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Effects of Genotype and Planting Time on Phenology and Performance of Rice (*Oryza sativa* L.)

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To judge the impacts of climate change on rice phenology and performance in terms of grain and above ground biomass yield, a field experiment was conducted under semiarid condition of Kanpur, to know the response of prevailing environments and their interaction with photosensitive genotypes (mahsoori) and photoinsensitive (Ashwani and Pant - 4). This study proved that the first year was more favorable for growth and development and the first year crop produced more biomass. Moreover second year was better for economic produce (grain yield) probably due to the congenial environmental conditions during reproductive phase. Maximum thermal time requirements (TTR) were recorded during first year. Maximum was for the period between sowing to tillering (1142.4 heat units) under first date of transplanting and minimum (486.5 heat units) was recorded for period between anthesis to maturity with last date of transplanting. Corresponding maximum thermal time requirements (TTR) for genotype was recorded for Mahsoori for the period between sowing to tillering (1111.5 heat units) during first year. During both the years photo insensitive varieties viz., ashwani and pant-4 proved better. Delay in planting force to advance the maturity significantly, long duration genotype mahsoori recorded maximum plant height 96.9 and 99.6 cm during both the years respectively. 1000-grain weight was not affected significantly by environment however it was recorded significantly differences due to genotypes during second year. Maximum above ground biomass production was recorded during first dates of planting (105.2 and 98.5 q/ha) and genotype mahsoori (106.4 and 97.9 q/ha).Harvest index being a typical genotypic character lest affected by environmental fluctuations, variety ashwani produced boldest seed (28.0 and 28.4 g /1000 seeds) and mahsoori produced cylindrical seeds with lowest seed weight (19.4 and 20.6g.

Keywords: Rice, Phenology, genotypes, climate change, photosensitivity, biomass, yield
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INTRODUCTION

Climate on earth is changing gradually either due to natural processes, external forcing,, persistent anthropogenic changes in the composition of the atmosphere or land use. The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) confirms that the global average temperature increased by 0.74°C over the last 100 years and the projected increase in temperature by 2100 is about 1.8 to 4.0°C. Crop productivity is projected to decrease even by small rise in temperature (1-2°C) at the lower latitudes, especially in the seasonal dry and tropical regions. Global warming poses a potential threat to agricultural production and productivity throughout the world and this might affect the crop yields, incidence of weeds, pests, plant diseases and the economic costs of agricultural production. The reduced length of growing seasons as a result of climatic change is causing detrimental effects on agriculture. If suitable measures are not taken, crop yield could be decreased up to 50 percent by 2050 in South Asia (IPCC 2007). Study conducted at selected places in India to understand the nature

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Table 1. Effects of planting time and genotypes on rice thermal time requirement (TTR) to attained different phenological stages

Treatment	Planting Time							
	First Year				Second Year			
Treatment	15th July	25th July	5th August	CD (5%)	15th July	25th July	5th August	CD (5%)
Tillering	1142.4	1033.2	1004.3	NS	1060.5	1007.0	977.3	36.2
Panicle initiation	605.2	595.0	547.7	NS	542.7	533.0	541.4	NS
Anthesis	578.0	583.7	566.7	NS	570.3	542.5	554.1	NS
Maturity	654.6	600.8	524.6	84.5	600.2	543.0	486.5	17.6
	Varieties							
	First Year				Second Year			
Treatment	Ashwani	Pant -4	Mahsoori	CD (5%)	Ashwani	Pant -4	Mahsoori	CD (5%)
Tillering	1005.1	1063.1	1111.5	43.3	963.3	1009.9	1070.8	50.2
Panicle initiation	530.9	572.3	644.6	NS	439.7	517.2	670.3	52.7
Anthesis	496.5	562.7	668.9	71.3	501.2	538.9	626.9	27.8
Maturity	520.0	620.9	640.0	73.1	490.6	540.8	598.2	20.4

Table 2. Effects of planting time and genotypes on rice growth and development

Treatment	First Year					Second Year				
	LAI (At P.I.)	*Plant ht (cm)	*Shoots /m2	*Dry matter (g/hill)	Days to Maturity	LAI (At P.I.)	*Plant ht (cm)	*Shoots /m2	*Dry matter (g/hill)	Days to Maturity
Planting Time										
15th July	4.21	98.4	290.3	28.25	117	3.40	103.67	289.7	27.16	114.3
25th July	4.26	87.8	283.7	25.50	113	3.29	91.67	283.6	26.74	109.6
5th August	4.22	77.5	278.3	24.89	110	3.17	80.21	269.8	25.61	106
CD (5%)	NS	3.1	6.2	0.94	3.3	NS	9.17	15.0	1.46	3.4
Varieties										
Ashwani	4.23	82.8	286.7	25.51	100.1	3.38	84.21	283.1	24.54	98.3
Pant- 4	4.16	83.9	280.6	24.36	113	3.31	88.15	261.5	22.86	109.7
Mahsoori	4.29	96.9	285.6	28.81	126	3.61	99.64	274.1	26.91	122
CD (5%)	NS	5.4	NS	2.12	3.6	NS	8.03	NS	2.14	5

and magnitude of yield gains and losses of important crops exposed that integrated impact of rise in temperature and CO_2 concentration on crops yield may be negative. It is estimated that 2°C increase in air temperature could decrease rice yield by about 0.75 tons ha^{-1} in high yielding areas. There is 5% decrease in rice yield for every 1°C rise in temperature above 32 °C (FAO 2009). Rice is staple food for South East Asian countries including India; this region itself is consuming almost 90% of rice production. India is the second largest rice producer in world following by China. Rice *(Oryza sativa* L) is known as miracle crop and responding well due its unique adoptability to diverse agro-ecological / climatic situation. It is its unique capacity to adopt in any situation. Present day rice is grown from tropics to temperate condition, below sea level in Kerala to above 5000 M in Nepal and handsomely adopted to problematic soils viz. acidic to saline alkaline. Being one of the most important cereals, everyday rice is sown and harvested in the global village. World vide rice is grown on about 145 million hectares with a production of 600 million tones. In India area under rice cultivation ranges 38 to 43 million hectares with a productivity of 2.6 ton/ha only. Further, our rice productivity with other producer viz., Egypt, Korea, Japan, Australia and China our productivity is not very satisfactory. The state of low productivity coupled with climate change poses the challenge among the scientist to find out the causes and ways to remove them. (Singh *et al.* 2009).

Rice interacts well with existing environment. Planting time and selection of variety may play the deciding role in performance of rice, hence choice of correct variety and selection of right time for transplanting under particular agroclimatic condition call for success of rice production under changes climatic scenario. Plant growth and development indicated by various phenological stages viz., tillering, panicle initiation, anthesis and maturity. Thermal

Table 3. Effects of planting time and genotypes on rice yield attributes of rice

Treatment	First Year					Second Year				
	Panicle /m2	Panicle length (cm)	Rachilae/ panicle	Grain wt/ panicle (g)	1000-seed wt (g)	Panicle/m2	Panicle length (cm)	Rachilae/ panicle	Grain wt/ panicle (g)	1000-seed wt (g)
Planting Time										
15th July	236.3	22.88	10.21	2.48	24.9	245.4	23.55	11.28	2.63	25.11
25th July	228.1	22.28	10.11	2.40	24.7	233.2	22.91	10.70	2.55	24.89
5th August	216.7	21.15	9.67	2.29	24.5	223.8	21.81	9.92	2.48	24.21
CD (5%)	6.2	NS	0.37	0.07	NS	9.8	1.29	1.25	0.15	NS
Genotypes										
Ashwani	238.4	22.37	10.15	2.51	28.0	251.8	22.95	11.18	2.73	28.4
Pant -4	235.7	21.79	9.98	2.38	26.8	239.4	21.55	10.68	2.58	26.9
Mahsoori	211.7	21.14	9.60	2.28	19.4	221.5	23.77	10.04	2.42	20.6
CD (5%)	10.4	NS	NS	0.10	0.7	13.01	NS	1.01	0.14	2.6

Table 4. Effects of planting time and genotypes on above ground biomass and grain yield of rice

Treatment	First Year				Second Year			
	Above Ground Biomass (q/ha)	Grain Yield (q/ha)	Stover Yield (q/ ha)	Harvest Index (%)	AGBM (q/ ha)	Grain Yield (q/ ha)	Stover Yield (q/ ha)	Harvest Index (%)
Planting Time								
15th July	105.2	36.1	69.1	34.3	98.5	39.6	58.8	40.7
25th July	97.1	33.8	63.1	34.7	87.0	33.4	53.6	38.8
5th August	82.9	28.0	54.1	34.0	78.8	30.1	48.7	40.0
CD (5%)	2.8	1.8	4.4	NS	5.3	3.2	6.4	NS
Genotypes								
Ashwani	94.4	37.4	61.5	39.6	89.4	39.3	50.1	44.1
Pant -4	84.3	32.9	56.6	39.0	77.7	35.2	42.6	46.3
Mahsoori	106.4	27.6	68.7	25.9	97.1	28.7	68.5	29.9
CD (5%)	6.0	2.4	2.8	2.2	10.8	3.4	10.6	6.3

time requirements (TRR) play a fundamental role in crop phenology and successful completion of life cycle. Prevailing weather conditions play a vital role in the performance of any crop including rice crop. Low temperature during active vegetative phase may result poor tillering and less productive tillers. Similarly during reproductive phase higher temperature coupled with speedy wind may cause poor setting of seed, consequently leads to pitiable harvest (Singh and Singh 2007). In rice, grain yield is a polygenic trait which shows higher magnitude of interaction variance.

To know the impact of imminent climate change on rice, present study was conducted at Kanpur (26 °.29' N 80° 18 E) located in semi-arid climatic zone of Uttar Pradesh.

MATERIALS AND METHODS

Field experiments were carried out in the Department of Agronomy, C S A University of Agriculture and Technology, Kanpur during kharif season to know the cause and effect relationship between environment and genotype under semi arid conditions. The trial was conducted in a medium fertile sandy loam soil with status with pH value of 7.7. Experiment was laid down in split plot design (SPD) with four replications, keeping environment (planting time i.e. 15th July, 25th July and 5th August) in a main plot to match with changing climate and genotypes (i.e. varieties ashwani, pant 4 and mahsoori) in sub plot. In this experiment three micro environments viz. planting times early, middle and late were compared with three leading genotypes having different maturity groups i.e. early (Ashwani) medium (pant 4) and late Mahsoori. Most importantly first two varieties are photo-insensitive in nature (Under normal conditions these genotypes switchover to reproductive phase after certain period of time), whereas Mahsoori is photosensitive, which flower only when appropriate photoperiod is available.

Transplantation of seedling to the main field was done at the age of 21 days in each case during both the years. Period up to tillering was taken in to account from nursery sowing. Recommended dose of fertilizers were applied and plant protection measures were taken care as per standard package of practices. Thermal time requirements (TTR) for various phenological stages viz., tillering, panicle initiation, anthesis and maturity was calculated using formula provided by Nagail (1962).

Observations and data were recorded on growth and development parameters viz. leaf area index at panicle initiation stage during vegetative phase, while other parameters were recorded after harvest. Postharvest data were recorded on plant height (cm), shoots/ M^2, dry matter production (g/hill), days taken to maturity. Data on yield attributes viz., panicle length (cm) and panicle grain weight / panicle (g) and thousand seed weight (g) were recorded. Above ground biomass (q/ha), stover yield (q/ha), grain yield (q/ha) and harvest index (%) were also worked out to know the real impacts of both the tested factor under change climate circumstances. This study was carried out under semi arid upland agro-ecosystem to study the interaction impact of leading genotypes of both group (photosensitive and insensitive) with aim to adjust under extend possible planting time. Varying degree of environmental condition were provided for different phenological stages by providing different sets of planting time to all the three varieties under study and the main effects of environment and genotype were presented separately.

RESULTS AND DISCUSSION

Response of rice genotype to its prevailing environmental/weather condition was studied by several workers under different agro-ecosystems with varying degree of interaction magnitudes. To get clear-cut idea on the responses of each component results were discussed in the light of existing scientific know how.

Effect of environmental conditions on performance of rice

Performance of any crops depends on various variables but environmental condition is one of the vital components to make cropping successful and *vice versa*. Under normal weather conditions at Kanpur normal time of rice planting is 15-25 July and planting can be done as early as last week of June and its goes up to first week of August or even further depending upon several factors, environmental conditions being of the them. In this study three normal planting times was selected to study the effect of varying environmental conditions.

Effect of environmental conditions on thermal time requirements (TRR) of rice

Perusal of data presented in table 1 revealed that significant variation were recorded in thermal time requirements (TTR) during both the years in due transplanted time especially from sowing to tillering (second year) and from anthesis to maturity during both the years. Crop transplanted on first date availed more TTR (heat units) than third date from anthesis to maturity and sowing to tillering during second year, but TTR between anthesis and maturity decreased significantly with delay in transplanting. Early planting availing more thermal time requirements (TTR) than delay planting were also reported by (Singh *et al*, 2009) and (Singh and Singh 2007). Erratic response due to variation in transplanting dates may be sign of marked impact of gradual climate change however variation in response during different phenological stages was also reported by Singh and Singh (2007).

Effect of environmental conditions on growth and developments:

Data presented in Table 2 revealed that days taken to complete life cycle (maturity) was reduced with each successive delay in planting in both the years, however first year crops taken more time than second year and early maturity (approximately 3.3 days) was recorded. It might be due to the environmental condition that was not same for both years (Babu1988, Ghadekar *et al*, 1988 and Hariom et *al*, 1997). All the growth and developmental parameters studies were also influenced by varying environments. Each and every parameter were tuned sluggish with delay in planting except leaf area index (LAI), which marginally increased in the second planting dates in the first year, but over all effect was non significant for both the years. Other parameters showed their significant variation with the same trend. Early planting availed more time to complete lifecycle i.e. maturity in both the year (117 and 114 days) , maximum dry matter was produced when crop was planted earlier in both the years 28.25 g and 27.16 g respectively, but maximum plant height was observed (103.67 cm) in the first year at early dates of planting. More leaf area index (LAI) was recorded in the first year in all three environments (table1). Shoots/ M^2 were also recorded maximum 289.7 during first year and at early planting dates. Over all first year and early planting dates prove more congenial to growth and development in comparison to other tested environments (Kulkarni *et al.* 1988, Singh *et al.* 1997 and Yoshida *et al*. 1976).

Effect of environmental conditions on yield attributes:

Perusal of table 3 showed that all the yield deciding components were reduced drastically with (variable environment) each delay in transplanting except panicle length and 1000-seed weight in second year. The entire yield components which were studied performed better during the second year as compared to first year (Table 3). The similar results were also reported by Babu 1988, Ghadekar *et al.* 1988 and Hariom *et al.* 1997 and Kulkarni *et al.* 1988. This result clearly indicates that second year environments were more conducive during reproductive phase while first year was good for vegetative growth i.e. dry matter production.

Effect of environmental conditions on above ground biomass and grain yield:

The foregone discussion suggests that second year environmental condition was much better for grain production than first year which was good for vegetative growth (Table 4). Delay in planting significantly reduced the above ground biomass, grain yield and stover yield but it was more pronounced in second year. The production of above ground biomass an stover yield was more in first year and grain yield and harvest index in second year. Maximum above ground biomass (105.2q/ha) was obtained during first year where as highest grain yield (39.6 q/ha) was recorded in second year at early dates of planting. Similar results were reported by Mazid and Ahmed (1995), Shivraj *et al.* (1991).

Effect of genotypes on performance of rice

Performance of any living organism is governed by two parameters i.e. genetic makeup and prevailing environmental conditions. The role of genotype and its response with environment is discussed briefly.

Effect of genotypes on thermal time requirements (TRR) of rice

Thermal time requirements (TRR) by different genotypes between all the phenological stages were variable in both the years (Table 1). Longer duration genotype Mahsoori availed more TRR (heat units) between phenological stages than medium duration genotypes Pant -4 and short duration Ashwini during both the years. More pronounced variation was recorded during second year (Table 1) Similar findings were also reported by Singh and Singh (2007).

Effect of genotypes on growth and developments:

Genotype behaviors in response to its environments were clearly recorded in this study. Early maturing *ashwani* take less time to attaine maturity (100.1 and 98.3 days) during both the years in comparison to other tested varieties viz. pant -4 (113 and 109.7 days) and *Mahsoori* (126 and 122 days) respectively (Table 2). During second year crops took less time and completed its life cycle in quick succession. As compared to first year, genotype *mahsoori* accumulated maximum dry matter (28.81g and 26.91g/hills) than other genotype under study. However genotype *ashwani* produced more dry matter (25.51 and 24.54 g /hill) than other tested varieties pant - 4 and Mahsoori (24.36 and 22.86g/ hill) during both the year respectively. In general all the growth and development parameters were recorded higher magnitude in first year except leaf area index (LAI) and shoot/ m^2. Other parameter sbows significant differences among the genotypes. Babu (1988), Hariom *et al.* (1997) Kulkarni *et al.*(1988) Singh and Singh (2007) also reported parallel to this finding.

Effect of genotypes on yield attributes

Perusal of data presented in table 3 revealed that genotype *ashwani* produced significantly highest panicle/m^2, grain weight / panicle and 1000 seed weight in both the year and numerically bigher value for other yield determining components, though the quantum was more pronounced in the second year for all most all the yield characters except few traits (Tahles 3). Genotype *ashwani* (28 and 28.4 g) and pant - 4 (26.8 and 26.9 g) has produced significantly higher 1000 - seed weight than long maturing photo sensitive *mahsoori* (19.4 and 20.6 g) during both year respectively (table 3). Most of the parameters had more value for variety *ashwani*. Genotype *mahsoori* proved poor performer under upland semi arid condition being long duration and photosensitive genotype adapted well to low land water regime Venkateswarlu (1976), Singh *et al.* 2007 Hariom *et al.* 1997 and Kulkarni *et al.*1988) .

Effect of genotypes on above ground biomass and grain yield:

Genotype *Mahsoori* produced significantly higher above ground biomass during both the years to the tune of 106.4 and 97.1 q/ha in comparison to other tested varieties viz. *ashwani* (94.4 and 89.4 q/ha) and pant -4 (84.3 and 77.7 q/ha) respectively. Similar trend was also observed in case of stover yield in both the years (table 4). However trend for grain yield was just reverse and genotype *ashwani* significantly outyielded during both the years and produced 37.4 and 39.3 q/ha then other tested varieties viz., pant - 4 (32.9 and 35.2 q/ha) and *mahsoori* (27.6 and 28.7 q/ha). Genotype pant -4 and *ashwani* performed better converters of photosythates to economic produce and due to this their harvest index was 39.0 and 46.3 and 39.6 and 44.1 respectively during both the years which was significantly higher than genotype *mahsoori* (25.9 and 29.9 Perusal of data revealed that the response of all the genotype improved in the second year. It might be due to favorable environmental conditions during reproductive stages as it was also reflected by mean effect. Similar results were reported by by Venkateswarlu (1976), Singh *et al.* 2007 Hariom *et al.* 1997 and Kulkarni *et al.* 1988).

This study proves that second year environmental condition were better for economic produce (grain yield) whereas first year conditions were good for growth and development. In tested genotypes photo insensitive varieties viz. *ashwani* and *pant -4* showed better performance during both the years. Hence for successful cultivation under semiarid conditions, best time is around 10-20 July with high yielding genotype under impending climatic change situation.

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