows a high quality of rice to achieve the domestic demand and also for exports. Rice adds 2.7 percent in the value added in agriculture and 0.6 percent in GDP (Govt. of Pakistan, 2013). Hybrid rice was first commercially cultivated in China in 1976 and its area had been expanded to more than 13 million hectares by 1990 (Jumin *et al.*, 2000).

It is expected that in 2025 the world population will increase to 9 billion. So for daily food 4.3 billion people will depend upon rice (Bisne *et al.*, 2009). As the population and urbanization are increasing day by day, the demand of rice is also rising worldwide (Mishra, 2009), increasing the market price for consumers. In April 2008 rice prices reached more than double just in seven months. To fulfill the world's demand of food by 2025, we had to increase the rice production 60% globally (Fageria, 2007). We can fulfill the world demand only by developing high yielding varieties.

The key objective in agricultural production is to enhance yield and reduce cost. Many researchers discussed economic aspects of different crops generally and rice crop mainly. Hussain *et al.* (2008) studied the cost benefits analysis of different rice varieties in district Swat. Seven varieties were used.

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The Benefit Cost Ratio (BCR) of variety JP-5, Basmati-385, Sara Saila, Dil Rosh-97, Swat-1 and Swat-2 and Fakhr-e- Malakand was 2.24, 3.20, 1.80, 1.80, 1.46, 1.54 and 4.36. The variety *Fakhr-e-Malakand* gave the highest BCR value. The performance of rice hybrid and other varieties planted in growing areas of rice of Baluchistan and Sindh was found. The results show that average yield of hybrid rice was 7800 kg ha-1 followed by IRRI-6 (6040 kg ha-1), Rosi (3760 kg ha-1) and B-2000 (3640 kg ha-1). However, the growers of hybrid rice get low price than growers of IRRI-6 variety. This study shows that overall growers get more profit by growing hybrid seed (Khushik *et al.*, 2011). To evaluate the economic efficiency and comparative performance of two hybrid rice varieties, Sonarbangla-2 and Sonarbangla-3 with three usual modern commercial varieties BRRIdhan33, BRRIdhan32 and BR1, an experiment was done. The result showed that highest economic return and yield was obtained from hybrid Sonarbangla-3 followed by BRRIdhan-32 (5.70 t ha-1) and the lowest in BRRIdhan-33 (4.17 t ha-1). Maximum amount of straw was obtained from the hybrid Sonarbangla-2. It was concluded that over all maximum economic return and profit was obtained from hybrid Sonarbangla-3 (Awal *et al.*, 2007).

The crop productions mostly depend upon the nutrients (Ananthi *et al.*, 2010). As we applied the nutrients the crop performance increased and vice versa. The performance of three rice varieties Krishnahamsa (V1), Vasumathi (V2) and KRH-2 (V3) at six nutrient management practices was studied at Directorate of Rice Research farm, Rajendranagar. The results indicate that hybrid KRH-2 gave significantly higher net economic return, straw yield and grain yield as well as nutrient uptake. In context of economics the hybrid KRH-2 through 50% RDN (organic) + 50% RDN (inorganic) with vermin compost gave highest net and gross returns (Rs 46,398 and Rs 70,013ha-1) but maximum benefit cost ratio (2.07) was found in hybrid KRH-2 with combination of 100% RDN (through urea) (Ranjitha *et al.*, 2013).

Radiation use efficiency is a useful parameter in studying crop productivity (Curt *et al*., 1998) and has been used in many crop growth models to estimate total or above-ground biomass and crop yields (Apakupakul, 1995). Radiation use efficiency is different among crop plants; therefore, they have different growth rates and yields (Curt *et al.*, 1998). Determining radiation use efficiency is an important approach for understanding crop growth and yield (Sinclair and Muchow, 1999). Radiation use efficiency varied from 1.18 g MJ-1 to 1.94 g MJ-1 IPAR for above ground total dry matter in the Pakistan's conventional rice belt at different locations (Ahmad *et al.*, 2009). According to Ahmad *et al.* (2008) linear relationships were calculated between grain yields, total dry matter, cumulative ET and accumulated intercepted PAR. It is reported by Choudhury (2001) that there is much room to increase the RUE in crops.

With the passage of time a lot of rice types such as basmati, hybrid and coarse rice are being grown. The production technology of these rice types is different from each other. There is a numerical difference in the inputs and water requirements of different rice types. The net profit obtained from these types is different. The growers only meant to his profit. So they are confused to select a rice type which gives them maximum economic return. This study will help them to select a most profitable rice type. Some varieties have more radiation use efficiency and some have lower potential to use radiation. We should identify best radiation efficient varieties to get good economic return and to maximize profit. So the purpose of our study is to identify the rice type and variety that use radiation more efficiently and effectively.

MATERIALS AND METHODS

The study was conducted at Agronomic Research Area, University of Agriculture, Faisalabad (31.4180° N, 73.0790° E) during kharif season 2013. It was a factorial experiment with two factors in treatments. Factor A includes six varieties two varieties of Basmati rice, two varieties of Hybrid rice and two varieties of Inbred (Coarse) rice {V_1 = Arize H-64 (Bayer crop Sciences), V_2 = Arize Swift (Bayer crop Sciences), V_3 = Basmati 515, V_4= Basmati Super, V_5 = KSK 133, V_6= IRRI 6} and factor B includes two fertilizer levels {F_1 = NPK 150–88–58 kg ha^{-1} (recommended for Basmati rice) and F_2 = NPK 175–100–78 kg ha^{-1} (recommended for coarse rice)}. In this experiment was laid out in a randomized complete block design (RCBD) with factorial arrangement in three replications. Net plot size was 2 m x 4 m. nursery was sown using standard method for each and was transplanted during last week of June, 2013 at row to row and plant to plant spacing of 22.5 cm. Fertilizer was applied as per treatment and all other Agronomic practices were kept normal and uniform for all the treatments.

All the dose of phosphorus and potassium were applied as a basal dose and nitrogen were applied in split doses.

One third quantity of urea with total amount of DAP and SOP will be applied to the field as a basal dose before transplanting of seedlings, while the remaining amount of nitrogen will be applied at critical stages of crop into two splits i.e. tillering and panicle initiation. Observation on number of tillers, no. of grain per panicle, 1000 grain weight, grain yield and biological yield were recorded. The economic analysis was also done based on cost of cultivation and cost of harvests at the prevailing market prices.

In case of yield parameters it is not possible to compare hybrid with basmati and coarse rice. So we compared hybrid with hybrid, basmati with basmati and coarse rice with coarse rice varieties.

Sampling

One half of each plot area was allocated to destructive used for the growth parameters and the remaining half plot reserved for final harvest data. A sample of four plants from each plot was harvested at ground level fortnightly intervals leaving appropriate borders. Fresh and dry weights of component fractions of plant (e.g., leaf, stem and panicle) were determined. A sub-sample of each fraction was taken to dry in an oven at 70°C to a constant weight. ATDM was obtained by adding weight of all the components. An appropriate sub sample (10 g) of green leaf laminae was used to record leaf area using electronic leaf area meter. These measurements of leaf area and dry weights were used to calculate the growth of rice crop.

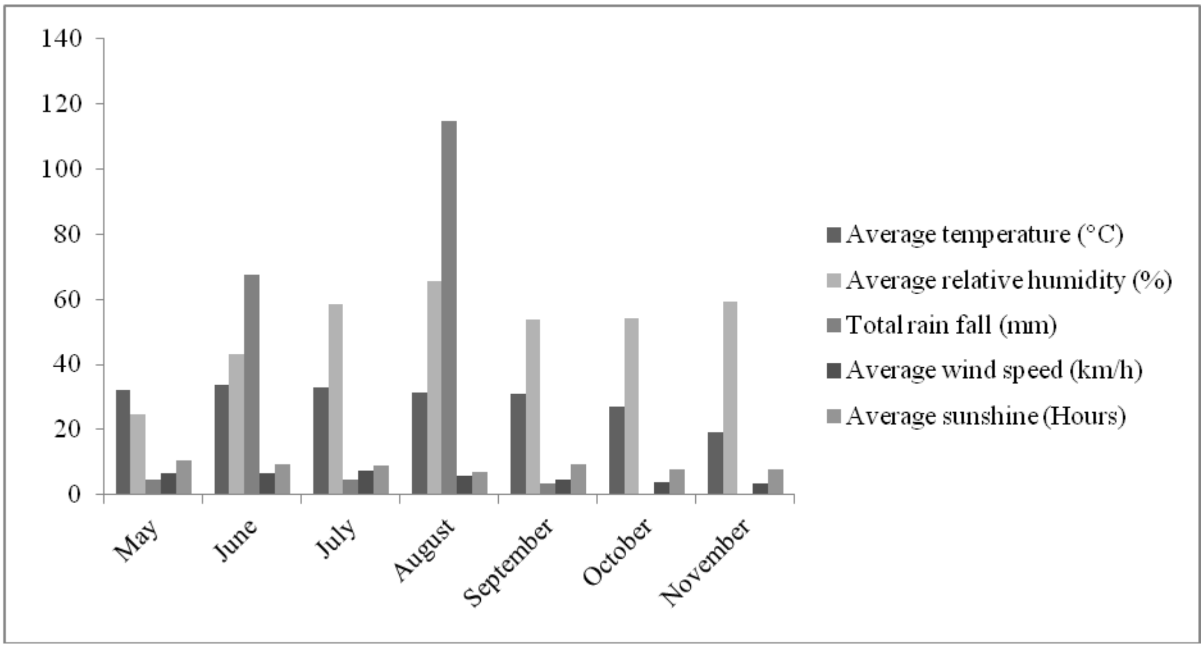

Fig1. *Weather conditions during rice growing period (2013)*

Source:

Department of Crop Physiology, University of Agriculture, Faisalabad, Pakistan.

Leaf area index:

LAI was calculated as the ratio of leaf area to land area (Hunt, 1978).

LAI = Leaf area / Land area

Leaf area duration (days):

Leaf area index (LAI) is an indicator or the size of the assimilatory system of a crop. It is an important parameter of rice canopy because it is directly and positively associated with crop photosynthesis. However, excessively increased LAI causes increased shading and tiller mortality and is linked with reduced tillering rate in rice crop (Graf *et al.*, 1990).

LAD was estimated according to the formula suggested by Hunt (1978).

$$LAD = (LAI_1+LAI_2)/2 \times (T_2–T_1)$$

Where LAI_1 and LAI_2 were the leaf area indices at time T1and T2, respectively. Cumulative LAD was calculated at final harvest by adding all the LAD values attained at different stages.

Crop growth rate (g m-2 d-1)

CGR was calculated as proposed by Hunt (1978) for each harvest after 15 days interval.

$$CGR = (W_2- W_1) / (T_2- T_1)$$

Where $W_1$and W_2 was the total dry weights harvested at times T_1 and T_2 respectively. Mean CGR was calculated between first harvest and the last harvest.

Net assimilation rate (g m-2 d-1)

The mean net assimilation rate (NAR) was estimated by using the formula of Hunt (1978).

$$NAR = ATDM / LAD$$

Where, ATDM and LAD are the final total dry matter and leaf area duration, respectively.

Interception of radiation:

The fraction of intercepted radiation (Fi), twice a month was calculated by the method of Gallagher and Biscoe (1978) as;

$$Fi = 1- \exp(-K \times LAI)$$

Where, K is an extinction coefficient for total solar radiation equal to 0.63 for rice (Ritchie *et al.*, 1998). The amount of IPAR was determined by multiplying values of Fi with daily IPAR during the season. Daily IPAR values were taken as 50% of total solar radiation values (Szeicz, 1974).

Radiation use efficiency (RUE)

RUE was calculated as the ratio of ATDM to cumulative IPAR for each plot, and the plot values subjected to anova. Alternatively, RUE was also estimated from the slope of the linear regression of cumulative IPAR on ATDM obtained from the sequential samplings for all crops (Montieth, 1977; Kiniry *et al*., 2001).

$$RUEA_{TDM}= ATDM/\sum Sa$$

Economic Analysis

The experimental data will be analyzed by using methodology described in CIMMYT (1988). Net benefit and benefit cost ratio will be calculated. Net benefits will be calculated by subtracting the total variable cost from the total benefits for each treatment combination. For economic analysis three types of rice were compared with each other.

Statistical Analysis

Data collected on growth and RUE were analyzed statistically using Fischer's analysis of variance technique and significance of treatments means was tested using Tukey's HSD (Honestly significant difference) at 5% probability level (Steel *et al.*, 1997). For yield and other all parameters varieties of each type was compared with variety of same type

RESULTS AND DISCUSSION

Effect of Various Varieties on Yield and Yield Parameters

The significantly higher number of grains per panicle was observed in Arize H-64 as compared to Arize Swift in case of hybrid type. The results are shown in the table 4.1. While in case of basmati rice and coarse rice varieties the number of grains per panicle was not significantly differ in different varieties as shown in sub table 4.2 and 4.3. There was a small difference was present in case number of grains per panicle in different varieties but it was not significant. It was may be due to that there is no large yield potential difference in these varieties. The number of productive tillers per square meter was also different significantly in hybrid varieties. The variety Arize H-64 produced more number of productive tillers, which was significantly different from Arize Swift variety. In basmati rice varieties the basmati 515 produced more number of productive tillers but it was not significantly different from basmati super. While in case of coarse rice varieties the KSK-133 produced significantly more number of productive tillers as compared to IRRI-6.

While in case of straw yield and Biological yield the variety Arize H-64 was significantly different from other hybrid variety. It was may be due to more yield potential of this variety. This variety efficiently used all the resources. Basmati-515 produced efficiently more straw yield. It was due to the more vegetative growth in this variety. While in overall, biological yield was not significantly higher in basmati-515 as compared to basmati super. The coarse rice varieties were not significantly different in straw and biological yield. The results of all these parameters are shown in the table 4.

Table4. *Effect of different fertilizer levels and varieties on yield and yield contributing parameters*

Treatments	Plant Height (cm)	1000 Grain Weight(g)	No. of Grain Panicle^{-1}	No. of Prod. Tillers	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})	Biological Yield (t ha^{-1})
4.1-Hybrid Varieties							
Arize H-64	99.69 A	24.10 A	135.23 A	272.27 A	87.5 A	11.29 A	20.04 A
Arize Swift	82.20 B	20.53 B	163.68 B	227.73 B	76.00 B	9.30 B	16.9 B
F_1	90.23	21.81	151.91	229.73 B	75.33 B	9.54 B	17.07
F_2	91.65	22.82	146.99	270.27 A	88.16 A	11.04 A	19.86
4.2-Basmati Varieties							
Basmati-515	107.65	21.45 A	119.74	175.73	44.16	7.70 A	12.12
Basmati Super	105.27	18.40 B	134.04	168.30	40.66	6.93 B	11.00
F_1	105.24	19.5	131.00	168.00	42.00	7.05	11.25
F_2	107.68	20.35	122.78	176.04	42.83	7.58	11.86
4.3-Coarse Rice Varieties							
KSK-133	86.98	21.10	133.51	202.54	56.00	9.90	15.50
IRRI-6	81.24	19.88	137.01	196.85	53.50	9.44	14.79
F_1	77.30 B	19.12 B	142.50	181.58 B	49.33 B	8.90 B	13.84 B
F_2	90.92 A	21.87 A	128.03	217.80 A	60.16A	10.44 A	16.46 A

F_1 = NPK 150–88–58 kg ha^{-1} F_2 = NPK 175–100–78 kg ha^{-1}

Means not sharing a letter in common differ significantly at 5% probability.

Interaction = Non-significant

Effect of Fertilizer Levels on Yield and Yield Parameters

The responses of different yield contributing parameters to different levels of fertilizer are shown in table. As hybrid and coarse rice types required more fertilizer so these varieties gave good results at F_2 fertilizer level. Grain yield is a function of productive tillers, 1000-kernel weight and balanced application of NPK nutrients (Hasanuzzaman *et al*., 2010). The number of productive tillers, grain yield and straw yield was significantly higher at F_2 level in the hybrid rice varieties. The plant height, number of grains per panicle, 1000 grain weight and biological yield was not affected significantly by fertilizer levels.

Basmati rice did not show significantly increase in yield contributing parameters. It was due to that F_1 is the recommended dose of fertilizer for basmati, so by increasing the fertilizer, straw yield and vegetative growth increased to some extent but it was not economical and significant. Basmati varieties have not potential to use efficiently higher amount of fertilizer. While coarse rice varieties showed increase in all yield parameters by increasing fertilizer dose. Increased grain yield in F_2 may be due to the favorable growth with higher nutrient uptake, more translocation of carbohydrates towards the sink which increased yield attributes and resulted in producing higher grain yield (Jayakumar and Krishnasamy, 2005). All results are given above in table 4.

Economics

The key objective in agricultural production is to enhance yield and reduce cost. Farmers are concern to their profits. With the passage of time a lot of rice types such as basmati, hybrid and coarse rice are being grown. The production technology of these rice types is different from each other. There is a numerical difference in the inputs and water requirements of different rice types. The net profit obtained from these types is different, so we made economic analysis of all these rice varieties to help the growers to select a most profitable and suitable rice variety.

Table5. *The total expenditure, total income, profit and benefit-cost ratio of different rice varieties (Rs Acre^{-1})*

Treatments	Yield (Mound Acre^{-1})	Expenditure	Markup 9% on Investment	Harvesting & Thresh exp.	Total exp. Rs.	Total Income	Profit	M.R.R
F1V1	83	49082	2208	14293	65583	135134	69550	2.06
F1V2	67	49082	2208	11537	62828	108879	46051	1.73
F2V1	91	51758	2329	15670	69757	148200	78443	2.12
F2V2	84	51758	2329	14465	68552	136381	67828	1.98
F1V3	43	45232	2035	11465	58732	107684	48951	1.83
F1V4	40	45232	2035	10665	57933	99999	42066	1.72
F2V3	44	47908	2155	11732	61796	110387	48591	1.78
F2V4	41	47908	2155	10932	60996	102763	41767	1.68
F1V5	50	47882	2154	9443	59480	90514	31034	1.52
F1V6	48	47882	2154	9065	59102	86872	27769	1.46
F2V5	61	50558	2275	11521	64354	110123	45769	1.71
F2V6	58	50558	2275	10954	63787	104720	40933	1.64

As it is clear from table 5 that maximum yield obtained from hybrid rice varieties at fertilizer level F_2. After the hybrid rice coarse rice gave the maximum yield at same F_2 level. Minimum Yield obtained from basmati rice varieties at fertilizer F_1 level. But when go for economic analysis its clear from the table that maximum profit was obtained from Arize H-64 at fertilizer level. The maximum marginal rate of return was also obtained from this variety also. After the Arize H-64, the maximum economic return was obtained from Arize Swift.

As it's clear from the data that coarse rice gave the more yield than basmati varieties but when we go for economic analysis, we noted that basmati varieties give the more profit and benefit-cost ratio. Our results are in accordance with the results of Kavitha and Balasubramanian, (2006). Rice hybrids produce about 20 percent higher grain yield over inbred cultivars (Kavitha and Balasubramanian, 2006). High grain yield of hybrid rice may be due to vigorous vegetative growth, more biomass production, larger panicles, higher leaf area and more tillering capacity (Islam *et al.*, 2009).

Radiation use efficiency

Table6. *Effect of different fertilizer levels and varieties on yield and yield contributing parameters*

Treatments	TDM	LAI	RUE_{GY}	RUE_{TDM}
Arize H-64	1083.7 A	6.62 A	1.00 A	1.82 A
Arize Swift	982.7 B	6.00 B	0.85 B	1.64 B
F_1	963.90 B	5.98 B	0.85 B	1.61 B
F_2	1102.6 A	6.64 A	0.99 A	1.85 A
Basmati-515	1013.2	6.24 A	0.47	1.51
Basmati Super	932.9	5.30 B	0.43	1.42
F_1	963.48	5.59	0.45	1.46
F_2	982.60	5.95	0.45	1.47
KSK-133	1033.4 A	6.17	0.62	1.51 A
IRRI-6	968.1 B	5.83	0.57	1.41 B
F_1	952.4 B	5.69 B	0.53 B	1.39 B
F_2	1049.1 A	6.31 A	0.67 A	1.53 A

F_1 = NPK 150–88–58 kg ha^{-1} F_2 = NPK 175–100–78 kg ha^{-1}

The table 6 shows that Arize H-64 has significantly higher TDM, LAI, RUE_{GY} and RUE_{TDM} as compared to Arize swift, and fertilizer level F_2 has significantly higher all these values as compared to $F_{1.}$ In case of basmati the variety and fertilizer level has nit significant effect on all these parameters except LAI value of basmati 515. In case of course rice fertilizer level F_2 has significant higher values of all parameters as compared to F_1.

CONCLUSIONS

So we conclude from all observations that hybrid rice varieties are more profitable and give maximum marginal rate of return as compared to all other varieties. So training programs should be launched to create awareness among people about this fact. If growers will sow this variety, they will earn more profit and it is also valuable for country.

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