Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 881-888

Rajan Chaudhari
Department of Agricultural Meteorology, Narendra Deva University of Agriculture & Technology Narendra Nagar, Kumarganj, Faizabad, Uttar Pradesh, India

SR Mishra
Department of Agricultural Meteorology, Narendra Deva University of Agriculture & Technology Narendra Nagar, Kumarganj, Faizabad, Uttar Pradesh, India

Ashish Singh
Department of Agricultural Meteorology, Narendra Deva University of Agriculture & Technology Narendra Nagar, Kumarganj, Faizabad, Uttar Pradesh, India

Devraj Singh
Department of Vegetable Science, Narendra Deva University of Agriculture & Technology Narendra Nagar, Kumarganj Faizabad, Uttar Pradesh, India

Atul Yadav
Department of Horticulture Narendra Deva University of Agriculture & Technology Narendra Nagar, Kumarganj, Faizabad, Uttar Pradesh, India

Correspondence
Rajan Chaudhari
Department of Agricultural Meteorology, Narendra Deva University of Agriculture & Technology Narendra Nagar, Kumarganj, Faizabad, Uttar Pradesh, India

Phenophases effect of variable weather condition on growth and yield of rice cultivars

Rajan Chaudhari, SR Mishra, Ashish Singh, Devraj Singh and Atul Yadav

Abstract
A field experiment was conducted during *kharif season* of 2014 at N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) in sandy loan soil. The experiment consisted of 9 treatment combinations comprised of three transplanting dates *viz*., July 5 (D_1), July 15 (D_2) and July 25 (D_3) and three varieties viz., Sarjoo-52 (V_1), NDR-359 (V_2) and Swarna (V_3). It was observed that different phenophases of rice markedly varied with not only dates of transplanting but also different weather variables which ultimately creates the different crop growing environment to harvest the yield accordingly Among the three varieties it was also observed that different phenophases has taken higher days in V_1 as compare to V_2 and in different days of transplanting It was observed that different phenophases of rice markedly varied with not only dates of transplanting but also different weather variables which ultimately creates the different crop growing environment to harvest the yield accordingly. As panicle initiation during 10-15 Sept (transplanted on July 15) recorded the highest yield as compared to 2–7 September PI stage. Variation in daily mean temperature & solar radiation during reproductive and ripening period also has marked affect. Highest yield to the tune of 48.57 q/ha was obtained when cumulative BSS during panicle initiation to dough phases in the area exist 199 hrs. Heat use efficiency (HUE) at vegetative, reproductive and ripening stage on no. of tillers and effective tillers showed that both effective tillers and total no. of tillers/m^2 increased with increasing HUE in all the growth phases of rice. Among varieties Swarna (V_3) was harvested maximum yield & yield contributing characters in early transplanted environment (D_1) followed by V_2 than V_1.

Keywords: Phenophases, GDD, HUE, LAI, Total dry matter and Yield

Introduction
Rice (*Oryza sativa* L.,) belongs to the family Gramineae, genus *Oryza* and has two cultivated and 22 wild species. The cultivated species are *Oryza sativa* and *Oryzaglaberrima*. *Oryza sativa* is grown all over the world while *Oryzaglaberrima* has been cultivated in West Africa for the last ~3500 years. Most rice researchers agree that the area of *Oryza sativa* is located in a belt extending from the Assam-Meghalaya area in India to mountain ranges in the mainland Southeast Asia and Southwest China. The impact of air temperature on rice growth would be location-specific because of the different sensitivity of different locations with regard to temperature. In tropical regions, the temperature increase due to the climate change is probably near or above the optimum temperature range for the physiological activities of rice [Baker *et al.*, 1992**]**. Such warming will thus reduce rice growth. In addition, higher temperatures will cause spikelet sterility owing to heat injury during panicle emergence. In temperate regions, increased air temperatures should hasten rice development, thereby shortening the time from transplanting (or direct seeding) to harvesting and reducing the total time for photosynthesis yield development ([Neue and Sass, 1994]). To supply to this increasing demand, the methods of rice production will require significant improvement. Achieving this goal, however, is sure to be a challenge with respect to future climatic changes, which will basically be characterized by current global warming trends. The rise in temperatures and levels of carbon dioxide and uncertain rainfall associated with climate change may have serious adverse effects either directly or indirectly on the growth, development, and yield of rice crops ([Lobell *et al.*, 2011]). Among the rice growing countries, India stands first in area and second in production next after China. Uttar Pradesh is largest rice growing state after West Bengal in the country. Rice production in Asia has increased by 2.6 times since 1961, primarily as a result of the "Green Revolution", which dramatically increased the rice productivity in the high input irrigated system (Khush 1997). Weather and climate greatly influence the agricultural productivity in any region. Agricultural production and productivity of any region is being regulated by the prevailing climate of that area through temperature, rainfall, light intensity, radiation, sunshine duration etc. (Goswami *et al.*, 2006).

Temperature is one of the most pivotal environmental factor which effects the growth and development of crop plants particularly phenology and yield (Bishnoi *et al*. 1995). Plants have a definite temperature requirement to attain phonological stages. Among the major plant nutrients nitrogen is the most critical element in crop production including rice (Nachimuthu *et al*. 2007). Rice is very sensitive to higher temperature during reproductive stage especially flowering and anthesis. It is necessary to identify genetic donors for heat stress from high temperature rice growing environments. Temperature stress affects at reproductive stage by adopting three different planting dates with 15 days interval at different temperature regimes from 35.6 degrees C (E1) to 39.2 degrees C (E3) at reproductive stage. The elevated temperature at the time of flowering and maturity determines the yield *per se* of the genotypes. Under high temperature stress, the response of genotypes depended on developmental stage, but highest sensitivity was recorded at reproductive stage. The time of sowing, days to flowering (duration group), heat escape (early morning flowering) and inbuilt tolerance were the crucial factors in determining the performance of genotypes to varying temperature. Hence, it is necessary to select genotypes by keeping in view the above factors for different temperature stress within and across the environment. Raju, N.S. *et al.,* (2013). A combination of these growth variables explains variations in yield better than any individual growth variable (Ghosh and Singh, 1998). Similarly, Thakur and Patel (1998) reported that dry matter production, leaf area index are ultimately reflected in higher grain yield of rice. Lu et al. (1999) obtained higher yield of rice due to higher net assimilation rate and better distribution of leaf area index after heading. For successful rice production, timely planting, appropriate control of vegetative growth throughout the duration of the crop, suitable transplanting densities for optimum tillering and control of leaf growth by controlling water, fertilizer and chemical inputs are essential for improving the growth variables responsible for high yield (Ghosh and Singh, 1998).

Materials and Methods

A field experiment was conducted during *kharif season* of 2014 at N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) in sandy loan soil. The experiment consisted of 9 treatment combinations comprised of three transplanting dates *viz*., July 5 (D_1), July 15 (D_2) and July 25 (D_3) and three varieties viz., Sarjoo-52 (V_1), NDR-359 (V_2) and Swarna (V_3). The experiment was conducted in split plot design (SPD) and replicated the three times. The details of experiment has been described elsewhere Rajan Chaudhari 2015. The different growth parameters studied were measured as Days taken to different phenophases, Leaf area index, Dry matter accumulation (g m^{-2}), Heat use efficiency (g m^{-1} degree $days^{-1}$), Number of effective tillers per hill, Number of grains per spike, Test weight (g), Grain Yield, Straw yield (t ha^{-1}).

Results

Days taken to attain different phenophases of rice cultivars at different days of transplanting have been depicted in table: 1. From table it was revealed that Days taken to attain different phenophases at I^{st} date of transplanting on July5 (D_1) was 30 days after transplanting (DAT) while panicle initiation started at 58 days, 50% flowering at 74 days, milking at 83 days, dough at 92 days and physiological maturity at 102 DAT. At II^{nd} date of transplanting on July15 (D_2), different phenophases *viz.* maximum tillering attained at 26 DAT, panicle initiation at 56 days, 50% flowering attained in 72 DAT while milking and dough was at 80 and91 DAT respectively, followed by physiological maturity which attained in 106 days after transplanting. At III^{rd} date of transplanting on July25 (D_3), for maximum tillering to physiological maturity the days taken to attain different phenophases were lower as compared to the either D_1 or D_2.Quantitatively the values for days taken was 25 DAT for maximum tillering, 51 DAT for panicle initiation, 67 DAT for 50% flowering, 74 DAT for milking, 85 DAT for dough and 95 days after transplanting for physiological maturity.

The days taken to attain maximum tillering for Sarjoo-52 (V_1) was 26 DAT while panicle initiation started at 52 DAT, 50% flowering at 67 DAT, milking at 74 DAT, dough at 84 DAT and physiological maturity at 98 DAT. NDR- 359 (V_2), has taken 24 DAT for maximum tillering, panicle initiation attained at 48 DAT, 50% flowering at 64 DAT, milking at 72 DAT, dough at 82 DAT and physiological maturity at 89 DAT. From maximum tillering to physiological maturity the days taken to attain different phenophases for Swarna (V_3), were more as compared to either V_1 or V_2 as 31 DAT took for maximum tillering against the 26 and 24 DAT for V_1 andV_2. Panicle initiation started at 65 DAT for V_3, 50% flowering at 82 DAT, milking 91 DAT, dough 102 and physiological maturity at 116 DAT.

Growing degree days (GDD) of rice cultivars taken in different phenophases at different days after transplanting (DAT) has been depicted in **table: 2**. From table it was revealed that the value of growing degree days GDD 1939.75^0 days was required from maximum tillering to physiological maturity at I^{st} date of transplanting on July 5 (D_1), while panicle initiation attained 1153.75^0 days, 50% flowering 1448.49^0 days, milking 1672.63^0 days, dough 1785.24^0 days. At II^{nd} date of transplanting on July15 (D_2), requirement of growing degree days to attain different phenophases *viz.* maximum tillering was 507.25^0 days, panicle initiation 1110.75^0 days, 50% flowering required 1278.91^0 days while for milking and dough requirement was 1557.90^0 days and 1739.49^0 days respectively. Physiological maturity required 1942.75^0 days since transplanting and greater than D1. The requirement at III^{rd} date of transplanting on July 25(D_3) was lower than the either D_1 or D_2 for all phenophases except 50% flowering. In 50% flowering D_2 required lowest GDD followed by D_3&D_1.

GDD to attain maximum tillering for Sarjoo-52(V_1), was 487.6^{70} days while panicle initiation attained 1084.7^{50} days, 50% flowering 1318.7^{30} days, milking 1460.7^{30} days, dough 1617.6^{50} days and physiological maturity 1832.0^{80} days**.** At II^{nd} variety NDR-359(V_2), required 468.43^0 days to attain maximum tillering while requirement of GDD for panicle initiation was 940.86^0 days, 50% flowering 1214.64^0 days, milking 1360.68^0 days, dough 1562.42^0 days and physiological maturity 1672.42^0 days. At III^{rd} variety Swarna(V_3), maximum tillering to physiological maturity the GDD requirement to attain different phenophases were more than the either V_1 or V_2. Quantitatively the values were 611.07^0days, for maximum tillering,1311.91^0 days for panicle initiation, 1570.03^0 days 50% flowering, 1866.80^0 days for milking, 2002.90^0 days for dough and 2176.75^0 days for physiological maturity.

Table 1: Days taken to attain different phenophase of rice cultivars at different days after transplanting (DAT).

Treatment	Phenophase					
Date of transplanting	Vegetative stage		Reproductive stage			
	Maximum tillering	Panicle initiation	50(%) Flowering	Milking	Dough	Physiological Maturity
(D_1)	30	58	74	83	92	102
(D_2)	26	56	72	80	91	106
(D_3)	25	51	67	74	85	95
Varieties						
(V_1)	26	52	67	74	84	98
(V_2)	24	48	64	72	82	89
(V_3)	31	65	82	91	102	116

Table 2: Growing Degree Days (GDD) in different phenophases of rice cultivars at different days after transplanting (DAT).

Treatment	Growing Degree Days (GDD) (Degree days)					
Date of transplanting	Vegetative stage		Reproductive stage			
	Maximum tillering	Panicle initiation	50(%) Flowering	Milking	Dough	Physiological Maturity
(D_1)	583	1153.75	1448.49	1672.63	1785.24	1939.75
(D_2)	507.25	1110.75	1278.91	1557.90	1739.49	1942.75
(D_3)	476.92	1073	1376	1457.67	1658.24	1798.75
SEM±	12.11	25.94	31.47	35.29	42.97	47.57
CD (5%)	41.91	NS	108.89	122.11	NS	NS
Varieties						
(V_1)	487.67	1084.75	1318.73	1460.73	1617.65	1832.08
(V_2)	468.43	940.86	1214.64	1360.68	1562.42	1672.42
(V_3)	611.07	1311.91	1570.03	1866.80	2002.90	2176.75
SEM±	10.93	18.71	50.82	28.59	33.63	36.33
CD (5%)	32.48	55.58	150.99	84.94	99.92	107.94

Table 3: Meteorological data in different phenophases of rice cultivars at different days after transplanting (DAT).

Meteorological data in different phenophases of rice cultivars at different days after transplanting (DAT).								
Treatment			Date of transplanting			Varieties		
Phenophases			**(D_1)**	**(D_2)**	**(D_3)**	**(V_1)**	**(V_2)**	**(V_3)**
Vegetative stage	Maximum Tillering	T max (^{0}C)	33.33	33.38	33.82	33.45	33.35	33.67
		T mean(^{0}C)	29.8	29.74	29.79	29.79	29.74	29.30
		Sun shine (hrs)	3.67	3.83	4.84	4.03	3.87	4.44
	Panicle Initiation	T max (^{0}C)	34.60	34.25	33.92	34.21	34.46	33.65
		T mean(^{0}C)	28.35	30.10	29.91	30.07	30.25	29.65
		Sun shine (hrs)	6.04	6.14	5.91	5.82	6.08	5.76
Reproductive stage	50(%) Flowering	T max (^{0}C)	31.75	32.56	33.28	33.16	32.89	32.73
		T mean(^{0}C)	28.45	28.84	29.00	29.23	29.09	28.07
		Sun shine (hrs)	3.93	4.78	6.28	5.86	5.19	5.82
	Milking	T max (^{0}C)	33.77	33.50	33.07	32.45	33.06	31.85
		T mean(^{0}C)	29.38	28.37	27.42	28.07	28.75	26.18
		Sun shine (hrs)	7.11	7.00	6.35	4.99	5.76	6.59
	Dough	T max (^{0}C)	33.44	32.27	27.36	32.40	32.63	30.27
		T mean(^{0}C)	28.13	26.65	22.56	27.34	27.68	24.14
		Sun shine (hrs)	6.94	5.36	4.18	6.1	5.93	5.14
	Physiological Maturity	T max (^{0}C)	31.1	29.66	30.7	31.17	31.87	29.78
		T mean(^{0}C)	25.65	23.55	24.07	25.38	26.34	22.41
		Sun shine (hrs)	4.5	5.23	5.55	5.54	6.07	5.34

Meteorological data in different phenophases of rice cultivars taken in different phenophases at different days after transplanting (DAT) has been depicted in table: 3. From table it was revealed that the value of Variation in daily mean temperature & solar radiation during reproductive and ripening period also has marked affect. Mean temperature 29.5-30 ^{0}C during vegetative stage & 26.6 ^{0}C - 28.8 ^{0}C during reproductive stage was congenial to harvest maximum yield. But 0.5-1. ^{0}C reduction in mean temperature at reproductive stage available at early transplanted environment caused non-significant difference in number of effective tillers, number of grains/spike and test weight over optimum. The average temperature 29 ^{0}C during crop period was congenial to harvest maximum yield. Maximum temperature 32 ^{0}C – 33 ^{0}C during flowering phase was optimum to harvest maximum yield as compared to 31-32 ^{0}C available in early transplanted environment. Cumulative bright sunshine hours (BSS) during flowering to dough phases were linearly correlated with yield and Yield was increased with increase of cumulative BSS hrs. Highest yield to the tune of 48.57 q/ha was obtained when cumulative BSS during panicle initiation to dough phases in the area exist 199 hrs.

Leaf area index (LAI) of rice cultivars at different dates of transplanting has been depicted in table: 4. From table it was revealed that maximum leaf area index (LAI) 4.73was recorded at Maximum leaf area index (LAI) 4.73was recorded at 60 DAT at July 5(D_1), transplanting then after LAI decreased to 3.95 up to 90 DAT. At IInd date of transplanting

on July15(D_2), leaf area index (LAI) was recorded maximum 4.98at 60 DAT higher than D_1. At IIIrd date of transplanting on July25 (D_3), the maximum leaf area index was 4.35 at same 60DAT. LAI in D_3 were lower than the either D_1 or D_2.
Sarjoo-52 (V_1) attained maximum leaf area index (LAI)4.50 at 60 DAT. NDR- 359 (V_2) responses better for LAI at 60 DAT with highest LAI 4.69 as compared to V1. Swarna (V_3), attained higher LAI as compared to V_1& V_2 at all dates of transplanting with maximum value of LAI 4.88at 60 DAT and recorded highest LAI among all varieties under test.

Table: 4. Leaf area index (LAI) of rice different rice cultivars at different dates of transplanting.

Treatment	Leaf area index (LAI)					
Date of transplanting	Days after transplanting (DAT)					
	15	30	45	60	75	90
D_1	0.94	2.02	3.90	4.73	4.58	3.95
D_2	1.05	2.35	4.11	4.98	4.82	4.16
D_3	0.84	2.05	3.58	4.35	4.20	3.63
SEM±	0.02	0.05	0.09	0.19	0.10	0.09
CD (5%)	0.08	0.19	0.34	0.41	0.36	0.32
Varieties						
V_1	0.95	2.12	3.70	4.50	4.35	3.75
V_2	0.98	2.21	3.87	4.69	4.53	3.92
V_3	0.90	2.30	4.02	4.88	4.72	4.07
SEM±	0.01	0.04	0.07	0.09	0.08	0.06
CD (5%)	0.05	0.12	0.21	0.27	0.24	0.20

Total dry matter (g/m^2) of rice cultivars at different dates of transplanting has been depicted in table: 5. From table it was revealed that maximum accumulation of dry matter (g/m^2) at Ist date of transplanting on July5 (D_1), the maximum accumulation of TDM was 871.93 g/m^2, with successive accumulation from 15 DAT to 105 DAT. At IInd date of transplanting on July15 (D_2), maximum accumulation of total dry matter was recorded at 105 DAT & contained 930.12 g/m^2 of dry matter higher than D1. At IIIrd date of transplanting on July25 (D_3), the lowest value of dry matter i. e. 804.68 g/m^2 was recorded at 105 DAT followed by D_1& D_2. Among different dates of transplanting accumulation of total dry matter (g/m^2) in D_2 was highest over D_1 and D_3.
Maximum accumulation of the total dry matter 821.37g/m^2 was recorded in Sarjoo-52 (V_1) at 105 DAT, 868.45 g/m^{2}in NDR-359 (V_2) and927.92 g/m^{2}inSwarna (V_3) respectively. Swarna (V_3) accumulated higher dry matter over V_2& V_1. Among the three varieties the total dry matter (g/m^2) in V_3 was highest as compare to V_2&V_1. From the significant analysis, it was evident that varieties were significant among each other at all dates of transplanting.

Table: 5. Total dry matter (g/m^2) of rice cultivars at different days of transplanting**.**

Treatment	Total dry matter (g/m^2)						
Date of transplanting	Days after transplanting (DAT)						
	15	30	45	60	75	90	105
(D_1)	36.67	132.17	250.17	444.67	699.17	792.67	871.93
(D_2)	39.07	140.57	268.57	478.07	746.57	845.57	930.12
(D_3)	32.53	118.53	228.03	405.53	647.53	731.53	804.68
SEM±	0.94	3.29	5.79	10.44	16.48	18.32	20.15
CD (5%)	3.24	11.38	20.05	36.13	57.04	63.39	69.72
Varieties							
(V_1)	35.20	121.20	235.70	421.70	669.70	746.70	821.37
(V_2)	38.00	132.00	250.50	441.00	694.00	789.50	868.45
(V_3)	35.07	138.07	260.57	465.57	729.57	843.57	927.92
SEM±	0.77	2.81	4.66	8.05	12.57	14.63	16.09
CD (5%)	2.29	8.35	13.85	23.93	37.36	43.48	47.82

Heat use efficiency (HUE) (gm^2/^{0}days) of rice varieties at different days after transplanting has been depicted in table: 6. From table it was revealed that maximum Heat use efficiency HUE (gm^2/^{0}days) 47.6gm^2/^{0}days was recorded at 75 DAT atIst date of transplanting on July 5 (D_1).HUE increased successively from 15 DAT to 75 DAT then after decreased. Heat use efficiency (HUE) gm^2/^{0}days x 10^{-2} possess higher value in D2as compared to D_1 and recorded maximum HUE 50.8 at 75 DAT as compared to 47.6 in D_1 at same DAT. Decreasing pattern of HUE was also observed in D_2 like D_1 at 90 and 105 DAT. At IIIrd date of transplanting on July25 (D_3), the maximum HUE 44.4 was recorded at 75 DAT but was lowest among three dates of transplanting. Increasing pattern of HUE from 15 DAT to 75 DAT was observed in IIIrd date of transplanting like D_1&D_2 but after 75 DAT decreasing behavior of HUE was recorded in the IIIrd date of transplantingD_3too.
Sarjoo-52(V_1), possess maximum Heat use efficiency (gm^2/^{0}days x 10^{-2}), 45.7 at 75 DAT. HUE was increasingly utilized with DAT in V_1up to 75 DAT, then after possess decreasing trend. NDR- 359(V_2), attained highest HUE content 47.4 at 75 DAT with increasing trend from 15 DAT to 75 DAT, then after decreasing behavior was observed up to 90 DAT like V_1. In Swarna (V_3), from 15 DAT to 75 DAT the Heat use efficiency increased & attained highest value 49.8 at 75 DAT. Further, after 75 DAT to 105 DAT, the HUE characteristics were the decreasing trend as incase of V_1&V_2. HUE in variety V_3 recorded highest Heat use efficiency as compared to V_1&V_2 at all DAT's followed by V_2&V_1. From the significant analysis, it was evident that varieties were significant among each other at all dates of transplanting.
Over all it may be concluded that HUE was maximum at 75

DAT when total dry matter maximum and LAI were also maximum *i.e.* dry matter production occurred during reproductive stage may be due to maximum HUE. Hence HUE may be supposed to be simply linked with photosynthetic production during reproductive stage.

Table 6: Heat use efficiency (HUE) (gm^2/degree days) of rice cultivars at different days after transplanting (DAT).

Treatment	**Heat use efficiency (HUE) (gm^2/degree days x 10^{-2})**						
Date of transplanting	**Days after transplanting (DAT)**						
	15	**30**	**45**	**60**	**75**	**90**	**105**
(D_1)	13.0	22.6	28.5	37.3	47.6	45.3	45.0
(D_2)	13.4	23.9	29.8	40.3	50.8	48.9	48.2
(D_3)	10.9	19.6	25.2	34.1	44.4	43.8	42.46
SEM±	0.293	0.507	0.708	0.940	1.216	1.163	1.05
CD (5%)	1.012	1.753	2.451	3.253	4.208	NS	3.65
Varieties							
(V_1)	12.2	20.5	26.4	35.5	45.7	43.5	43.06
(V_2)	13.1	22.3	28.0	37.1	47.4	46.0	44.66
(V_3)	12.1	23.3	29.1	39.2	49.8	49.1	48.24
SEM±	0.219	0.407	0.550	0.733	0.886	0.871	0.86
CD (5%)	0.650	1.209	1.634	2.178	2.632	2.587	2.56

The yield and yield contributing characters of rice cultivars at different dates of transplanting have been depicted in table: 7. From table it was revealed that number of effective tillers/m^2 at Ist date of transplanting on July 5 (D_1), was recorded 535 while number of grains/spike was 181, test weight(g), grain yield (q/ha), straw yield (q/ha) and harvest index (%) were 23.93,45.50,67.95 and 39.95(%). At IInd date of transplanting on July 15 (D_2), number of effective tillers/m^{2}was 555, while number of grains/spike at 186, test weight(24.23g), grain yield 47.77 (q/ha), straw yield 70.81(q/ha) and harvest index 40.26 (%)were recorded. Similarly at IIIrd date of transplanting on July 25 (D_3), the values of number of effective tillers/m^{2}to harvest index (%) were all lower than the either D_1 or D_2. Quantitatively the values were 512 for number of effective tillers/m^2, number of grains/spike was 175, test weight (g) 23.57, grain yield (q/ha) 41.57, straw yield (q/ha) 63.33 and harvest index (%)39.61. From the table it was also observed that different yield and yield contributing characters in D_2 was higher than D_1 and D_3. From the significant analysis, it was evident that among that of transplanting grain yield (q/ha) and straw yield (q/ha)was significant among each other while number of effective tillers/m^2, number of grains/spike, test weight (g) and harvest index (%) were non-significant among each other.

Among the varieties for Sarjoo-52 (V_1) the number of effective tillers/m^2 was recorded510, while number of grains/spike 174, test weight (g) 24.47, grain yield (q/ha) 41.90, straw yield (q/ha) 63.78 and harvest index (%) 39.64. Similarly for variety NDR- 359 (V_2), number of effective tillers/m^2 was recorded 519, while number of grain/spike 171, test weight (g) 25.17, grain yield (q/ha) 44.07, straw yield (q/ha) 66.52 and harvest index (%) 39.84. Similarly IIIrd variety Swarna (V_3), number of effective tillers/m^2 to harvest index (%) were more than the either V_1 or V_2 as number of effective tillers/m^2 573 against the 510 and 519number of effective tillers/m^2 for V_1 and V_2. Number of grain/spike 197 for V_3, test weight (g) was 22.10, lower than V_1 & V_2, grain yield (q/ha) 49.57, straw yield (q/ha) 7180 and harvest index (%) 40.33. Among the three varieties it was also observed that yield and yield contributing characters wear higher in (V_2) as compare to (V_1), variety (V_3) recorded highest yield followed by (V_2) & (V_1). From the significant analysis, among the varieties it was evident that number of effective tillers/m^2, number of grain/spike, test weight (g), grain yield (q/ha), straw yield (q/ha) were significant among each other while harvest index (%) was non-significant among each other.

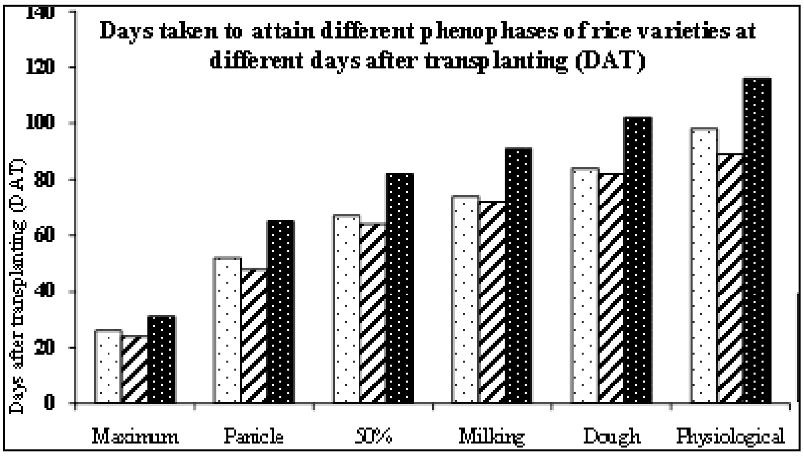
Increasing trend in No. of grains/ spike was directly related to dry matter production during reproductive stage in (D_2) & (V_3) hence harvested better yield. Bright sunshine hours were also directly related during reproductive stage in (D_2) & (V_3) was higher as compared to other dates of transplanting & varieties. This showed that No. of grains/spike or spikelet were more in numbers with test weight causing better yield may be due to reduction in spikelet sterilely too including other factors of physiological importance.

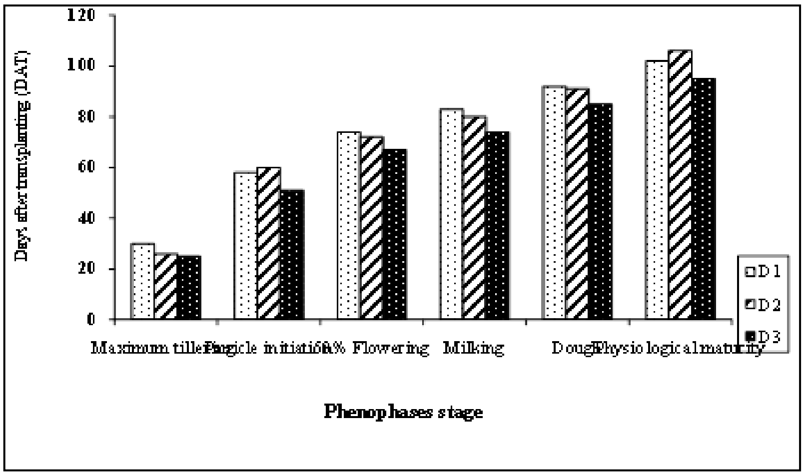
Table 7: Yield and yield contributing characters of rice cultivars at different dates of transplanting.

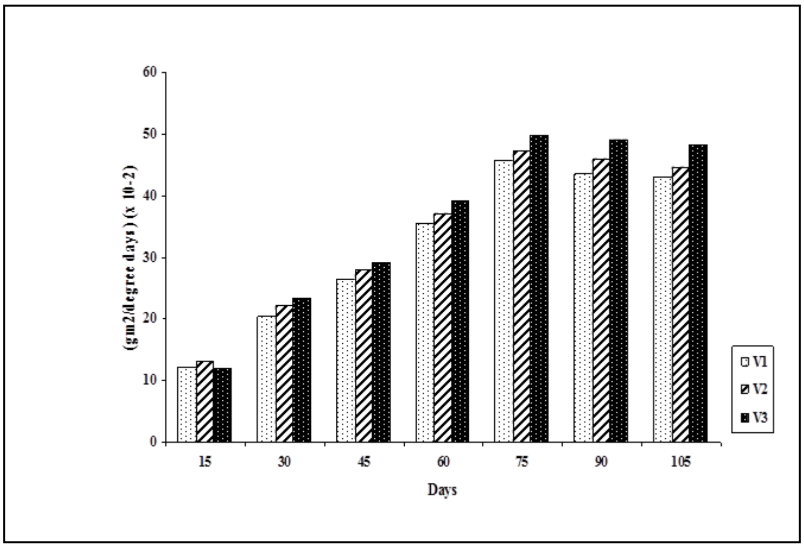
Treatment	**Yield and yield contributing characters**					
Date of transplanting	**No. of effective tillers/m^2**	**No. of grains/spike**	**Test weight (g)**	**Grain yield (kg/ha)**	**Straw yield (kg/ha)**	**Harvest index (%)**
(D_1)	535.00	181	23.93	4550	6795	39.95
(D_2)	555.67	186	24.23	4777	7081	40.26
(D_3)	512.00	175	23.57	4157	6333	39.61
SEM±	12.41	4.70	0.63	1.13	1.56	0.81
CD (5%)	NS	NS	NS	3.92	5.40	NS
Varieties						
(V_1)	510.00	174	24.47	4190	6378	39.64
(V_2)	519.33	171	25.17	4407	6652	39.84
(V_3)	573.33	197	22.10	4857	7180	40.33
SEM±	9.496	3.70	0.46	0.86	1.22	0.55
CD (5%)	28.213	11.00	1.34	2.58	3.64	NS

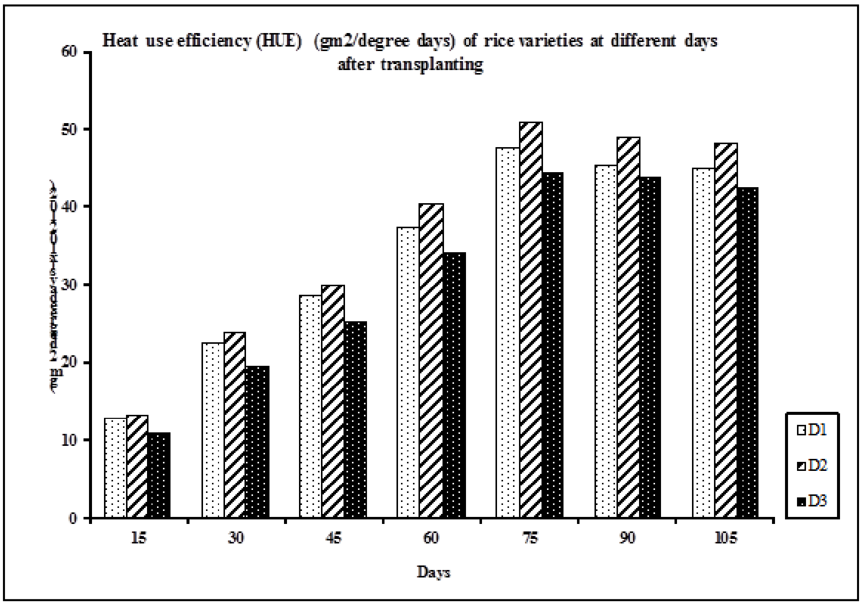
Conclusion

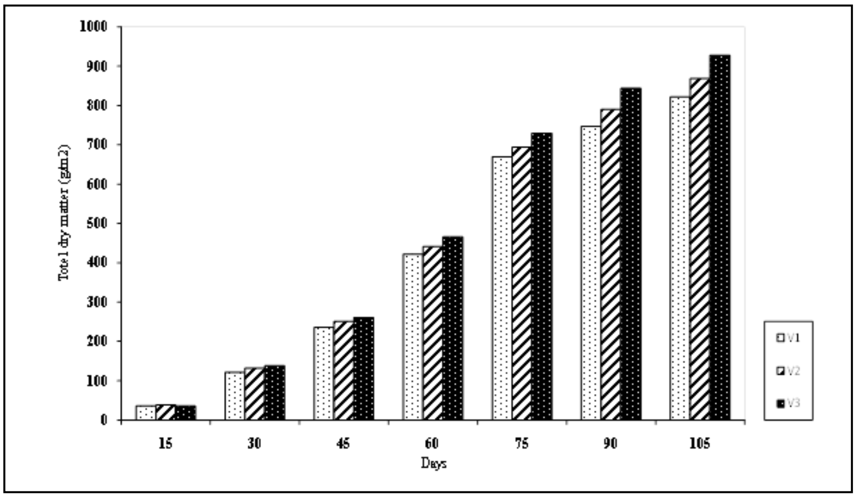
It is concluded that present study in highest yield to the tune of 48.57q/ha was obtained when cumulative BSS during panicle initiation to dough phases in the area exist 199 hrs. Heat use efficiency (HUE) at vegetative, reproductive and ripening stage on no. of tillers and effective tillers showed that both effective tillers and total no. of tillers/m^2 increased with increasing HUE in all the growth phases of rice. Among varieties Swarna (V_3) was harvested maximum yield & yield contributing characters in early transplanted environment (D_1) followed by V_2 than V_1.

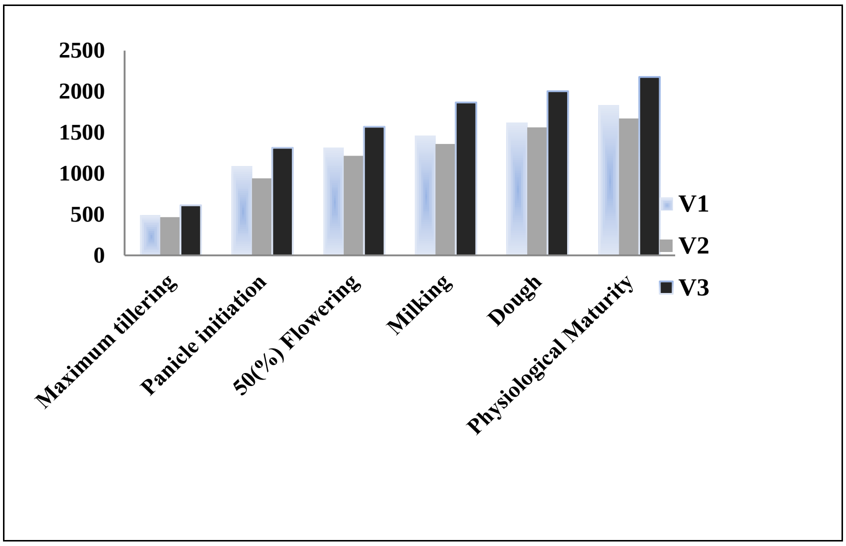












Reference

1. Baker JT, Allen LH, Boote KJ.Temperature effects on rice at elevated CO2 concentration. J Exp Bot. 1992; 43:959-964.
2. Bishnoi OP, S Singh, R Niwas. Effect of temperature on phonological development of wheat (*Triticumaestivum*L.) crop in different row orientation. Indian J. Agric. Sci. 1995; 65:211-214.
3. Goswami B, GS Mahi, US Saikia. Effect of few important climatic factors on phenology, growth and yield of rice and wheat. *J. Agrometeorol*.2006; 27:223-228.
4. Nachimuthu G, V Velu, P Malarvizhi, S Ramasamy, L Gurusamy. Standardisation of Leaf Colour Chart based nitrogen management in direct wet seeded rice (*Oryzasativa* L.). *J. Agron.* 2007; 6(2):338-343.
5. Ghosh DC, Singh BP. Crop growth modeling for wetland rice management. Environ and Ecol. 1998; 16(2):446-

449.
6. Khus GS. Origion, dispersal, cultivation and variation of Plant Mol. Biol. 1997; 35:25-34.
7. Lobell DB, Schlenker W, Costa Roberts J. Climate trends and globalcrop production since 1980. Science 2011; 333:616-620.
8. Lu Q, Jiang D, Weng XY, Xi HF. The effect of potassium nutrition on dry matter production and photosynthesis of different genotypes of rice. J Zhejiang Agric Univ. 1999; 25(3):267-270.
9. Neue HU, Sass R. Trace gas emissions from rice fields. In: Prinn RG (ed) Global atmospheric-biospheric chemistry, Plenum Press, New York. 1994; 19-148.
10. Nuttonsoon MY. Wheat climate relationships and the use of phenology in ascertaining the thermal and photothermal requirements of wheat. American Institute of Crop Ecology, Washington. DC. 1955,388.
11. Raju NS, Senguttuvel P Voleti SR, Prasad ASH, Bhadana VP, Revathi P. Stability analysis of flowering and yield traits to high temperature stress adopting different planting dates in rice (*O. sativa* L.).International Journal of Agricultural Research. 2013; 8(3):137-148.
12. Thakur DS, Patel SR. Growth and sink potential of rice as influenced by the split application of potassium with FYM in inceptisols of eastern central India. J Potassium Res. 1998; 14(1,4):73-77.