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An analysis on the yield and yield contributing characters of rice in tarai region of Uttarakhand

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Abstract
Rice is the most important cereal food crop of India. It occupies about 23.3% of gross cropped area of country. It plays a vital role in national food security. Rice contributes of about 43% of total food grain production and 46% of total cereal production of country. It is the staple food for more than 60% of the world's population especially of most of the people of South-East Asia. The main rice growing season in the country is the 'Kharif'. In the present study, an attempt has been made to study yield and related attributes such as number of tillers per plant, panicles per plant, test weight alongwith grain yield and straw yield at different dates of transplanting in rice cultivation.

Keywords: Rice, tillers per plant, panicles per plant, test weight, grain yield, straw yield

Introduction
Rice is an important and unsurpassed crop. India is regarded as the world's largest producers of brown and white rice thereby accounting for 20% of the whole world's rice production. It is the staple food of the people of eastern and southern parts of the country. India is said to have one of the largest area under rice cultivation. The sowing time of rice is June-July and it is harvested in November. Among the rice growing countries of the world, India has the largest area under rice crop and ranks second in production next to China. Uttarakhand has 0.8 million ha of cultivated area constituting 16% of total geographical area. Over 55% of cultivated area is rainfed with frequent moisture stress to crops. The soils are low to medium in fertility status.
Rice being climatically the most adaptable cereal, it is grown over a large spatial domain and wide range of landscape types. With such a large variation in landscapes and climates in the rice-growing regions of India, a large number of unique paddy farming methods have also evolved, based on farming type (irrigated, rainfed, deepwater), crop management (single crop, multi crop), and seasonality (wet season, dry season). However, production of rice, as for other crops, is beset by constraints such as drought, flooding, salt stress and extreme temperatures, all of which are expected to worsen with climate change. Drastic changes in rainfall patterns coupled with rising temperatures will introduce unfavourable growing conditions (due to drought, flooding, and etc.) into cropping calendars thereby modifying growing seasons which could subsequently reduce crop productivity.
Climate change is one of the important environmental aspects which increase the pressure on Indian agriculture, in addition to the on-going stresses of yield stagnation, land-use, competition for land, water and other resources and globalization. Climate variability is a threat to food production. It will directly affect future food availability and increase the difficulty of feeding the rapidly growing world's population. Long-term climate variability influences sowing date, crop duration, crop yield, and other management practices adapted in rice production.

Review of Literature
Mazid and Ahmad (1975) [15] observed that higher number of panicle per hill, number of grain per panicle and grain yield was found with crop transplanted on 16th June. Significantly higher yield (8.07 t/ha) was found with the crop planted on 30th June whereas delay in planting the yield decreased linearly to the lowest level of 3 t/ha Trivedi and Kwatra (1983) [32]. Akram *et al.* (1985) [1] conducted a field experiment at Kashmir valley with rice *cv.* Basmati revealed that 8th June planted gave significant higher yield than that planted on 24th May, 24th June and 8th July.

Decrease in number of fertile spiklets per panicle and yield due to late planting has been reported by various workers (Dhaliwal, *et al.* 1986 and Roy, 1987) [3, 26]. Ghadeker *et al.* (1988) reported that the crop transplanted on 9th July recorded highest yield (51.02 q/ha) than that transplanted on 25th June. The effect of transplanting dates on rice *cv.* Basmati 385 was recorded highest yield 5.3 t/ha with crop transplanted on 15th June than the crop transplanted on 1st June, 16th July and 15th August. Li *et al.* (1989) studied photosynthetic characteristics of the plant population of rice hybrid Shanyou 63, they reported that early planted crop received more amount of light and yield was closely correlated with amount of light received. Reddy and Ghosh (1989) [24] reported that delay in planting beyond 13th July resulted in decreased panicle length and grain yield. Gangwar and Ahamedi (1990) [9] recommended planting of rice within June or latest by first week of July when yield attributes and grain yield are highest while delay in planting after first week of July decreased drastically the number of grains per panicle, 1000 grain weight and grain yield. Experiment conducted at DRR, Hyderabad (1990) [6] on traditional scented rice varieties in different dates of planting showed that time of planting significantly influenced the grain yield and 2nd July planting produced significantly higher grain yield of 3.30 t/ha. A reduction in grain yield of 16.0, 22.2 and 34.5 per cent were recorded under 16th July, 31st July and 5th August planting as compared to the yield levels reported under 2nd July planting (AICRIP, 1991). Bali and Uppal (1995) [2] from a field experiment with Basmati rice, reported earlier transplanting on 10th July gave higher grain yield of 5 and 8.6 per cent in 1989 and 1991, respectively as compared to 30th July transplanting. The results of experiments conducted at DRR, Hyderabad during Kharif 1995 [7] indicated that planting on 25th July registered significantly higher grain yield (5510 kg /ha) than planting on 5th and 15th August (DRR, 1995a). Similar study conducted at Pantnagar showed higher grain yield (6230 kg/ha) of rice hybrids (DRRH 1, APHR 2, PA 103 and CRH 1) with 15th July planting. Parihar *et al.* (1995) [22] reported that the crop planted on 15th July gave higher grain yield as compared to both early and late planted crop of 30th June and 30th July respectively. In a field experiment at Waraseoni (MP), Paliwal *et al.* (1996) [20] found that significant reduction in panicle length and grain yield due to delay in transplanting beyond 25th July. On other hand Singh *et al.* (1996) in 4-year field study at Ludhiana with cv. PR 106, showed no effect of different dates of transplanting (16th, 31st May and 16th June) on the ear length of rice. A field experiment conducted at CRRI, Cuttack in 1996-97 showed that rice hybrids PA 103, VRH 4, KMRH 2, and DRRH 1, planted on 22nd July recorded significantly higher grain yield of 3.78 t/ha than that planted on 1st August (3.33 t/ha) and 11th August (3.27 t/ha) (CRRI, 1997). Song *et al.* (1996) [31] conducted an experiment to analyze growth, yield characters, and rice quality by different seeding rate at direct seeding in a paddy field. Two rice cultivars, *Unbongbyeo* and *Milyang 95* were seeded from 26th April to 10th June with 15 days interval. The number of days from seeding to seedling emergence decreased as the seeding was delayed in all cultivars. The period from seeding to heading also decreased linearly as seeding was delayed; degree of decreasing in cultivar *Milyung 95* was higher than cultivar *Unbonghyeo*. As seeding date was delayed, leaf area per tiller, leaf area ratio (LAR) and specific leaf area (SLA) were increased significantly in cultivar *Unbongbyeo*, but leaf area for cultivar *Milyung 95* was higher at early seeding than at late seeding. LAR and SLA were not affected by different seeding dates. The seeding dates for best yield were 25th May for cultivar *Unbongbyeo*, 10th May for cultivar *Milyung 95*. Also 100-grain weight and spikelets m^{-2} were the main factors affecting grain yield in cultivar *Unbongbyeo* and cultivar *Milyung 95*. The results of a field experiment conducted by Om *et al.* (1997) at Kaul in Kharif season of 1993 and 1994 with hybrids ‘ORI 161’ (PHB 71), ‘PMS 2A/IR 31802’ and ‘PMS 10A/PR 106’ revealed that higher panicle weight and grain yield were recorded on 25th June transplanting. They also reported a 10, 3 and 43 per cent, and 11, 5 and 78 per cent increased in grain yield with 25th June transplanting over 15th June, 5th and 25th July in 1993 and 1994, respectively. Singh *et al.* (1997) observed that rice planted on 15th June gave 20.5 per cent higher grain yield than planted on 29th June (27.37 q/ha) owing to 17.8 per cent more productive tillers per m^2, 20 per cent filled grain per panicle and 29 percent grain weight per panicle. Experiment conducted at CSAUA&T, Kanpur on traditional scented rice varieties with different dates of planting showed that the time of planting significantly influenced the grain yield and 5th July planting produced significantly higher grain yield of 36.97 q/ha. The per cent reduction in grain yield of 4.86 and 16.20 were recorded under 20th July and 4th August planting as compared to the yield levels reported under 5th July planting (Singh *et al*., 1997). Kumar *et al*. (1998) [12] from a 2-year field study with rice hybrids ‘PA103’, ‘APHR 2’ ‘DRRH1’ reported significantly higher grain yield (5.1 t/ha) due to early planting (25th July) than the delayed planting (5th and 15th August) during both the years of study. Mahal *et al.* (1999) [14] from a field study at Ludhiana reported that planting on 19th July gave significantly higher grain yield as compared to planting on 5th July and 2nd August. An year round experiment conducted by Naher *et al.* (1999) [17] in Bangladesh with cultivar ‘BR 11’ and ‘BR 14’ revealed that the transplanting dates showed significant differences in grain yield. July planted crop produced higher grain yield than the crop planted in August and September. Patel (1999) found significantly more grain yield with early planting on 15th July than with delayed planting on 30th July and 14th August. Pandey *et al.* (2001) [21] observed that early planting on 20th July resulted in significantly higher grain yield than with delayed planting on 5th and 20th August. Reddy (2002) [25] reported that highest grain yield were recorded on 16th August transplanting and which was significantly superior to 1st and 16th September transplanting. Nayak *et al.* (2003) [18] conducted a field experiment at Bhubaneshwar during wet season of 1999 and 2000 to find out the response of hybrid rice ‘PA6201’ to dates of planting (16th, 31st July and 16th August) reported that a fortnight delay in planting from 16th July reduced the grain yield by 7.6 and 4.5 percent during first year and second year, respectively. One month delay in planting from 16th July reduced the grain yield by 24.3 per cent. The results are in conformity with the findings of Gopain and Saikia (1996) [11] and Kumar *et al.* (1998) [12]. Also, Dixit *et al.* (2004) conduced a experiment on rice hybrid ‘Sahyadri’ at Maharashtra and observed that 25th June planted crop showed significantly highest grain yield (53.22 q/ha) than that planted on 5th, 10th and 15th June. Singh *et al.* (2004) carried out a field experiment on hybrid rice ‘PRH10’ at New Delhi reported that delay on transplanting significantly reduces the yield and yield attributes, timely transplanting on 3rd July led to 8.4 and 19.1 per cent higher grain yield than to crop transplanted on 10th and 17th July, respectively. Verma *et al.* (2004) [33] studied the response of hybrid rice ‘PA 6201’ to date of planting and found that early planting on 20th July produced significantly higher grain yield than late planting on 5th and 20th August. Dongarwar *et al.* (2005) [5] reported that early transplanting on 15th and 30th July resulted significantly higher grain yield 31.29 and 32.61 q/ha, respectively than late transplanting on 15th August (28.40 q/ha).

Material & Methods

The field experiment was conducted at plot number A1, A3 and B7, Norman E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, U.S Nagar (Uttarakhand) during kharif seasons of 2013. Pantnagar is situated in the Tarai belt, at latitude of 29.2°N, 79°E longitude and at an altitude of 243.80 m above the mean sea level. The climate of Pantnagar comprises of sub-humid to sub-tropical with hot dry summers and cool winters. Generally, the monsoon sets in around third week of June and lasts upto September end. The mean annual rainfall is 1433.4 mm. May is the hottest month of the year and temperature generally rises up to 45.5±1.5°C. However, minimum temperature can be low as 1.5±1.0°C in the month of January. A few showers generally occur during the winters and occasionally during the summer. Maximum relative humidity remains in the range of 90-95 percent which is experienced during monsoon season and also during winter season. The meteorological data used for the study (i.e. minimum and maximum temperature, bright sunshine hours, relative humidity, rainfall) were taken from the Meteorological Observatory located at Norman E. Borlaug Crop Research Centre Pantnagar, which is located 18 m away from experimental site. The soil of the experimental site is sandy loam. The soil is moderately dark in colour and moderately well drained. The soils have developed from calcareous medium to moderately low textured material under the predominant influence of tall grasses in moderately well drained conditions. Important physio-chemical properties of experimental soil are given in table 1 below:

Table 1: Physio-chemical properties of the soil of experimental field during 2013

S. No.	Particulars	Values		Method used
		0-15 cm	15-30 cm	
1.	Organic carbon (%)	0.82	0.87	Walkley and Black's method (Jackson, 1973)
2.	Available nitrogen (kg/ha)	218.01	215.93	Alkaline KMnO4 (Subbiah and Asija, 1956)
3.	Soil texture (%) Clay (%)	17.54	18.25	Hydrometer method (Bouyoucos, 1927)
	Silt (%)	61.25	61.67	
	Sand (%)	21.21	20.08	
4.	Textural class	Sandy loam		Triangular method
5.	Field capacity (%)	23.11	23.68	Field method (piper method, 1950)
6.	Wilting point (%)	9.89	10.63	Pressure plate apparatus (Richards, 1954)
7.	Bulk density, moist (g/cm3)	1.45	1.48	Core method (Richards, 1954)
8.	Extractable P_2O_5 (kg/ha)	76.17		-
9.	Extractable K_2O (kg/ha)	141.12		-

The variety of rice selected for the experiment was Sarju 52. The maturity period of the selected cultivar is 130-133 days. The plants are generally dwarf up to 98 cm, erect, green and with medium foliage. Grains are long, bold and white in colour. It is most suited for irrigated regions. It generally gives yield of 50-55 q/ha. The nursery was sown by dry method at three different sites. The seed beds were flooded on alternate days. The nursery was regularly inspected for pest and disease infection. The nursery bed was irrigated before uprooting in order to make the soil soft so that on pulling the seedlings one by one the root should not damage. The roots of uprooted seedlings were then washed to remove the mud. Harrowing of field was done a week before transplanting. Layout was made with proper spacing and bunds. Transplanting was done 21 days after nursery sowing. A day before transplanting, the field was flooded with water and puddled on the following day. A thin film of water was maintained in the field during transplanting upto seedling establishment. About a week after transplanting, missing plants were re-transplanted by gap filling. The crop was transplanted at three different transplanting dates i.e. 26th June, 2nd July and 11th July 2013 with five replications in a randomized block design. Nitrogen (100 kg/ha), Phosphorus (45 kg/ha) and Potassium (60 kg/ha) was applied in the form of urea, single super phosphate and muriate of potash (MOP) respectively. MOP and SSP were applied at transplanting. Urea was applied 50% after 15 days of transplanting, 25% at panicle initiation and remaining 25% at flowering stage. Table 2 given below depicts the experimental detail:

Table 2: Experimental detail

S. No.	Treatment	
(A).	Date of sowing	26th June
		2nd June
		11th July
(B).	Varieties	Sarju-52
(C).	Details of layout	
1. Design used	Random block design	
2.	No. of replications	5
3.	Dates of sowing	3
4.	Variety	1
5.	Treatment combinations	3
6.	Total no. of plots	15
7.	Spacing	20×20 cm

After the rice was transplanted in the main field the herbicide and insecticide spray was done to save the crop from the attack of insects and pests. The chemical used and its amount that was sprayed in the field is mentioned below in Table 3:

Table 3: details of chemical application

S. No	Plot No.	Area (ha)	Herbicide				Insecticide	
			Butachlor	Dated	Nomeeni gold	Dated	Triazophos	Dated
1.	A1	2.5	6.5 litre	20-7-2013	400 ml	25-7-2013	2.5 litre	02-09-2013
2.	A3	5.0	15.0 litre	10-7-2013	1000 ml	19-7-2013	6.0 litre	31-08-2013
3.	B7	1.5	4.0 litre	29-6-2013	-	-	1.5 litre	02-09-2013

Manual weeding was done regularly during crop growth. When crop attained the phase of maturity and 90% of the panicle was ripened, the crop was harvested manually. Threshing was done with the help of thresher the day after harvesting.

Observation recorded

For the purpose of recording observations, ten plants were randomly selected from each replication. Observations were recorded on per plant basis. Methods of recording observations on various traits includes i) the number of effective tillers was recorded by taking the number of shoots from each replication at maximum tillering stages, ii) total number of grains found in a single tiller of the tagged plants were counted and then averaged iii) total number of panicles for each tagged plant were counted and then averaged. Also the number of panicle was determined in per meter square area of each plot iv) the weight of 1000 grains of field crops. The samples were collected randomly from the cleaned grains of each plot and 1000 grains were taken. With the help of electronic balance, weight of these 1000 grains were recorded in grams and expressed as test weight v) Biomass yield (q ha^{-1}), after harvesting the total plant biomass obtained from each plot bundled, labelled and sun dried in the field for almost five days. Bundle of every net plot was weighed to get biomass yield value in kg m^{-2}, which was later converted into the unit of kg ha^{-1} vi) Grain yield (kg ha^{-1}) or economic yield after threshing the whole produce the grain yield obtained from each plot was weighed in kg m^{-2} and then converted to kg ha^{-1} for recording data. vii) Straw yield (kg ha^{-1}) is obtained by weighing the plant bundle that is left behind after threshing of the grains. Straw yield per plot was found by subtracting the grain yield per plot from biomass yield of the respective plot.

The experimental data was analyzed by using analysis of variance technique in randomized block design. The critical difference at 5 percent of probability were calculated for testing the significance of difference between any two means wherever F test was significant (Snedecor and Cochran, 1967).

Results and Discussion

The observations recorded on different growth and development characters in the present investigation. Some of the parameters considered in the present study are: i) the number of effective tillers was recorded by taking the number of shoots of ten randomly selected plants from each replication at maximum tillering stages, ii) total number of grains found in a single tiller of the tagged plants were counted and then averaged iii) total number of panicles for each tagged plant were counted and then averaged. Also the number of panicle was determined in per meter square area of each plot iv) the weight of 1000 grains of field crops. The samples were collected randomly from the cleaned grains of each plot and 1000 grains were taken. With the help of electronic balance, weight of these 1000 grains were recorded in grams and expressed as test weight v) Biomass yield (q ha^{-1}), after harvesting the total plant biomass obtained from each plot bundled, labelled and sun dried in the field for almost five days. Bundle of every net plot was weighed to get biomass yield value in kg m^{-2}, which was later converted into the unit of kg ha^{-1} vi) Grain yield (kg ha^{-1}) or economic yield after threshing the whole produce the grain yield obtained from each plot was weighed in kg m^{-2} and then converted to kg ha^{-1} for recording data. vii) Straw yield (kg ha^{-1}) is obtained by weighing the plant bundle that is left behind after threshing of the grains. Straw yield per plot was found by subtracting the grain yield per plot from biomass yield of the respective plot. A Table 4 shows all these parameters as below:

Table 4: Yield and yield attributes as affected by different dates of transplanting

Treatments→ Dates of transplanting↓	Total above ground dry weight per plant (gm)	Number of tillers per plant	Number of panicles per plant	Number of grains per panicle	Number of grains per plant	Test weight (g)
26th June	54.04	19.26	11.24	162.38	1310.60	23.46
2nd July	48.85	16.68	10.42	151.54	1288.80	21.94
11th July	47.42	16.54	9.28	146.24	1238.40	20.55
SEm±	0.28	0.47	0.11	4.73	3.10	0.70
CD at 5%	0.94	1.55	0.35	15.44	10.11	2.28

As it can be seen from the table that the number of tillers per plant of rice as affected by dates of transplanting. The effect of transplanting dates was significant with respect to number of tillers per plant. Transplanting done on 26th June 2013 was found to have more number of tillers per plant (19.26 in 2013) which was significantly higher than 2nd July transplanted crop (16.68), while less number of tillers were recorded with crop transplanted on 11th July (16.54). Number of tillers per plant decreased as the transplanting was delayed. The number of tillers per plant at maximum growth stages was significantly superior with the crop transplanted on 26th June followed by 2nd July and 11th July transplanting. The number of tillers per plant decreased with delayed transplanting. Similarly, the effect of different transplanting dates was found to be significant with respect to number of panicles per plant. The number of panicles per plant decreased as transplanting was delayed. 26th June transplanting recorded significantly more number of panicles per plant (11.24) than 2nd July transplanting (10.42), while with the crop transplanted on 11th July recorded, less number of panicles per plant (9.28). The effect of transplanting dates was significant with respect to number of panicles per plant during the experimental year. The crop transplanted on 26th June was found to have more number of panicles per plant which was significantly superior then 2nd July and 11th July transplanted crop. Number of panicles per plant decreased as the transplanting was delayed. Effective number of tillers per plant was responsible for number of panicles per plant which was more with timely transplanted to be significant with respect to number of grains per panicle. The crop transplanted on 26th June was found to have more number of grains per panicle (162.38) which was significantly superior over 2nd July transplanted crop (151.54), whereas less number of grains per panicle were recorded with the crop transplanted on 11th July (146.24). The number of grains per panicle decreased as the transplanting was delayed during the year 2013. It is possible due to the competition for limited assimilates, supplied by poorly developed canopy. The delayed transplanting might have resulted in high temperature resulting in improper grain development in panicle with significantly lower number of grains per panicle. Gangwar and Ahmadi (1990) [6] also reported that delay in transplanting has resulted in lesser number of grains per panicle. Also the influence of different dates of transplanting was found to be non-significant with respect to number of grains per plant. The crop transplanted on 26th June was found to have more number of grains per plant (1310.60) which was superior over 2nd July transplanted crop (1288.80), whereas less number of grains per plant were recorded with the crop transplanted on 11th July (1238.40). The number of grains per plant decreased as transplanting was delayed. The number of grains per plant decreased as the transplanting was delayed. The late planting on 11th July might have exposed the crop to relatively more adverse environmental condition in term of water stagnation at the tillering phase, low temperature at the reproductive phase and more infestation of insect pests and diseases which might have resulted in less number of grains per plant as compared to earlier planting. Delay of transplanting reduced rice yield has also been reported by Om *et al.* (1997). Different transplanting dates significantly altered the test weight of grains. Test weight decreased during the year 2013 as the transplanting was delayed. Crop transplanted on 26th June recorded significantly higher test weight (23.46) followed by 2nd July transplanting (21.94) while the test weight was found to be lowest with the crop transplanted on 11th July. The test weight (g) of 1000 grains decreased during the year 2013 as the transplanting was delayed. The delayed transplanting caused poor vegetative growth probably due to high temperature during early vegetative phase. Low LAI in association with low photosynthetic rate (Meena, 2009) [16] caused poor canopy development thereby limiting assimilate availability for development of grains resulting in reduced grain size with delayed grain sowing. Table 5 depicts the grain yield, straw yield and biological yield obtained during the study:

Table 5: Effect of transplanting dates on grain yield (kg/ ha), straw yield (kg/ha) and biological yield (kg/ ha) of rice crop

Treatments→ Dates of transplanting↓	**Grain yield (kg/ ha)**	**straw yield (kg/ ha)**	**biological yield (kg/ ha)**
26th June	4939	5222.60	10161.58
2nd July	4673.8	4801.40	9475.24
11th July	3450	3873.80	7323.78
SEm±	18.62	40.43	189.61
CD Value	60.73	131.87	618.36

The grain yield of rice was significantly influenced by different dates of transplanting. The highest grain yield (4939.0 kg / ha) was recorded with crop transplanted on 26th June which was significantly higher than the crop transplanted on other two dates. The lowest grain yield (4673.8 kg/ha) was recorded with 11th July. Grain yield decreased as transplanting was delayed. Grain yield (kg/ha) recorded with crop transplanted on 26th June was significantly higher than the crop transplanted on 2nd July. The lowest grain yield was recorded with 11th July transplanted crop. Grain yield decreased as the transplanting was delayed during the experimental year. The loss in grain yield due to delay in transplanting has been reported by Mahal *et al.* (1999) [14]. As far as the effect of transplanting dates with respect to straw yield is concerned, 26th June transplanting recorded significantly higher straw yields (5222.60 kg/ ha) followed by 2nd July transplanting (4801.40 kg/ ha). The lowest straw yield was observed with 11th July transplanting (3873.80 kg/ ha). Straw yield also decreased as the transplanting was delayed. The reduction in straw yield can be attributed to the reduction in the number of tillers due to delayed transplanting. Similar findings were also reported by Dubey *et al.* (2008) [8]. The effect of transplanting dates on biological yield was significant during the year 2013. The crop transplanted on 26th June recorded significantly higher biological yield (10161.58 kg/ ha) followed by 2nd July transplanting (9475.24 kg/ ha), whereas the biological yield recorded with 11th July sowing was the lowest (7323.78 kg/ ha). Biological yield decreased as the transplanting was delayed. This may be due to number of tillers which showed significant reduction due to delayed transplanting. These findings are in conformity with the findings of Ram *et al.* (2004).

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