



Phenology, Agrometeorological Indices and Yield of Pusa Basmati-1509 as Influenced by Sowing Dates and Nitrogen Levels under Temperate Conditions

Ashaq Hussain¹, Showkat A. Mughal¹, Intikhab Aalum Jehangir^{1*},
M. Anwar Bhat², N. R. Sofi¹, Waseem Raja², N. A. Teli¹, S. Sheeraz Mahdi²
and Latief A. Sofi³

¹Mountain Research Centre for Field Crops, (Shere-e-Kashmir University of Agricultural Sciences and Technology of Kashmir), Khudwani, Anantnag, J&K, 192 102, India.

²Faculty of Agriculture, SKUAST Kashmir, Wadura, Sopore, 193 201, India.

³DARS SKUAST-Kashmir, Budgam, 19007, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i1730557

Editor(s):

(1) Prof. Marco Trevisan, Catholic University of the Sacred Heart Via Emilia, Italy.

Reviewers:

(1) Tumiar Katarina Manik, Lampung University, Indonesia.

(2) G. Udhaya Sankar, Alagappa University, India.

Complete Peer review History: <https://www.sdiarticle4.com/review-history/71545>

Original Research Article

Received 18 May 2021
Accepted 27 July 2021
Published 02 August 2021

ABSTRACT

The purpose of the study was to optimize the sowing date and nitrogen level in early maturing rice (Pusa basmati 1509) under temperate climate for realizing higher yield. The experiment was conducted on silty clay loam soil, neutral in reaction, low in available nitrogen, medium in available phosphorus, potassium and organic carbon. Treatments included three sowing dates viz 20th April, 30th April, and 10th May and five nitrogen levels viz 0, 30, 60, 90 and 120 kg N ha⁻¹ laid out in split plot design with three replications. Among the sowing dates, 20th April took maximum no. days to reach different phenological stages and maturity. The GDD (1431) and HTU (15161 °C d⁻¹ hr⁻¹) requirement to reach maturity was maximum for 20th of April sowing. Significantly higher grain yield, higher HUE (2.90 kg ha⁻¹ °C⁻¹ d⁻¹) and HTUE (0.273 kg ha⁻¹ °C⁻¹ hr⁻¹) was realized from 1st date of sowing i.e., 20th of April. Higher doses of 120 kg N ha⁻¹ resulted in slightly more number of days to reach different phenological stages and maturity that was also reflected in higher

*Corresponding author: E-mail: intikhabaalum@gmail.com;

accumulation of more GDD 1403° and HTU (14987 °C d⁻¹ hr⁻¹) at maturity. Highest HUE (1.42 kg ha⁻¹ °C⁻¹ d⁻¹) and HTUE (0.133 kg ha⁻¹ °C⁻¹ hr⁻¹) was realized at 120 kg N ha⁻¹. Further among the sowing dates, 20th April and 30th April had significantly higher growth parameters viz. plant height, leaf area index, tillers m⁻², dry matter accumulation, leaf area index and SPAD reading as compared to 10th May. Most of the growth and yield parameters were found significantly higher at nitrogen level of 120 kg ha⁻¹. However, most of them were at par with followed by nitrogen level of 90 kg ha⁻¹.

Keywords: Pusa basmati-1509; transplanting dates; nitrogen levels; growth; yield; quality.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important crop in India and staple food for majority of the population. Worldwide, rice is grown on an area of 162.62 m ha [1] with a production and productivity of 503.2 m t [2] and 4.09 t ha⁻¹, respectively. Because of the large number of people subsisting on rice, its annual output should be increased by over 5 × 10⁶ t a year to keep pace with population growth [3]. It provides 32-59 per cent of the dietary energy and 25-44 per cent of the dietary protein in 39 countries [4]. Its cultivation is of prime importance to food security of Asia, where more than 90.6 per cent of global rice is produced and consumed [1]. It accounts for a major share of cereal consumption, ranging from 40% in India to 97% in Myanmar. India ranks first in area (43.77 m ha) and second in production (169.14 m t), only after China, but the productivity of rice is only 3.86 t ha⁻¹ (Patakh et al, 2020). India contributes 21.5 % of global rice production. Within the country, rice occupies 27% of the total cropped area, contributes about 40 to 43 percent of total food grain production, providing direct employment to 70 per cent of rural population. Rice export contributes 25% of the total agricultural exports in the country and basmati occupies a significant position among them. Among the different kinds of rices, basmati rice is characterized by extra-long slender grain, excessive elongation on cooking, soft and fluffy texture of cooked rice and pleasant aroma that make it unique [5]. There are various scented rice varieties, which are being cultivated on a commercial scale in India, e.g. Vasumati, Yamini, Pusa Sugandh 1, Pusa Sugandh 2, Pusa Sugandh 3, Pusa Sugandh 5, Basmati 6, PRH 10, Basmati 370, Ranbir Basmati, Pant Sugandhdhan 15, Sugandhamati, etc.

Recently some new high yielding semi-dwarf basmati varieties like Pusa Sugandh-2, Pusa Sugandh-3 and Pusa Sugandh-5 released by IARI, have been tested at Mountain Research

Centre for Field Crops (MRCFC), Khudwani. These varieties due to their longer duration (165-175 days), either failed to mature or matured as late as 20th October. Slow grain filling, low 1000 grain weight, high sterility, chalkiness and low HRR (<50%) are the problems, when these varieties are sown on the dates recommended for local rice varieties. Recently Pusa basmati 1509, a short duration basmati rice with high yield potential, released by IARI, New Delhi, has given promising results in preliminary studies carried out at MRCFC, Khudwani during 2013. Sowing/planting time is the single most important non-monetary input that influences the crop growth and yield especially in the region having a short growing season. Relatively, higher dose of nitrogen results in increased incidence of insect pest attack and lodging, which lowered yield and quality of Basmati rice [6]. Application of higher doses of nitrogen recommended for non-scented varieties prolongs the vegetative phase of basmati and delays its maturity and increase the incidence of disease, insect infestation and lodging. There is lack of information on agronomic aspects particularly sowing date and nitrogen levels on the yield of this variety under Kashmir conditions. Therefore, the present study was undertaken to evaluate the effect of different sowing dates and nitrogen levels on phenology, agrometeorological indices, heat use efficiency and yield of Pusa basmati 1509.

2. MATERIALS AND METHODS

A field experiment on “phenology, heat use efficiency and yield of Pusa Basmati-1509 as influenced by varied transplanting dates and nitrogen levels under temperate conditions” was carried out at the Mountain Research Centre for Field Crops, Khudwani, SKUAST-K during *Kharif* 2015. The site is situated at 33.74° N, latitude and 75.09° E longitude at an altitude of 1560 m above mean sea level. Thirty-day old seedlings were transplanted on well puddled soil at a hill spacing of 15 x 15 cm with 3 seedlings per hill. The mean meteorological data which recorded

during the cropping season at Meteorological Observatory of SKUAST-Kashmir, were presented in and Fig. 1. Total rainfall received during the experimentation period was 896.6 mm and total sunshine hours were 1164 hours. The mean minimum and maximum temperatures during the cropping season ranged from 6.24° and 32.31°C, respectively. There were heavy and continuous rains from 1st September to 9th September, 2014 and rainfall during this period was 173 mm. The crop during this period was exposed to minimum temperature of as low as 7.4 °C. The soil of the experimental field was silty clay loam in texture, neutral in reaction, low in available nitrogen (235 kg ha⁻¹), medium in available P (18.5 kg ha⁻¹) and K (268 kg/ha). The treatments comprised of three sowing dates viz 20th of April, 30th April and 10th May and five nitrogen levels viz 0, 30, 60, 90, 120 kg ha⁻¹. The design was factorial RBD with three replications. The growth and yield observations were taken using standard procedures. The Growing Degree Days (GDD), Heat Unit Efficiency (HUE), Photo Thermal Units (PTU) and Photothermal Use Efficiency (PTUE) was calculated as per following formulas.

Growing Degree Days (GDD)

GDD was calculated for different phenological-phases using the formula given by Summerfield *et al.* [7]

$$GDD = \sum_{i=1}^n \frac{T_{max} + T_{min}}{2} - T_{base}$$

Where, T_{max} is the maximum temperature
 T_{min} is the minimum temperature
 T_{base} is the base temperature = 10°C for rice

Heat use efficiency (HUE)

Heat use efficiency which indicates the grain yield produced per unit of growing degree days or thermal time. This was computed by using the following formula.

$$HUE = \frac{\text{Grain yield (kg/ha)}}{\Sigma GDD}$$

Helio thermal units (HTU)

The product of the growing degree days and the corresponding actual bright sunshine hours had

been termed as Helio thermal units (HTU) and expressed as °C days⁻¹ hrs⁻¹ [8].

Helio thermal units (HTU) = GDD × Actual bright sunshine hours

Helio thermal use efficiency (HTUE): Helio thermal use efficiency was calculated by dividing the grain yield at respective days by the accumulated helio thermal units and expressed as kg °C days⁻¹hrs⁻¹.

$$HTUE = \frac{\text{Grain yield (kg/ha)}}{\Sigma HTU}$$

3. RESULTS AND DISCUSSION

3.1 Phenology, GDD and HTU

The sowing dates had a significant effect on the number of days to reach various phenological stages. The 20th April sowing took 68, 86, 114, 127, 136 and 148 days to reach mid tillering, panicle initiation, flowering, milking, dough and maturity stages which was significantly higher than later sowing dates (Table 1). Earlier sowing is exposed to lower temperature during early phase of growth that prolongs the time window to reach each phenological stage. These results are in line with the findings of Dixit *et al.* [9]; Safdar *et al.* [10] who reported that panicle initiation and flowering took more days in early sown rice crop. In our study rice crop on an average took significantly more number of days to reach different phenological stages on applying 120 and 90 kg N ha⁻¹ as against the lower levels of 60, 30 kg N ha⁻¹ and control. Higher N rates forced the crop to take a greater number of days for achieving different phenological stages as compared to lower N rates. Delayed flowering with higher nitrogen dose may be due to more vegetative growth, as reflected by increased plant height, LAI, SPAD, which delayed maturity. These results are in accordance with and Haque *et al.* [11]; Abou-Khalifa *et al.* [12] and Mahajan *et al.* [13]. The corresponding effect on GDD accumulation at different phenological stages demonstrated a similar trend, with higher values for earlier dates of sowing. Twentieth April and 30th April sowing dates accumulated significantly higher number of GDDs to reach flowering, milking, dough and harvest as compared to 10th May sowing (Table 2). Since at higher N rates, crop took a greater number of days to reach different phenological stages and that lead to a significant and positive effect on GDD accumulation. Heliothermal unit accumulation, which provides the insight into the plants ability

of expressing changes in duration of phenological stage in response variable ambient temperature expressed an increasing trend at earlier sowing than late sowing. The reason behind this being the greater number of days taken to reach maturity in case of earlier sowing (Table 3). HUE and HTUE increased significantly in case of earlier sowing dates because of significant increase in grain yield (Table 2 and Table 3). Rice plant requires a particular temperature for attaining its phenological stages such as panicle initiation, flowering, panicle exertation from flag leaf sheath and maturity and these are much influenced by the transplanting dates [14]. Temperature is the main driving force for development in photoperiod insensitive genotypes and thus crop duration depends on the genotypic cardinal temperatures such as temperature sum, and base and optimum temperatures [15]. Sowing date primarily influences the length of vegetative period of rice, with early sown rice requiring a greater number of days to accumulate the same number of degree days units compared with later sown rice was also reported by Norman et al. [16]. Though the difference in GDD and HTU among the sowing dates is smaller at maturity but the larger difference between HUE and HTUE was induced due to enhanced grain yield in earlier sowing. The best use of the natural resources is made in case of earlier sowing and that too without any additional cost.

3.2 Growth and Yield Attributes

Earlier sowing on 20th April resulted in taller plants, more leaf area index, higher SPAD and dry matter accumulation as compared to later dates of sowing. Earlier sowing date also resulted in production of higher tiller number than later sowing dates. The possible reason for this improvement in growth and yield attributes of earlier sown crops could be due to synchronization of favorable weather conditions with the critical growth stages. By adjusting the sowing time suitably, the plant can take advantage of natural conditions favorable for its growth [17]. Higher N rate of 120 kg ha⁻¹ resulted in significantly taller plants with higher leaf area index, SPAD, dry matter accumulation and tiller number per unit area. As nitrogen enhances the vegetative growth of plants on account of increased cell division, elongation and meristematic activity [18,19] and Pramanik and Bera [20], which led to the improvement in growth and yield attributes. Furthermore, improvement in LAI and SPAD at higher

application rate of 120 kg N ha⁻¹ could be ascribed to higher leaf N being an important component of chlorophyll. These results were in line with the findings of Tari et al. [21] and Chakraborty [11].

Significantly highest number of panicles m⁻², filled grains panicle⁻¹, 1000 grain weight and lower sterility per cent were recorded for the 20th April sowing whereas lowest panicle number was recorded for the 10th May sowing. Application of 120 kg N ha⁻¹ resulted in a significantly higher number of panicles m⁻², filled grains panicle⁻¹, 1000 grain weight but the same was statistically at par with 90 kg N ha⁻¹. Application of 120 kg N ha⁻¹ resulted in a significantly higher sterility percentage as compared to 90 kg N ha⁻¹. Increased nitrogen application ensures better availability of nitrogen to plants during the tillering period of rice, which might have resulted in more productive tillers and consequently the panicle m⁻². The results are also in conformity with those of Pramanik and Bera [20] and Mahajan et al. [13].

3.3 Grain and Straw Yield

As far as the influence of transplanting dates on grain yield is concerned, it was observed that early sowing on 20th April recorded significantly higher grain and straw yield (Table 4). The increase in grain yield for the 20th April sowing was 12.57 per cent and 27.60 per cent over 30th April and 10th May sowing. This improvement in grain yield of early sown crop can be attributed to coincidence of optimum growing conditions particularly at heading and grain filling stage [22]. However, in case of N levels the increase in the grain yield was significant only up to 90 kg N ha⁻¹. The per cent increase in grain yield due to 120, 90, 60 and 30 kg N ha⁻¹ over control was 58.04, 56.38, 49 and 31.78 per cent, respectively. On the basis of the yield response equation the economic optimum dose of N worked out at 100 kg ha⁻¹ (Fig. 2).

However, N application increased the straw yield significantly up to 120 kg N ha⁻¹ (Table 4). All the yield attributes except the sterility percentage showed a strong and significant correlation with each other (Table 5). Higher grain yield reflected by earlier sown crop might be due to better utilization of heat units in contrast to late sown crop during the entire vegetative and reproductive phases of plant growth. The final yield being the product of panicles m⁻², grains panicle⁻¹ and 1000 grain weight are directly related to each other.

However, sterility being a negative yield attribute has demonstrated a negative correlation with the grain yield.

3.4 Relationship between Grain Yield and GDD

The GDDs accumulated at mid tillering, panicle initiation, flowering, milking, dough and maturity were plotted against the grain yield (Fig. 3). From the plots it was observed that GDD accumulated at milking stage had a strong and significant relationship with the grain yield followed by flowering, Panicle initiation, dough and tillering. However, the cumulative GDD at maturity though significant but was weaker as compared to preceding phenological stages. Similar trend was reflected by the relationship between HTU and

grain yield (Fig. 3). Furthermore, regression analysis revealed over 87 % variation in the grain yield owing to accumulation of GDD and HTU at milking stage (Figs. 3 & 4), indicating that accumulation of GDD and HTU at reproductive stage is more important as against vegetative and maturity stage. Incessant rains and delayed maturity resulted in cold stress in the latter date of sowing that lowered the grain yield. At the same time there was accumulation of GDD and HTU units that actually did not result in any yield improvement. This resulted in a weaker correlation between grain yield and GDD and HTU. The heat use efficiency was higher in early sown crop and at higher level of N application. Photothermal use efficiency demonstrated a similar trend. Similar results have been reported by [23].

Table 1. Effect of transplanting dates and nitrogen levels on days taken by rice crop to reach different phenological stages

Treatment	Mid tillering	Panicle initiation	Flowering	Milking	Dough	Harvesting
<i>Sowing dates</i>						
20 th April	68	86	114	127	136	148
30 th April	63	82	111	125	133	144
10 th June	63	81	108	120	128	138
SEm±	0.15	0.08	0.07	0.10	0.11	0.14
C.D (p≤0.05)	0.30	0.16	0.14	0.19	0.23	0.28
<i>Nitrogen levels (kg ha⁻¹)</i>						
Control	63	80	112	124	132	143
30	64	81	113	125	133	143
60	64	83	114	126	134	144
90	65	83	115	127	134	144
120	66	85	116	129	135	145
SEm±	0.19	0.10	0.09	0.14	0.15	0.18
C.D (p≤0.05)	0.39	0.21	0.19	0.23	0.30	0.37

Table 2. Effect of transplanting dates and nitrogen levels on GDD accumulation at different phenological stages

Treatment	Mid tillering	Panicle initiation	Flowering	Milking	Dough	Maturity	HUE (kg ha ⁻¹ °C ⁻¹ d ⁻¹)
<i>Sowing dates</i>							
20 th April	492	808	1183	1298	1363	1431	2.90
30 th April	488	780	1159	1284	1354	1392	2.60
10 th June	444	738	1129	1268	1332	1365	2.20
SEm±	1.09	1.05	1.23	0.63	0.48	0.54	0.032
C.D (p≤0.05)	4.34	4.20	4.91	2.50	1.91	2.16	0.128
<i>Nitrogen levels (kg ha⁻¹)</i>							
Control	460	743	1131	1258	1340	1391	1.42
30	468	761	1147	1277	1346	1392	2.09
60	473	778	1159	1287	1351	1396	2.78
90	482	791	1169	1293	1355	1397	3.25

Treatment	Mid tillering	Panicle initiation	Flowering	Milking	Dough	Maturity	HUE (kg ha ⁻¹ °C ⁻¹ d ⁻¹)
120	491	803	1178	1303	1358	1403	3.29
SEm±	1.85	1.79	2.09	1.07	0.82	0.92	0.054
C.D (p≤0.05)	5.61	5.42	6.34	3.23	2.47	2.79	0.165

Table 3. Effect of transplanting dates and nitrogen levels on HTU accumulation at different phenological stages

Treatment	Mid tillering	PI	Flowering	Milking	Dough	Maturity	HTUE (kg ha ⁻¹ °C ⁻¹ d ⁻¹)
<i>Transplanting dates</i>							
20 th April	3486	10288	13011	14448	14791	15161	0.273
30 th April	3547	10098	13137	14338	14774	14869	0.244
10 th June	3589	9857	13246	14194	14641	14791	0.203
SEm±	9.85	10.37	15.75	9.10	4.36	4.82	0.003
C.D (p≤0.05)	39.40	41.48	63.02	36.42	17.44	19.30	0.012
<i>Nitrogen levels (kg ha⁻¹)</i>							
Control	3521	9870	13011	14094	14691	14901	0.133
30	3586	9975	13137	14275	14720	14916	0.195
60	3636	10097	13246	14356	14741	14941	0.260
90	3711	10208	13287	14412	14758	14958	0.304
120	3791	10254	13403	14495	14767	14987	0.308
SEm±	19.42	17.67	26.85	15.52	7.43	8.22	0.004
C.D (p≤0.05)	58.85	53.55	81.36	47.03	22.52	24.92	0.015

Table 4. Effect of sowing dates and nitrogen levels on growth, yield attributes and yields of Pusa Basmati 1509

Treatment	Plant height at harvest (cm)	Leaf area index	SPAD reading	Tiller number m ⁻²	Dry matter accumulation (q ha ⁻¹)	Filled grains panicle ⁻¹	Sterility (%)	1000-grain weight (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
<i>Transplanting dates</i>										
20 th April	88.68	4.42	41.32	348.3	94.07	72.70	23.23	24.68	4.15	6.72
30 th April	86.18	4.25	39.45	333.0	90.73	63.80	28.06	23.51	3.63	6.48
10 th June	82.16	2.63	38.10	365.3	81.75	51.09	33.23	20.67	3.01	6.18
SEm±	0.59	0.04	0.72	3.5	1.22	0.61	0.68	0.26	0.10	0.06
C.D. (p≤0.05)	2.41	0.17	N S	14.1	4.74	2.37	2.66	1.09	0.39	0.23
<i>Nitrogen levels (kg ha⁻¹)</i>										
Control	79.3	3.23	36.54	308.3	80.31	57.03	26.53	21.73	1.99	6.01
30	82.71	3.63	38.93	329.1	85.42	60.84	26.82	22.83	2.91	6.22
60	86.98	3.86	39.93	354.7	89.28	62.48	27.60	23.16	3.90	6.33
90	88.99	3.98	40.88	363.2	93.51	65.99	28.63	24.01	4.56	6.83
120	90.37	4.12	41.82	368.1	95.72	66.32	29.47	25.69	4.62	7.04
SEm±	0.37	0.04	0.26	2.4	0.71	0.54	0.64	0.27	0.06	0.03
CD (p≤0.05)	1.09	0.13	0.77	7.1	2.13	1.56	1.87	0.80	0.17	0.10

Table 5. Correlation matrix between growth, yield attributes and yield of Pusa Basmati 1509 in the backdrop of varied sowing dates and N levels

	Grain yield	Straw yield	Tillers /hill	LAI	SPAD	Dry matter accumulation	Panicle length	Panicle weight	Spikelets /panicle	Filled grains /panicle	Sterility %age	1000-grain weight
Grain yield	1.00											
Straw yield	0.86**	1.00										
Tillers/hill	0.99**	0.87**	1.00									
LAI	0.96**	0.89**	0.97**	1.00								
SPAD	0.94**	0.91**	0.95**	0.96**	1.00							
Dry matter accumulation	0.89**	0.93**	0.91**	0.89**	0.93**	1.00						
Panicle length	0.90**	0.89**	0.92**	0.94**	0.91**	0.93**	1.00					
Panicle weight	0.95**	0.84**	0.92**	0.90**	0.85**	0.84**	0.88**	1.00				
Spikelets/panicle	0.87**	0.91**	0.89**	0.88**	0.92**	0.99**	0.90**	0.81**	1.00			
Filled grains/panicle	0.72**	0.78**	0.76**	0.76**	0.82**	0.92**	0.83**	0.63**	0.95**	1.00		
Sterility %age	-0.19*	-0.29*	-0.27*	-0.29*	-0.36*	-0.50*	-0.44*	-0.10*	-0.56*	-0.79*	1.00	
1000-grain weight	0.93**	0.93**	0.92**	0.90**	0.88**	0.89**	0.89**	0.95**	0.85**	0.66**	-0.10*	1.00

** Correlation coefficient is significant at 0.05 level, * Correlation coefficient is Significant at 0.01 level

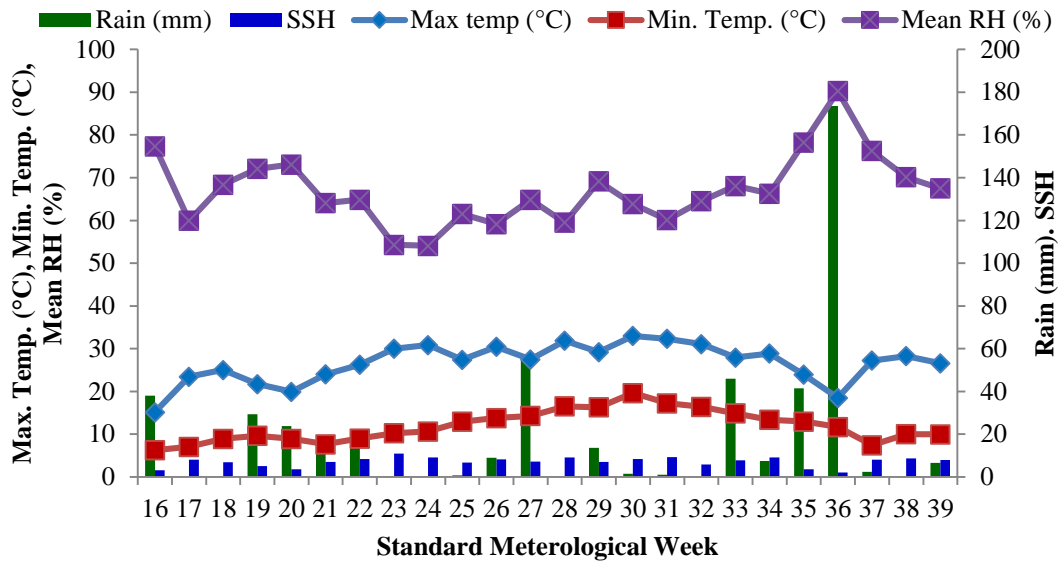


Fig. 1. Weather data during the crop growing season

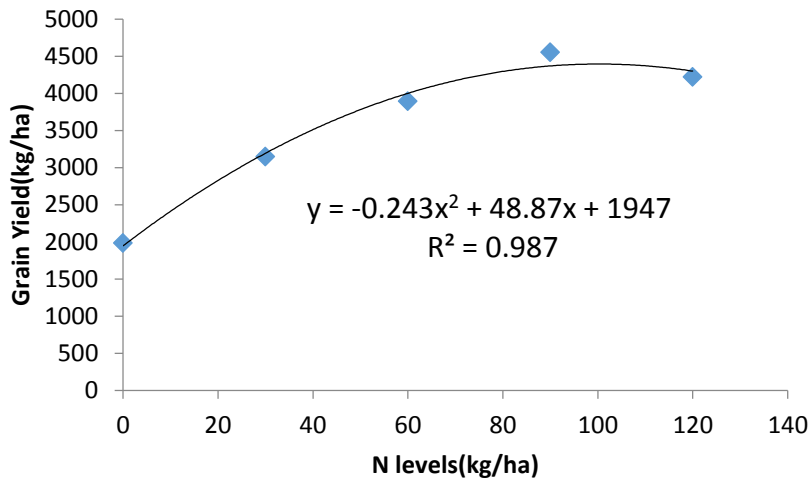
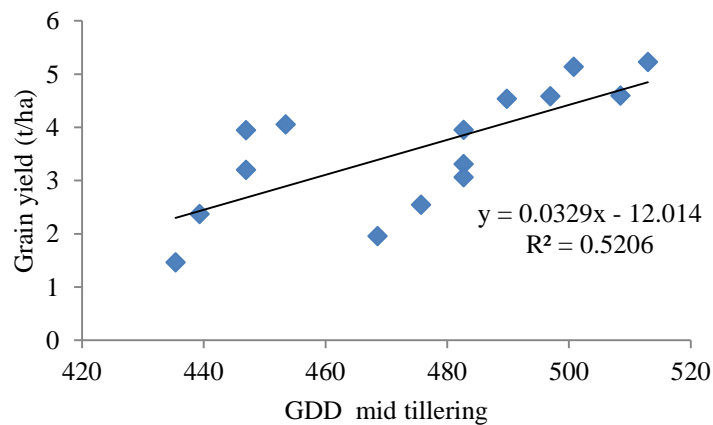


Fig. 2. Response of grain yield to nitrogen levels



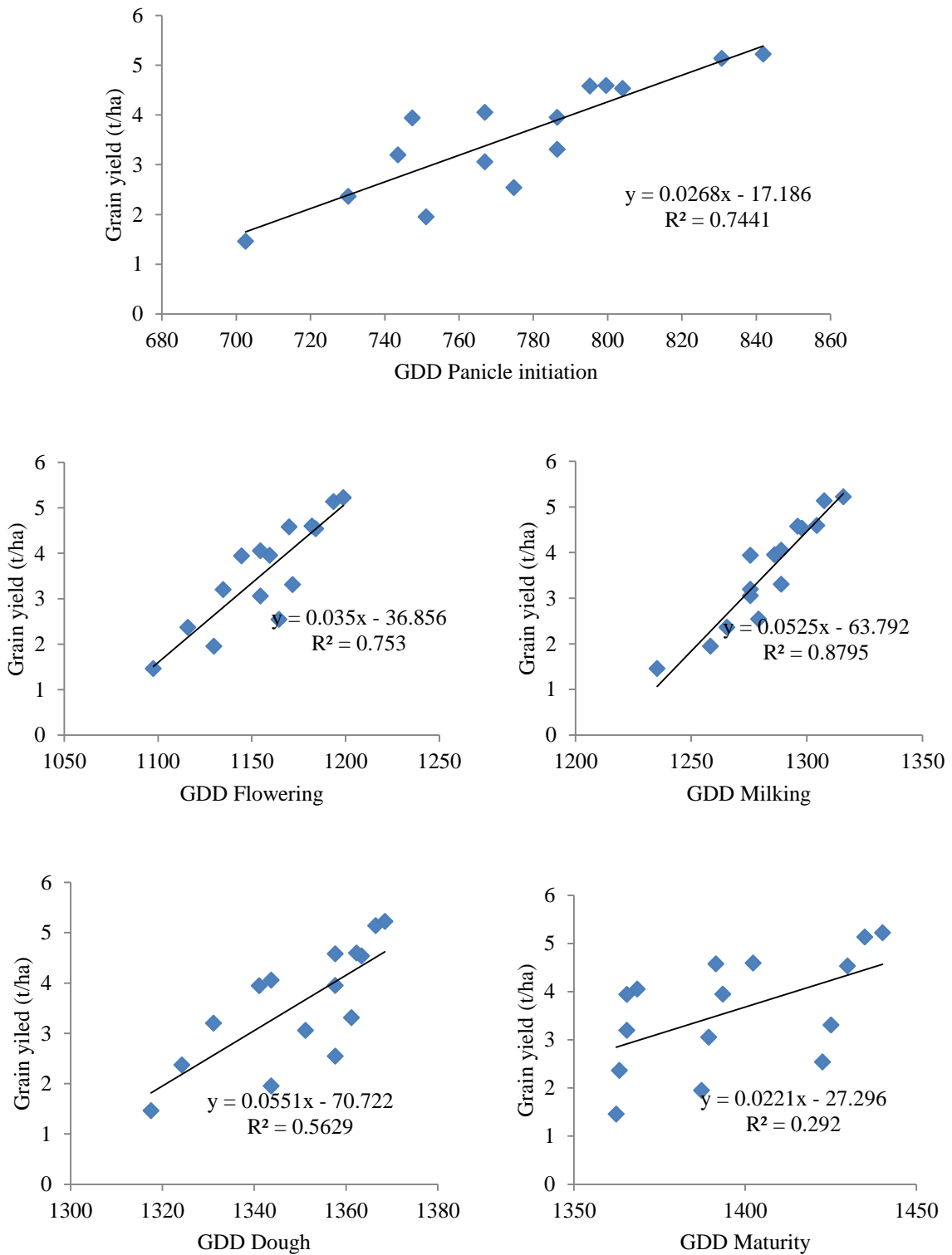
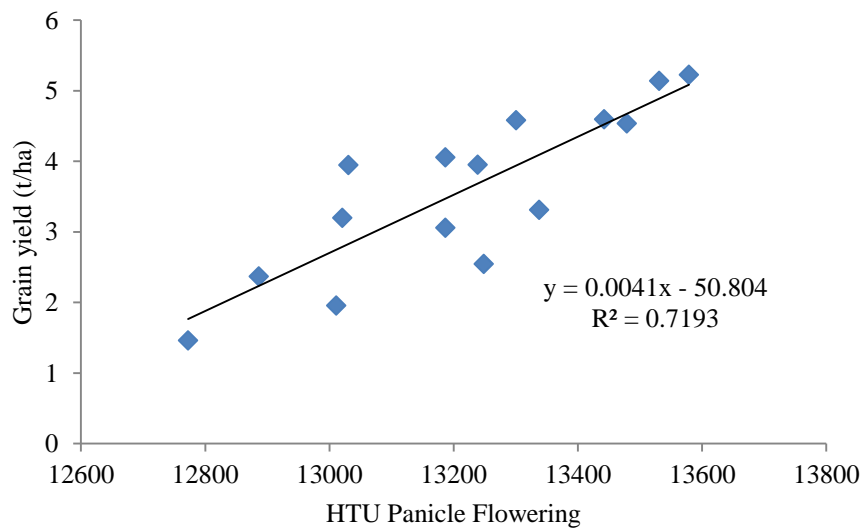
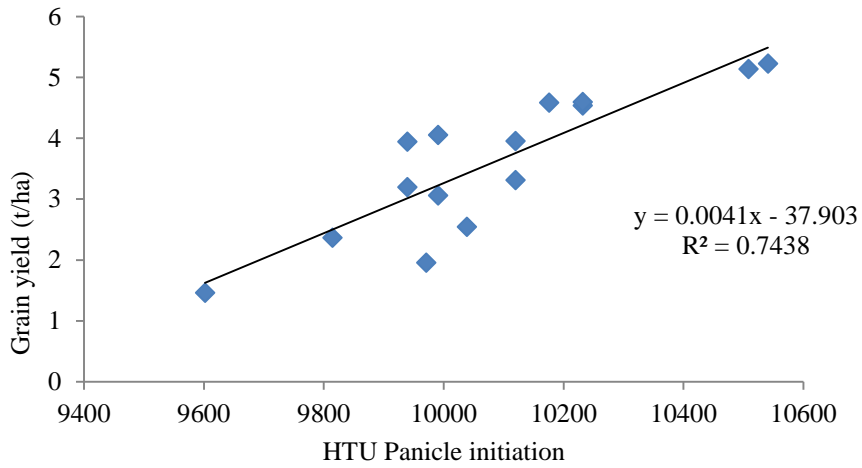
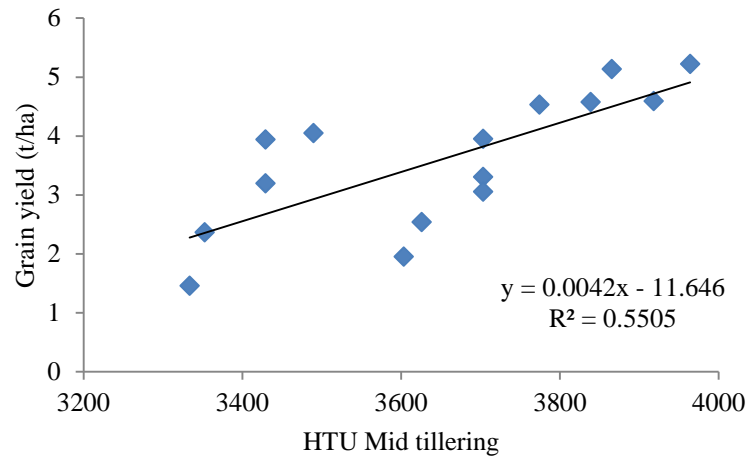


Fig. 3. Relationship between the cumulative GDD with grain yield at mid tillering, panicle initiation, flowering, milking, dough and maturity



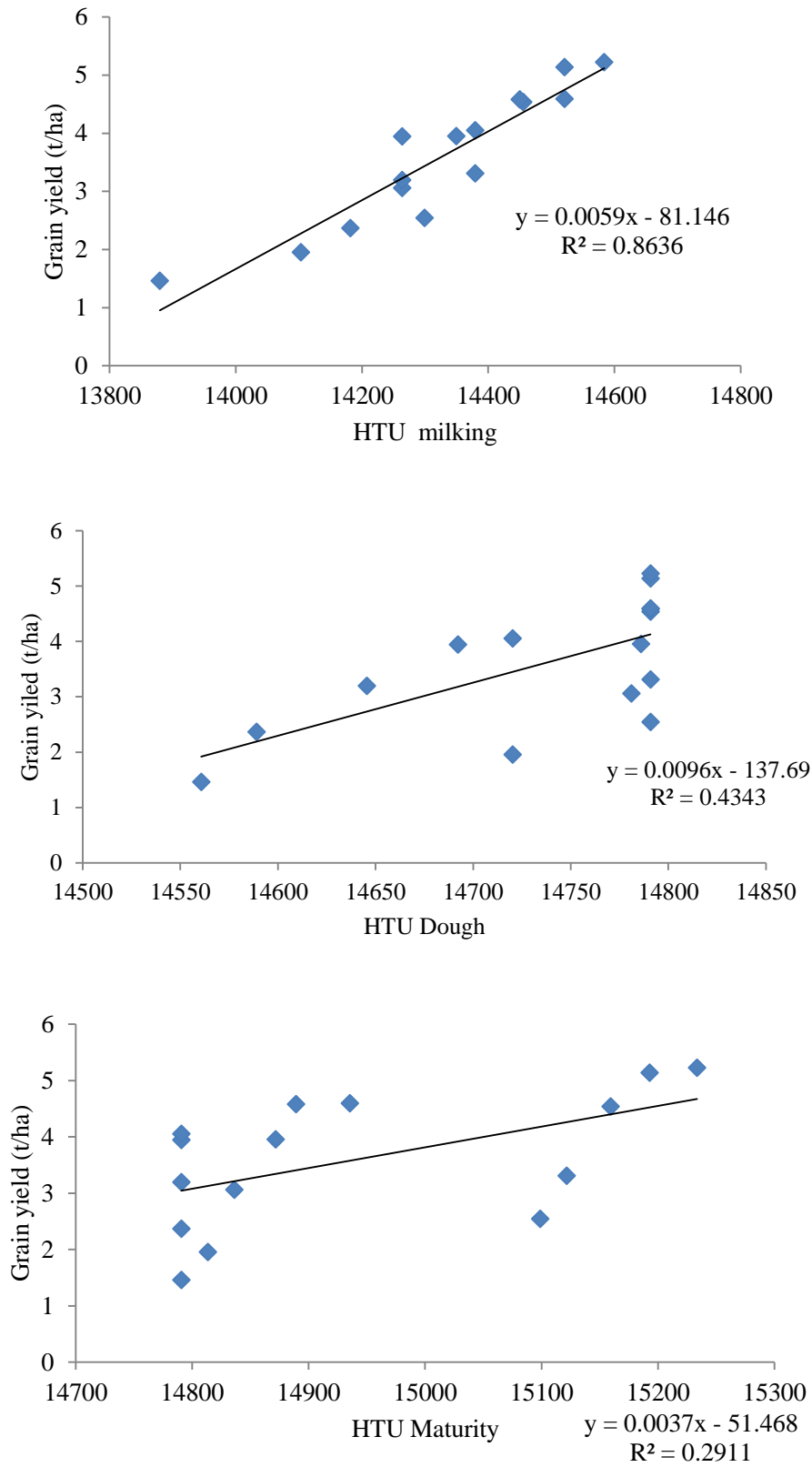


Fig. 4. Relationship between the cumulative HTU with grain yield at mid tillering, panicle initiation, flowering, milking, dough and maturity

4. CONCLUSION

From the study it is concluded that Pusa basmati 1509 though a nontraditional crop for Kashmir valley can be profitably grown when sown by 20th of April. Earlier sowing on 20th of April resulted in significantly more no. days to reach various phenological stages, accumulated higher number of GDD and HTU units and recorded higher HUE and HTUE. Sowing on 20th of April also resulted in significantly higher grain and straw yield. Among the nitrogen levels significant response in yield attributes and grain and straw yield was obtained only up to 90 kg N ha⁻¹. Sowing on 20th of April with and N dose of 90 kg ha⁻¹ can be recommended for obtaining maximum grain yield of Pusa Basmati-1560.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAO. 2019. Available: <http://www.fao.org/faostat/en/#data/QC/visualize> (Retrieved on 12/05/2021).
2. Childs NW. United States Department of Agriculture (USDA). Economic Research Service | Situation and Outlook: Rice Outlook. 2021;21A:1-14.
3. IRRI. Rice Almanac, 2nd ed. International Rice Research Institute, Los Banos, the Philippines. International Rice Research Institute. 1971. Annual Report for 1970.; Los Banos, Laguna, Philippines. 1997;265.
4. Shah RA, Kumar S. Effect of integrated nutrient management on vegetative growth and yield of transplanted hybrid rice (*Oryza sativa* L.) crop. International Journal of Agriculture and Crop Science. 2014;7(11):863-869.
5. Singh RP, Singh N, Mehta S, Godara AK. Adoption of fertilizers and weedicides in basmati paddy crop in Kurukshetra Distt. (Haryana). Agricultural Science Digest. 2008;28(1):36-38.
6. Sidhu MS, Sikka R, Singh T. Performance of transplanted basmati rice in different cropping systems as affected by N application. International Rice Research Notes. 2004;29:63-65.
7. Summerfield RJ, Collison ST, Ellis RH, Roberts EH, Penning de Vries FWT. Photothermal responses of flowering in rice (*Oryza sativa*). Annals of Botany. 1992;69:101-112.
8. Chakravarthy NV, Sastry PN. Some aspects of crop weather interactions in wheat cultivars. International Journal of Ecology Environment Science 1985;11: 139-144.
9. Dixit AJ, Thorat ST, Gaikward VV, Jadhav MG. Yield attributes and yield of parental lines of Sahyadri hybrid rice as influenced by sowing dates. Journal of Agrometeorology. 2004;6:95-97.
10. Safdar ME, Ali A, Muhammad S, Sarwar G, Awan TH. Effect of transplanting dates on paddy yield of fine grain rice genotypes. Pakistan Journal of Botany. 2008;40(6): 2403-2411.
11. Haque KMS, Khaliq QA, Aktar J. Effect of nitrogen on phenology, light interception and growth in aromatic rice. International Journal for Sustainable Crop Production. 2006;1(2):01-06.
12. Abou-Khalifa AAA. Response of rice varieties to nitrogen fertilization under varied agro-ecological conditions. Egyptian Journal of Plant Breeding. 2007;11(2): 681-691.
13. MahajanG, Sekhon NK, Singh NN, Kaur R, Sidhu AS. Yield and nitrogen-use efficiency of aromatic rice cultivars in response to nitrogen fertilizer. Journal of New Seeds. 2010;11:356-368.
14. Yoshida S. Fundamental of Rice Crop Science. International Rice Research Institute. Los Banos, Philippines; 1981.
15. Dingkuhn M, Kropff M. Rice. In: Photo-assimilate distribution in plants and crops, source-sink relationships (Eds. E. Zamski and A.A. Schaffer). Marcel Dekker, Inc., New York/Basel/Hong Kong. 1996; 519-547.
16. Norman RJ, Salton NA, Moldenharer KAV. Development of the DD50 database for new rice cultivars In: B.R. Wells Rice Research Studies 1998 ([Eds. R.J. Norman and T.H. Johnston]. Research Series.1999;468:250-256.
17. BRRI (Bangladesh Rice Research Institute). *Adunick Dhaner Chash* (Bengla), Pub. No. 5. Bangladesh Rice Research Institute Gazipur. 2004;12-35.
18. Haefele SM, Jabbar SMA, Siopongco JDLC, Tirol-Padre A, Amarante ST, Cruz PC. and Cosici WC. Nitrogen use efficiency in selected rice genotypes under different water regimes and nitrogen levels. Field Crops Research.2008;107:137-46.
19. Chakraborty K. Influence of inorganic N fertilizer on plant characters, yield

- generation and the incidence of yellow stem borer *Scirpophaga incertulas*, walker in the field of local scented paddy cultivar Tulaipanj. International journal of Applied Biology and Pharmaceutical Technology. 2011;2:264-273.
20. Pramanik K, Bera AK. Effect of seedling age and nitrogen fertilizer on growth, chlorophyll content, yield and economics of hybrid rice (*Oryza sativa* L.). International Journal of Agronomy and Plant Production .2013;4:3489-3499.
21. Tari BD, Pirdashti HA, Naasiri, M. Investigation of some agronomical traits of rice under different transplanting dates, planting spaces and nitrogen fertilization levels in north of Iran. World Applied Science Journal. 2009;6(8):1021-1027.
22. Sultana A, Shaikh NY, Zahan MS, Akhter R, Islam SA, Issak M. Agroclimatic indices of rice (*Oryza sativa* L.) influenced by different planting times. Bangladesh Rice Journal. 2019;23(2):87-94.
23. Shamim M, Singh Devendra, Gangawar B, Singh KK, Kumar V. Agrometeorological indices in relation to phenology, biomass accumulation and yield of rice genotypes under western Zone of Uttar Pradesh. Journal of Agrometeorology. (Special Issue II) 2013;50-57.

© 2021 Hussain et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<https://www.sdiarticle4.com/review-history/71545>