EFFECT OF SOWING DATES AND VARITIES ON YIELD AND YIELD ATTRIBUTES OF DIRECT SEEDED RICE IN CHITWAN CONDITION

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ABSTRACT

Rice transplanting and sowing time sometimes get delayed due to lack of assured irrigation or surplus of rainfall. Moreover, no specific varieties have been specifically developed for this purpose. An experiment was conducted to study the effect of sowing dates and varieties on growth and yield of direct seeded rice during rainy season in 2010. The experiment was laid out in split plot design with four sowing dates and three varieties in sub plot. Sowing date on June 13th contributed to higher grain yield; higher gross return; net return and higher B:C ratio per hectare. Similarly, the variety Hardinath-1 excelled better in all these parameters with early maturity. The interaction effect of Hardinath-1 with June 13 sowing took lower days for maturity; produced higher number of effective tillers (386.3); heat use efficiency (2.14); straw yield (7.43 t ha-1); and relatively higher grain yield (4.22 t ha-1); gross return (Rs.108.55 thousand); net return (Rs. 51.22 thousands) and B:C ratio (1.89). Therefore, variety Hardinath-1 with June 13 sowing is best suited to get higher yield, timely maturity and higher economic return in Chitwan conditions.

Key words: Direct seeded rice, sowing date, yield attributes, yield

INTRODUCTION

Rice (Oryza sativa L.) is consumed by about 3 billion people and is the most common staple food of a large number of people on earth; in fact it feeds more people than any other crop. Ninety percent of the world's rice is produced and consumed in Asia, where irrigated and rainfed rice ecosystems form the mainstay of food security in many countries (Wassmann et al., 2009). It is the most important crop of Nepalese agriculture and economy as it is grown in about 1.48 million ha with total production of 4.02 million tons. The average productivity of rice is 2.71 ton/ha (MoAC, 2011). Share of rice to the agriculture gross domestic product (AGDP) is 20% and to the total food production is 56% and it contributes more than 50% to the total calories requirement of Nepalese people (NARC, 2007). Food grain production of the country is deficit of 0.17 million tons as compared to its requirements for the fiscal year 2006/2007 (NARC, 2007), and 50% of the total food grain production is obtained from the rice crop (MoAC, 1999). The country's target is to achieve over 5 million tons of rice production by the year 2020 to be self sufficient in food (Joshy,1997). The increasing scarcity of water resources in irrigated rice systems and the competition from industrial, domestic and non rice agricultural sectors suggest the need to use and conserve rainfall and irrigation water more efficiently. Direct seeding is an alternative rice establishment method that is relatively less labor-intensive and less water consuming. The direct-seeded

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rice area in Asia is about 29 million ha, which is approximately 21% of the total rice area in the region. If only the rain-fed lowland and irrigated rice ecosystems are considered, the total direct-seeded area is about 15 million ha (Pandey and Velasco, 1999). Direct seeded rice technology allows planting of rice to be conducted at right time under dry land condition, replacing conventional transplanting. DSR culture is compatible with the irregular rainfall pattern, guaranteeing crop growth, which avoids the need to leave land idle due to failure of transplanting (Kabaki, 1998). It can results in earlier maturity of rice, which helps to improve wheat productivity through timelier establishment (Malik et al., 1998). Rice transplanting and sowing time sometimes gets delayed due to lack of assured irrigation or surplus of rainfall in the major areas of terai and inner-terai of Nepal. The adoption of a direct seeded method for rice culture would significantly decrease the cost of rice production in south East Asia (Flinn and Mandac, 1986). The exact sowing date for direct seeding of rice also play a vital role in improving its growth and increasing the yield. Sowing on time ensures that vegetative growth occurs during a period of satisfactory temperatures and high levels of solar radiation and guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved (Farrell *et al*., 2003). However at the same time no varieties have been specifically developed for this purpose. The existing varieties used for rice culture do not appear to be well adapted for growth and yield. Viewing these facts, an experiment was carried out to evaluate the effectiveness of sowing dates and varieties on growth and yield of direct seeded rice in Chitwan.

MATERIALS AND METHODS

A field experiment was conducted at farmer's field of Phulbari, Chitwan from May to November 2010. Geographically it is located at 27^{o} 37' N latitude and 84^{o} 25' E longitude with an elevation of 228 meter above mean sea level. The type of the soil was sandy loam with sand 81.3% against silt 9.7% and clay 9%. Soil was acidic with low organic matter content and total available nitrogen whereas available phosphorus was high but at the same time available potassium was medium. The total rainfall received by crops during growing season was 2308.60 mm. Similarly average maximum temperature ranged from 26.01 ^{0}C at 3rd week of November to 36.50 ^{0}C at 2nd week of June and minimum temperature ranged from 17.57 ^{0}C at3rd week of November and 27.5 ^{0}C at 1st week of June and August.

The experiment was laid out in split plot design with sowing dates on the main plot and variety on the sub plot. Experimental plots consisted three replications and 12 treatments combinations. The main plot factor consisted of four sowing dates at fifteen days interval starting from 29 May. Sub plot factor consisted of three different crop varieties viz. Hardinath -1, Sabitri and Ram. The net size of each plot was 11.04 m^2(4.6m x 2.4m). Total field area was 398 m^2 (15.5m x 59m). There was a bund of 0.5 m width between two experimental plots and each replication was separated by bund of 1 m width. Row to row distance was made at 20 cm apart and seed was sown continuously in the row.

Seeds were sown at the rate of 80 kg/ha in each date of sowing in the line. Gap filling was done after 15 days of sowing in the sparsely germinated rows to maintain the desired plant population. One third of the recommended dose of nitrogen (100 kg/ha) and full dose of phosphorus (30 kg/ha), potash (30 kg/ha) and zinc sulphate (20 kg/ha) were applied at sowing, and the remaining nitrogen was top-dressed in two equal splits, half at active tillering and half at panicle initiation stage. For effective weed control Pendimethalin @1 kg a.i.ha-1 was used in moist condition at evening hours in all the treatments just after sowing of rice. One hand weeding operations were done at 25 days after sowing (DAS). Single spraying of insecticide Thiodan (Endosulfan 35% EC) @ 2 ml. lit-1 of water was applied before milking stage of crop to control sucking insect particularly rice bug. Life saving irrigations was applied in research plot at the time of need during vegetative stage and light irrigation was applied before panicle emergence and flowering stage in each plot.

Harvest index (HI) was calculated as the per cent ratio of grain yield to the total biological yield i. e. total drymatter including grain yield. MSTAT-C was used for running statistical analysis. Duncan's Multiple Range Test (DMRT), a mean separation technique, was applied to identify the most efficient treatment. Calculation was done at 5% level of significance.

RESULTS AND DISCUSSIONS

EFFECT OF SOWING DATES AND VARIETIES ON YIELD ATTRIBUTING TRAINS IN DSR

Effective tillers per square meter

Sowing dates significantly influenced the number of effective tillers per square meter. Number of effective tillers per square meter in June 13 sowing was significantly higher (318) as compared to June 28, May 29 and July 13 date of sowing and they were statistically similar. Significantly higher effective tiller per square meter in June 13 might be due to favorable environmental conditions which enabled the plant to improve its growth and development as compared to other sowing dates. This result is in alignment with the findings of Pandey *et al.* (2001). There were significant differences in effective tillers per square meter among the varieties too. Hardinath-1 had the highest number of tillers per square meter (346.1) which was significantly more than Ram (303.3) and Sabitri (246.1). This might be due to significantly higher tiller mortality percentage of Sabitri (34.64%) than other varieties 20.91 and 26.13% respectively for Hardinath -1 and Ram (Table 1). The difference in tiller production among cultivars may be attributed to varietal characters (Chandrashekhar *et al.*, 2001).

Significant interaction effect of sowing dates and varieties was observed on effective tillers per square meter (Figure 1). The interaction of Hardinath -1 with all the sowing dates produced more effective tillers whereas the interaction of Sabitri with different sowing dates produced lower number of effective tillers. The interaction of June 13 sowing and Hardinath -1 produced more tillers (360.3) and significantly lower number of tillers were produced by the combination of July 13 and Sabitri.

Table 1. Effect of sowing dates and varieties on yield attributes

Treatments	Yield attributes No of effective tillers	Panicle length (cm)	Filled grain per panicle	Sterility %	Test weight(g)
Sowing dates					
May 29	291.9[b]	20.84[b]	91.24	15.80[b]	21.17[a]
June 13	318.0[a]	22.76[a]	92.36	14.53[b]	21.04[a]
June 28	298.9[b]	22.95[a]	89.07	15.84[b]	21.25[a]
July 13	285.2[b]	19.52[c]	88.55	19.90[a]	19.34[b]
LSD (P = 0.05)	13.76	1.01	NS	2.05	0.87
SEM ±	3.97	0.29	3.67	0.59	0.25
Varieties					
Hardinath-1	346.1[a]	23.00[a]	92.36	14.64[b]	19.99[b]
Sabitri	246.1[c]	18.86[b]	88.14	18.20[a]	21.02[a]
Ram	303.3[b]	21.93[a]	90.41	16.71[ab]	21.09[a]
LSD (P = 0.05)	12.9	1.93	NS	0.96	0.83
SEM ±	4.3	0.46	1.51	2.37	0.27
CV %	4.99	7.57	5.99	16.62	4.64
Grand Mean	298.5	21.26	90.31	16.51	20.69

Treatments mean followed by common letter (s) within column are not significantly different among each other based on DMRT at 5% level of significance

Panicle length

Panicle length was significantly influenced by sowing dates as well as varieties (Table 1).June 28 sown crop had significantly longer panicle length (22.95 cm) than panicle length of May 29 and July 13 (20.84 and 19.52 cm respectively) sown crop but it was statistically similar with the panicle length of June 13 sowing (22.76cm). Panicle length of varieties differed significantly among each other. Hardinath-1 had longer panicle (23.00 cm), which was significantly longer than Sabitri (18.86 cm) but had statistically at par, with Ram (21.93 cm). The latter two were statistically at par.

Interaction effect of sowing dates and varieties had no significant influence on panicle length. In general, Hardinath -1 with different sowing dates produced longer panicle length whereas Sabitri with different sowing dates produced shorter panicle length.

The lower number of filled grains per panicle beyond the June 13 sowing might be due to synchronization of grain filling stage with low temperature, which increased the grain sterility and hence less filled grain percentage. This result is aligned with the findings of (Janardhan *et al.*, 1980).

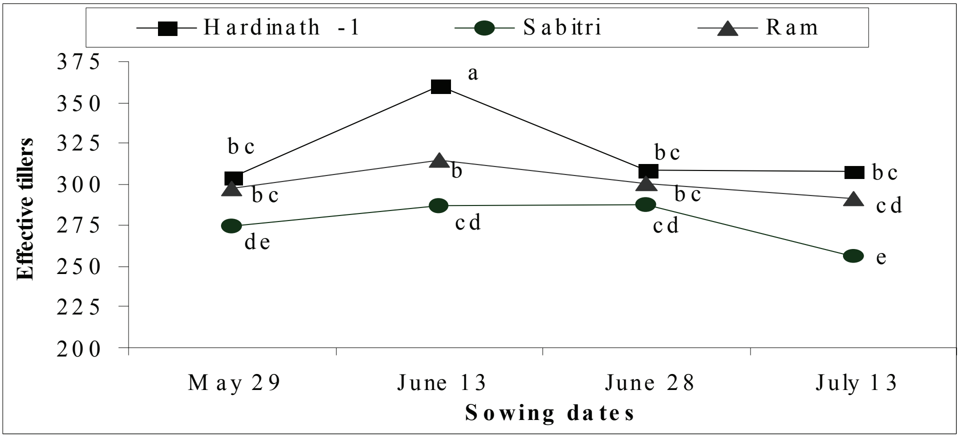

Figure 1. Interaction effect of sowing dates and varieties on effective tillers per square meter in direct seeded rice at Phulbari, Chitwan, Nepal, 2010

Late sowing, shortened the growth period of the plant which reduced the leaf area, length of panicle and number of kernels per panicle than early sowing. These results were in line with the findings of Shah and Bhurer (2005) who reported that more number of filled grains per panicle was visualized in the early seeding and declined gradually in the successive seeding dates.

Among the varieties relatively higher number of filled grains per panicle was recorded in Hardinath-1 (92.36) followed by Ram and Sabitri (90.41 and 88.14 respectively). The more filled grains in Hardinath-1 could be due to early maturation before low temperature conditions prevailed and higher sterility percentage in the Sabitri and Ram.

Interaction effect of sowing dates and varieties had no significant influence on filled grains per panicle. In general Hardinath-1 with different sowing dates produced more number of filled grains whereas Sabitri with different sowing dates recorded lower number of filled grains.

STERILITY PERCENTAGE

Percentage of empty grains is determined by air temperature during the critical growing stage, namely at the time of meiosis (9-12 days before flowering) and flowering (Shihua *et al*. 1991). Cold temperature during meiosis or hot or cold temperature at flowering caused high sterility. Significantly, more sterility was observed in July 13 sowing (19.90 %) whereas other sowing dates produced statistically similar sterility percentage (Table 1). Lower sterility in early sowing was due to optimum photoperiod availed by these treatments for growth, development and starch filling in the grains.

Among the varieties Sabitri had significantly higher sterility percentage (18.20 %) than Ram and Hardinath-1 (16.71 and 14.64 % respectively). Higher sterility percentage in Sabitri was due to its long growth duration, high nutrient and moisture requirement whereas low sterility in Hardinath-1 might be its ability to grow in marginal land with limited water and nutrient supply. Interaction effect of sowing dates and varieties had no significant effect on sterility percentage.

THOUSAND GRAIN WEIGHT (TEST WEIGHT)

The thousand grain weight was influenced by both the factors used in the experiment i.e. sowing dates and varieties. Significantly higher test weight was observed in June 28 sowing (21.25 gm) and it was statistically similar with May 29 sowing and June 13 sowing (21.17 and 21.04 g) and at the same time significantly lower test weight was observed in July 13 sowing (19.33g). Higher test weight in June 13 and June 28 sowing was attributed to optimum photoperiod availed by this treatment for growth, development and starch filling in the grains and sufficient soil moisture availed by well distributed rainfall.

Among the varieties, Sabitri had significantly higher test weight (21.08 gm) than the Ram (21.09 gm) and Hardinath-1 (19.98 gm). Greater thousand grain weight of Sabitri was probably due to the facts that it seeds are long and bulkier. There was no significant interaction between sowing dates and varieties on thousand grain weight.

EFFECT OF SOWING DATES AND VARIETIES ON YIELD IN DSR

Grain yield

Grain yield is a function of various yield components primarily number of kennels per panicle, productive tillers and 1000 grain weight etc. The grain yield in rice is determined by carbohydrates accumulated in the plant before heading and also after heading. Carbohydrates produced before heading mainly accumulate in the leaf sheath and stem and translocated to the panicles during grain filling (Fageria, 2007). Among the different sowing dates, June 13 sowing produced significantly higher grain yield (3.84 t ha^{-1}) as compared to other sowing dates. No significant differences in the yield was observed in the treatments of June 28 sowing (3.32 t ha^{-1}) and May 29 sowing (3.21 t ha^{-1}) whereas significantly lower yield was observed when rice was sown on July 13 (1.92 t ha^{-1}). This showed that the grain yield gradually decreases as the sowing was done before 13th June or delayed after 13th June. The higher yield in case of 13th June sowing was attributed to increased cumulative mean value of temperature and sunshine hour due to early sowing, more number of productive tillers, more number of grains per panicle, and higher test weight. These results are in line with that of Iqbal *et al.* (2008) who reported that the highest yield (4-5 tha^{-1}) was obtained when the rice crop was sown earlier in the season.

Likewise in the varieties, Hardinath-1 produced significantly higher grain yield (3.39 t ha^{-1}) as compared to Ram (3.07 t ha^{-1}) and Sabitri (2.76 t ha^{-1}). The higher grain yield of Hardinath-1 was because of higher LAI, slower leaf senescence which contributed to better light interception and higher assimilates production, higher dry matter production especially at the later growth stage of crop and higher harvest index. The greater remobilization of stem reserve towards the grain resulted in higher gain yield in Hardinath-1. Lower yield in the Sabitri was attributed due to the lower numbers of effective tillers per square meter, less panicle length, low numbers of grains per panicle and higher sterility percentage. No significant interaction between sowing dates and varieties on grain yield was observed. However, Hardinath-1 with different sowing dates produced comparatively higher grain yield and Sabitri with different sowing dates contributed to produce lower yield (Figure 2).

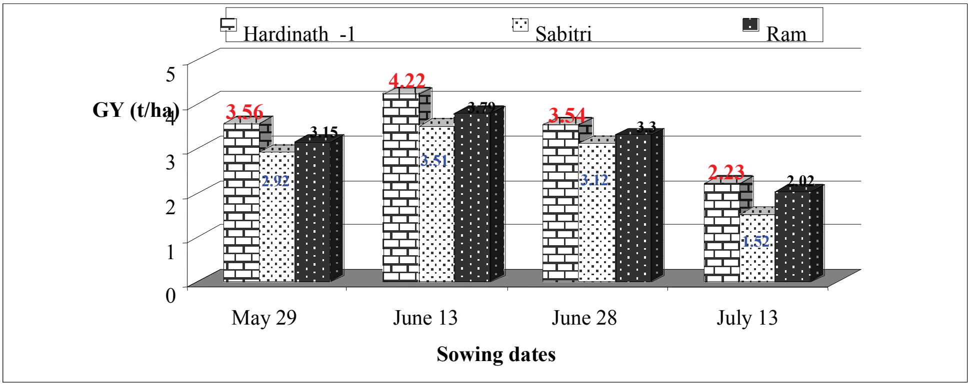

Figure 2. Interaction effect of sowing dates and varieties on grain yield (t/ha) in direct seeded rice, at Phulbari, Chitwan, Nepal 2010

STRAW YIELD

Straw yield (t ha^{-1}) was significantly influenced by the sowing dates and varieties (Table 2). The straw yield was the highest (6.85 t ha^{-1}) in June 13 sowing which was significantly superior to the straw yield from June 28, May 29 and July 13 sowing. July 13 sowing produced significantly lower straw yield (3.46). Similarly, significantly highest straw yield was observed in Hardinath-1 (6.07 t ha^{-1}) and lower straw yield was recorded in Sabitri (5.23 t ha^{-1}).

The significant interaction between sowing dates and varieties on straw yield was observed. In general, Hardinath-1 produced higher straw in all the sowing dates, followed by Ram and Sabitri. The interaction of Hardinath-1 with June 13 sowing produced the highest straw yield (7.43 t ha^{-1}) and was significantly higher than all other interaction of sowing dates and varieties. Sabitri produced the lowest straw yield (2.60 t ha^{-1}) with July 13 sowing.

HARVEST INDEX (HI)

Harvest index indicates the efficiency of assimilate partition to the parts of economic yield of the rice plants (i.e. panicle).

The significant difference was observed on Harvest index (HI) due to different sowing dates and varieties used in the experiment. Significantly higher harvest index was obtained with June 13 sowing (0.36) followed by June 28 sowing, May 29 and July 13 sowing (0.35, 0.34 and 0.33 respectively). Better assimilate partitioning from the source (leaf and non-laminar organ i.e., leaf sheath, stem, flag leaf) to the panicle (sink) occurred in the two varieties namely Hardinath-1 and Ram compared with Sabitri. Higher harvest index (HI) in Hardinath-1 and Ram was related to their higher grain yields while lower harvest index (HI) in the Sabitri was likewise related to lower grain yields. There were no significant interactions between sowing dates and the varieties on HI.

Table 2. Effect of sowing dates and varieties on grain yield, straw yield and HI

Treatments Date of sowing	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index
May 29	3.21^{b}	6.08^{b}	0.34^{c}
June 13	3.84^{a}	6.85^{a}	0.36^{a}
June 28	3.32^{b}	6.17^{b}	0.35^{b}
July 13	1.92^{c}	3.46^{c}	0.33^{d}
LSD (P = 0.05)	0.28	0.56	0.001
SEM ±	0.08	0.16	0.0003
Varieties			
Hardinath -1	3.39^{a}	6.07^{a}	0.35^{a}
Sabitri	2.76^{c}	5.23^{c}	0.33^{c}
Ram	3.07^{b}	5.63^{b}	0.34^{b}
LSD (P = 0.05)	0.11	0.13	0.0008
SEM ±	0.03	0.04	0.0002
CV %	4.42	2.85	3.75
Grand Mean	3.076	5.64	0.34

Treatments mean followed by common letter (s) within column are not significantly different among each other based on DMRT at 5% level of significance.

EFFECT OF SOWING DATES AND VARIETIES ON ECONOMIC PARAMETERS IN DSR

There was significantly higher gross return, net return and benefit cost ratio with June 13 sowing. Table 3 depicts clearly the economic analysis of direct seeded rice. Among the varieties, Hardinath-1 recorded significantly higher gross return, net return and benefit cost ratio. Regarding the interaction of sowing dates and varieties on economic parameter , no significant interaction was observed ,however the interaction of June 13 sowing and Hardinath-1 revealed comparatively higher gross return, net return and benefit cost ratio and at the same time combination of July 13 and variety Sabitri deserved lower value of economic parameters.

Table 3. Effect of sowing dates and varieties on cost of production, gross return, net return and B:C ratio in direct seeded rice at Phulbari, Chitwan, Nepal, 2010

Treatments	Economic Parameters Total cost NRs/ha (' 000)	Gross return NRs/ha (' 000)	Net return NRs/ha (' 000)	B:C ratio
Sowing dates				
May 29	60.33[a]	82.15[b]	22.09[c]	1.36[b]
June 13	57.33[b]	96.78[a]	39.98[a]	1. 69[a]
June 28	52.53[c]	84.45[b]	31.85[b]	1.60[a]
July 13	52.53[c]	48.76[c]	-8.19[d]	0.92[c]
LSD (P = 0.05)	0. 76	7.05	3.67	0.13
SEM ±	0.21	2.04	1.06	0.03
Varieties				
Hardinath -1	55.67	87.53[a]	31.87[a]	1.56[a]
Sabitri	55.67	66.85[c]	11.23[c]	1.19[c]
Ram	55.67	79.72[b]	21.20[b]	1.42[b]
LSD (P = 0.05)	NS	2.52	6.24	0.04
SEM ±	0.09	0.84	2.08	0.01
CV %	0	3.74	33.68	3.69
Grand Mean	55.67	78.03	21.43	1.39

CONCLUSIONS

Among the sowing dates, June 13 sown crop produced higher grain and straw yield along with higher gross return, higher net profit, and more favorable benefit-cost ratio. The variety Hardinath-1 produced significantly higher grain yield, net return and higher B: C ratio as compared to the variety Ram and Sabitri. Regarding the interaction, combination of Hardinath-1 with different sowing dates recorded to produce higher grain yield, straw yield. So, it would be better to use the variety Hardinath-1 and follow June 13 as optimum sowing date for rice cultivation along with the other elements for crop management under the direct seeded rice (DSR) in Chitwan.

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