International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 2057-2060

Received: 21-11-2020
Accepted: 30-12-2020

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Studies on heat unites on various phenophases of wheat (*Triticum aestivum*) under different growing environment

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DOI: https://doi.org/10.22271/chemi.2021.v9.i1ac.11526

Abstract
The present investigation entitled "Studies on Heat unites on various phenophases of wheat (*Triticum aestivum*) under different growing environment" was carried out during Rabi season of 2016-2017, at the Research Farm of Indira Gandhi Krishi Vishwavidhyalaya, Raipur to find out the wheat varieties under late sowing conditions in a rice based cropping system. The treatment combinations of three sowing dates (1st December, 11th December and 21st December,) and three varieties (Ratan, GW-273, and GW-366) were laid out in a randomized block design with three replication. The value of GDD, PTU, HTU, RUE and HTU for different varieties were recorded and maximum value in these parameter was found highest in GW-273 under D1 (1st December) growing environment.

Keywords: Heat unites (GDD, PTU, THU, HUE, RUE), varieties (Ratan, GW-273, GW-366), yield, dates of sowing

Introduction
Wheat is the world's number one cereal crop after rice, grown under diverse agro-climatic conditions, contributing nearly one-third of total food grains production. This grown is not only in the temperate zone but also in tropical and sub-tropical zone tropical and sub-tropical zones. It can be cultivated as high as 3500 meters above mean sea level. Major wheat producing countries of the world are China, India, United States of America, France, Russia, Canada, Germany, Turkey, Australia, Ukraine, and Pakistan. In the world, an area under cereals is 685.67 million hectare with the production of 2239.39 metric tons and productivity 3265.98 kg ha-1. In India crop is grown in an area of 302.27 lakh ha. with the production 93.50 million tons and productivity of 3093 kg ha-1. (Annual report 2015-16) [2].
Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Graur, 1995) [4]. It is an annual plant that belongs to the grass family Poaceae, tribe Triticeae, and subtribe Triticineae. It is thought to have originated on the Eurasian continent, a starting point from which man spread it throughout the world, including China and Central Europe (Haider, 2012).
Three main species commonly grown in the world including India are the common wheat *(Triticum aestivum)*, Marconi or durum wheat (*T. durum*) and emmer wheat (*T. dicoccum*) maximum area are covered by *T. aestivum* out of 3 species. In India, more than 80% of the total wheat area is under this species where as 12% and 1% area under Marconi and emmer wheat. (Draganka *et al*, 2004).
India has a large area under wheat and about 90% of total wheat production is contributed by five states *viz*., Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, and Rajasthan. The other wheat producing states are Bihar, Gujarat, Jammu and Kashmir, Maharashtra, West Bengal and Chhattisgarh. India the total food grain production for the year 2004 was 212.05 million tons and wheat occupies an area of 2.63 million hectares with the production of 7.2 millions tons and productivity of 2716.98 kg ha-1 (Anonymous, 2010) [3].

Material and Methods
The field experiment was carried out at the Research and Instructional farm of Indira Gandhi Krishi Vishwavidyalaya;

Raipur situated in Eastern Central part of Chhattisgarh at latitudes of 21^0.16' N, longitude 81^0.36' E and altitude 289.5 m above mean sea level.

The present experiment was conducted during three consecutive r*abi* seasons of 2016-17. Four prominent wheat cultivars, *viz.*, Ratan GW-273 and GW-366 were used and cultivated in a factorial Randomized Block Design (RBD) with three sowing dates 1 December (D_1), 11th December (D_2) and 21st December (D_3). The GDD, PTU, HTU, Intercepted PAR and HUE were computed by using following formula:

1. Growing degree days (GDD)

GDD = [(Tx + Tn)/2 – Base temperature]

Where,
Tx = Daily maximum temperature
Tn = Daily minimum temperature

2. Photo thermal unit (PTU)

PTU is calculated by multiplying GDD with maximum possible sunshine hours

PTU = GDD X N

Where,
N = maximum possible sunshine hour.

3. Heliothermal unit (HTU)

HTU is calculated by multiplying GDD with actual sunshine hours (n).

HTU = GDD X n

Where,
n = actual sunshine hour.

4. Heat use efficiency (HUE)

Heat use efficiency (HUE) for total dry matter was obtained as under

$$\text{HUE (g/m}^2\text{/0 day)} = \frac{\text{Biomass (g/m}^2\text{)}}{\text{GDD (0 days)}}$$

5. Radiation use efficiency

RUE for total dry matter was obtained as under formula

RUE = yield (kg/m^2)/IPAR (MJ2)

Where,
IPAR is cumulative intercepted photo synthetically active radiation.

The photo synthetic active radiation can be calculated by using the following

Results and Discussion

1. Growing degree day (GDD)

The growing degree days accumulated by variety under various growing environment from emergence to harvesting are shown in table 1. It is quite clear from the table that at harvest the highest value of accumulated GDD was recorded under D1 (1st December) growing environment by all three varieties tasted and third date of sowing. Rajput *et al.* 1987 [7] and Agrawal *et al.* 1999 [1] were also reported similar finding.

2. Photo thermal unit (PTU)

Different varieties responded differently in terms of accumulated photo thermal units (PTU) at the sowing to the harvest as data sown in table 2. The value of photo thermal unit computed during the course of investigation indicates that it was highest under D1 (1st December) growing environment in the all the varieties tested followed by D2 and D3 growing environment at harvest stage. Overall highest value of PTU was (22570) recorded in variety GW-273 under D1 sown crop at last stage of crop followed by GW-366 (21925) and Ratan (21917).

3. Heliothermal unit (HTU)

The calculated value of accumulated Helio Thermal units recorded (HTU) at various stage at crop for different varieties of wheat grown in different dates is given in the Table 3. The helio-thermal units observed highest in first date of sowing under all the varieties tested followed by D2 and D3 sowing date. In overall GW-273 recorded maximum value of HTU (16005) at harvest stage followed by GW-366 (15525) and Ratan (15501).

4. Heat use efficiency (HUE)

Heat Use Efficiency (HUE) for different varieties under different growing environments varied considerably (Table 4). Higher HUE was observed with wheat variety Ratan followed by GW-273. Whereas minimum HUE was observed with variety GW-366. Maximum HUE was observed under D1 (1st December) sowing followed by D2 (11th December) sowing and the minimum HUE was observed under D3 (21st December) sowing.

The mean HUE in kg ha-1 degree day-1 varied from 2.21 for normal date (1st week of December) of sowing to 1.27 for vary late sowing (1st week of January) Patra and Sahu (2007). Similar findings were also reported by Rao *et al.* (1999) [8]. The results revealed that under normal sowing condition the crop accumulated higher amount of heat unit than late sown condition. The HUE was also higher for earlier sowings than later sowings.

5. Radiation use efficiency (RUE)

Radiation Use Efficiency (RUE) of different varieties recorded under different growing environments varied considerably (Table 5). On the mean basis higher RUE value was observed under D1 (1st December) sowing followed by D2 (11th December) D3 (21st December) sowing. Among the varieties GW-273 showed better in terms of RUE followed by Ratan and GW-366.

In case of GW-273 maximum RUE was observed in D1 (1st December) followed by D3 (21st December) and D2 (11th December). In Ratan variety the highest RUE was observed in 11th December followed by 1st December and 21st December. But in case of GW-366 highest RUE value was recorded on 11th December followed by 21st December and 1st December. Lowest RUE was observed under D3 (21st December) sowing in the all varieties.

Table 1: Accumulated growing degree days (GDD) at different growth stages of wheat varieties under different growing environments

Sowing dates	Emergence	CRI	Tillering	Penicle initiation	Booting	Penical emergence	Flowering	Milking	Dough	Maturity	Harvest
V1 (Ratan)											
D_1 - 1 December	103	318	502	721	811	886	1118	1281	1491	1627	1876
D_2 - 11 December	91	267	448	707	787	850	1024	1211	1483	1684	1776
D_3 - 21 December	63	265	430	708	813	882	1089	1265	1472	1591	1773
V2 (GW-273)											
D_1 - 1 December	103	318	502	706	795	871	1101	1262	1492	1792	1934
D_2 - 11 December	78	281	460	693	770	850	1061	1192	1464	1672	1885
D_3 - 21 December	63	265	445	725	796	882	1069	1225	1491	1666	1796
V3 (GW-366)											
D_1 - 1 December	103	305	488	661	721	841	1066	1225	1492	1710	1865
D_2 - 11 December	78	267	434	648	723	819	1024	1230	1464	1672	1825
D_3 - 21 December	63	265	430	677	677	743	1069	1265	1491	1672	1796

Table 2: Accumulated photothermal units (PTU) at different growth stages of wheat varieties under different sowing dates

Sowing dates	Emergence	CRI	Tillering	Penicle initiation	Booting	Penical emergence	Flowering	Milking	Dough	Maturity	Harvest
V1 (Ratan)											
D_1 - 1 December	1119	3468	5489	7895	8929	9791	12457	14381	16667	19661	21917
D_2 - 11 December	995	2923	4912	7834	8753	9475	11697	13715	16982	18533	20543
D_3 - 21 December	690	2912	4727	7931	9130	9932	12408	14523	17229	18272	20317
V2 (GW-273)											
D_1 - 1 December	1119	3468	5489	7731	8746	9618	12261	14153	17229	20977	22570
D_2 - 11 December	855	3077	5046	7671	8559	9475	11921	13492	16749	19277	21540
D_3 - 21 December	690	2912	4899	8119	8934	9932	12172	14045	16912	19002	20556
V3 (GW-366)											
D_1 - 1 December	1119	3327	5341	7238	7895	9275	11864	13704	17229	19661	21925
D_2 - 11 December	855	2923	4763	7146	8008	9118	11476	13715	16912	19524	20550
D_3 - 21 December	690	2912	4727	7575	8328	9537	12172	14523	16749	19277	20530

Table 3: Accumulated heliothermal units (HTU) at different growth stages of wheat varieties under different sowing dates

Sowing dates	Emergence	CRI	Tillering	PI	Booting	Penical emergence	Flowering	Milking	Dough	Maturity	Harvest
V_1-Ratan											
D_1 - 1 Dec.	769	2491	3804	5299	6153	6751	8560	10118	12143	13025	15501
D_2 - 11 Dec.	765	2155	3194	5304	6044	6647	8146	9854	12006	12964	14612
D_3 -21 Dec.	501	1792	2992	5443	6084	6645	8857	9533	11941	13881	14360
V_2-GW-273											
D_1 - 1 Dec.	769	2491	3804	5169	5936	6364	8446	9922	12143	14832	16005
D_2 - 11 Dec.	652	2261	3295	5160	5880	6647	8331	9668	11822	13719	15322
D_3 - 21 Dec	501	1792	3118	5605	6038	6751	8651	9918	11941	13385	14600
V_3-GW-366											
D_1 -1Dec.	769	2408	3726	4824	5299	6400	8323	10206	12098	13881	15525
D_2 -11 Dec.	652	2261	3194	4880	5441	6349	7955	10061	11822	13719	14635
D_3 -21 Dec.	501	1792	2992	5145	5771	6222	8651	9535	11941	13792	14551

Table 4: Heat use efficiency (HUE) at different growth stages of wheat varieties under different growing environments

Varieties	Heat use efficiency (g/m^2 deg. Day)			Mean
	D_1-1 December	D_2-11 December	D_3 21 December	
Ratan	0.47	0.44	0.41	0.44
GW-273	0.43	0.45	0.39	0.42
GW-366	0.42	0.39	0.43	0.41
Mean	0.44	0.43	0.41	

Table 5: Radiation use efficiency (RUE) at different growth stages of wheat varieties under different growing environments

Varieties	Radition us efficiency (g MJ-1)			
	D_1-1 December	D_2-11 December	D_3 21 December	Mean
Ratan	1.20	1.25	1.18	1.21
GW-273	1.27	1.17	1.23	1.22
GW-366	1.10	1.12	1.02	1.08
Mean	1.19	1.18	1.14	

Conclusion

Based on the above findings it was concluded that under 1 December as it produced higher plant height, dry matter, length of spikes, number of effective tillers, test weight, harvest index, as compared to sowing on 11th December and 21st December. However D1 growing environment are best for getting higher yield in all wheat varieties. With respect to the heat unites *viz*., growing degree days, Helio thermal unit, photo thermal unit the early sowing of wheat on 1st December (D_1) is also suitable for wheat cultivation in Chhattisgarh plain region and variety GW-273 is suitable cultivar for getting higher grain yield

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