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Study on agrometeorological indices for barley crop under different growing environments

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ABSTRACT

An investigation on various heat summation indices *viz*., accumulated growing degree days (AGDD), accumulated helio-thermal units (AHTU), photothermal units (APTU), radiation use efficiency (RUE) and heat use efficiency (HUE) in relation to phenology of barley variety-BH-393 was conducted at Research farm of CCS Haryana Agricultural University, Hisar during *rabi* season of 2005-06.The 10th November sown crop consumed more heat units at early stages of crop growth as compare to other two dates of sown crop. In early sown crop, higher values of AGDD, AHTU and APTU were accumulated to attain physiological maturity as compared to later sown dates. RUE and HUE increased gradually till crop reached milking stage and then decreased towards physiological maturity among all three dates of sowing as well as four row spacing. All the row spacings have shown variation RUE and HUE.

Key words : Barley, phenology, AGDD, AHTU, APTU, RUE and HUE.

Barley (*Hordeum vulgare* L.) crop is now becoming popular in Haryana and neighbouring states. In Haryana, it is grown over 85.1 thousand ha with a production of 28.7 thousand tonnes (Anonymous, 2004). Barley is a photo-and thermo-sensitive long-day plant. It is therefore, useful to determine duration of development phases in a particular environment and their association with yield attributes for achieving higher yield. The duration, growth and yield are decided by the thermal and photoperiod conditions experienced by the crop during its life cycle. Solar radiation controls plant growth, development and production. The interception of solar radiation by plant and the utilization of radiant energy for plant biomass production present the fundamental processes governing crop growth and yield. A variation from the optimum temperature, during its vegetative or reproductive growth, adversely affects the onset and duration of phenophasic development and yield of crop. The quantification of HUE (the amount of dry matter produced per unit of growing degree day) is useful for the assessment of yield potential of a crop in different environments. Keeping in view the importance above factors, the present investigation was carried out to study phenology of barley crop in relation to various agrometeorological indices such as

GDD, HTU and PTU, RUE and HUE of barley at different growth stages under varied environments.

MATERIAL AND METHODS

A field experiment was conducted at Research farm of CCS Haryana Agricultural University, Hisar located at 29°10'N latitude, 75°46'E longitude and altitude of 215.2 m amsl; during *rabi* season of 2005-06. The experiment was laid out in split plot design with four replications. The treatments consisted of three sowing dates viz. 10th, 30th November, and 20th December in main plots and four row spacings viz. 15, 22.5, 30cm and 15:30cm (paired row) in subplots. A uniform fertilizer dose of 40 kg ha^{-1} urea, 24 kg ha^{-1} DAP and 24 kg ha^{-1} zinc sulphate were applied. A uniform seed rate per row length was applied. Only one irrigation was given at CRI stage and other operations were carried out as per recommended package of practices for barley crop. The various phenological stages of the crop, *viz*., emergence, tillering, jointing, flag leaf, heading, anthesis, milking and physiological maturity (PM) were identified visually on randomly selected plants. Weather parameters were recorded at the agro-meteorological observatory located at 20 meters away from the experimental field. Growing degree days (GDD) or heat units were determined as per Nuttonson (1955), using base temperature of 5°C (Cao, W. and Moss, D.N. 1989). The helio thermal units (HTU) is product of GDD and corresponding actual bright sunshine hours for that day. For photothermal units (PTU), the product of GDD and corresponding day length hours (for Hisar) was computed on daily basis. The three parameters were accumulated from sowing to each phenological stages. The radiation use efficiency is a ratio of biological or biomass yield and accumulated intercepted radiation and expressed as g MJ^{-1} as:

$$\text{RUE (g MJ}^{-1}\text{)} = \frac{\text{Biomass yield}}{\text{Accumulated intercepted radiation}}$$

The HUE was computed to compare the relative performance of crop under different environments with respect to utilization of heat using the following formula:

$$\text{HUE (kg day}^{-1}\,{}^{\circ}\text{C)} = \frac{\text{Biomass yield}}{\text{Accumulated heat units}}$$

RESULTS AND DISCUSSION

The accumulated growing day degrees (AGDD) to reach various growth stages showed appreciable variation among the dates of sowing and row spacing (Table 1). 10th November sown crop consumed more heat units at early stages of crop growth as compare to other two dates of sown crop probably due to the retention of more physiologically active leaf area for longer duration. The range of AGDD among four row spacings consumed to reach physiological maturity stage was highest in 10th November sown crop (1369-1416 day°C), followed by 20th December (1168-1228 day°C) and 30th November (1103-1150

Table 1 : Effect of sowing time and spacing on agrometeorological indices at different growth stages in barley

Treatments	Growth stages								
	Emergence	CRI	Tillering	Jointing	Flag leaf	Heading	Anthesis	Milking	PM
10th November									
AGDD	89-126	319-347	371-396	541-551	622-650	739-771	889-934	1099-1132	1369-1416
AHTU	952-1355	3408-3696	4009-4192	5700-5799	6549-6338	7786-8149	9469-9980	11829-12221	15266-15829
APTU	756-1096	2591-2821	3064-3197	3951-4013	4345-4514	5202-5405	6374-6663	7688-8015	9654-10074
30th November									
AGDD	63-81	167-178	212-240	383-402	494-526	652-697	843-878	1011-1053	1103-1150
AHTU	649-836	1723-1838	2184-2480	3977-4175	5169-5524	6940-7448	9087-9514	11107-11607	12208-12771
APTU	492-635	1226-1250	1405-1594	2328-2488	3122-3413	4335-4630	5599-5956	6868-7013	7467-7887
20th December									
AGDD	65-83	130-137	196-228	433-475	639-685	744-790	839-878	1056-1101	1168-1228
AHTU	670-859	1344-1424	2037-2376	4623-5094	6935-7454	8153-8704	9290-9758	11891-12435	13257-14031
APTU	280-404	655-701	997-1138	2721-3062	4103-4377	4953-5324	5674-5836	7268-7696	8270-8851

Table 2 : Effect of sowing time and spacing on radiation use efficiency (g MJ^{-1}) and heat use efficiency (kg day $^{-1}$°C) at different phenological stages in barley

Treatments	Phenological stages						
	Tillering	Jointing	Flag leaf	Heading	Anthesis	Milking	PM
10th November							
RUE	0.74-0.87	1.31-2.09	1.75-2.46	2.07-2.63	2.31-2.72	2.37-2.76	1.87-2.16
HUE	0.97-1.07	2.39-3.41	3.69-5.35	5.36-7.27	6.52-7.64	6.66-7.75	5.68-6.67
30th November							
RUE	0.35-0.44	0.63-0.78	1.01-1.36	1.24-1.68	1.34-1.74	1.62-1.82	1.54-1.77
HUE	1.12-1.45	2.36-2.80	4.06-5.36	5.22-6.01	5.57-6.33	6.16-6.63	5.57-6.51
20th December							
RUE	0.16-0.19	0.37-0.46	0.63-0.79	0.92-1.09	0.98-1.11	1.15-1.31	0.96-1.17
HUE	0.94-1.22	1.87-2.34	2.70-3.48	4.37-5.33	4.58-5.45	4.87-5.67	4.79-5.52

Range covers all the spacing treatment 15, 22.5, 30 and 15:30cm

day°C). Pal *et al.*, (1996) observed the variation in the GDD with delayed sowing. The accumulated heat units were found to be variable in early growth stages; however, at maturity the variation was less. This confirms the finding reported by Sompal (1999) and Juskiw *et al.*, (2001). The favorable photoperiodic conditions in 30th November and 20th December sown crops forced the crop to enter reproductive phase early thus shortening the vegetative growth phase. But reproductive phase was also squeezed due to supra thermal conditions at reproductive phase which leads to forced maturity.

The accumulated helio-thermal units (AHTU) showed considerable variation among the dates of sowing and the row spacing (Table 1).The range of AHTU among four row spacings consumed to reach physiological maturity stage was highest in 10th November sown crop (15266-15829 day°C), followed by 20th December (13257-14031 day°C) and 30th November (12208-12771 day°C). In early sown crop, higher values of heat summation indices (GDD, HTU and PTU) were accumulated to attain physiological maturity as compared to later sown dates..

The accumulated photo-thermal units (APTU) showed considerable variation among the dates of sowing and the row spacing (Table 1). The range of APTU, the crop consumed 9654-10074, 8270-8851 and 7467-7887day°C to reach physiological maturity in 10th November, 30th November and 20th December sown crops, respectively. The photothermal units increased with delay in sowing (Agarwal *et al.*, 1999). All the row spacing have shown variation in three dates of sowing due to variation in their maturity duration

Radiation use efficiency (RUE) increased gradually till crop reached milking stage and then decreased towards physiological maturity among all three dates of sowing as well as four row spacing (Table 2). Highest RUE was recorded in 10[th] November sown crop followed by 30[th] November and 20[th] December sown crops. Sharma *et al.*, (2000) reported that radiation use efficiency decreased with delay in sowing. The continuous increase in biomass upto the milking stage resulted in increased RUE at successive growth stages. However, a slight fall in RUE at maturity was because of slower rate of increase in biomass during this period because of high temperature stress and leaf senescence and only translocation of biomass was happening from source to sink. Similar results were reported by Kemanian *et al.*, (2004). Among the four rows spacing 15cm row spacing was more efficient in RUE than others three row spacing .The variations in RUE was less due to differential dry matter production in four row spacing by utilizing the intercepted radiation.

Heat use efficiency (HUE) increased gradually till crop reached milking stage and then decreased towards physiological maturity among all three dates of sowing as well as four row spacing (Table 2). Highest HUE was recorded in 10[th] November sown crop followed by 30[th] November and 20[th] December sown crops. This was because of less biomass production and less accumulated thermal time in delayed sown crop. Similar results were obtained by Singh (2001) in wheat crop. The HUE was reduced significantly with delayed in sowing dates due to low biomass production. The plant spacing had significantly effect on HUE as spacing had effect on biomass accumulation and accumulated thermal units

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