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Accumulated Heat Unit Requirement and Yield of Irrigated wheat (*Triticum aestivum* L.) Varieties under Different Method of Sowing in South Western Punjab

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ABSTRACT

The present investigation was carried out at KVK, Farm and Faridkot and at farmer's field during *rabi*, 2020-2021 cultivars of wheat viz., BWL-8855, HD-3086 and HD-3226 were cultivated under different methods of sowing viz., conventional method, happy seeder and Super seeder. The phenology, accumulation of growing degree days (GDD), Helio-thermal Units (HTU), Photo-thermal units (PTU) and Heat Use Efficiency (HUE) and performance of wheat (*Triticum aestivum* L.) varieties under different sowing methods were studied. The crop sown with super seeder technology took maximum calendar days, growing degree days (120.4°C/day), photo-thermal units (1328.9 °C day hour) and helio-thermal units (769.6 °C day hour) for emergence count m^{-2} and heading stage. The grain yield was recorded the maximum in happy seeder technology (51.65q/ha) followed by conventional method (50.57q/ha) and Super seeder method (49.50q/ha). Conventional sowing took the maximum number of days from sowing to maturity i.e.,169.6 days followed by happy seeder 166.0 days and super seeder 163.4 days. The maximum duration from heading to physiological maturity was observed in happy seeder (71.4 days) followed by Conventional method (68.1days) and supper seeder (64.7days). The maximum Helio-thermal units were observed in conventional method of sowing (10117.6 °C day hour) followed by happy seeder (9788.57 °C day hour) and conventional sowing (9670.3 °C day hour). The maximum heat use efficiency at maturity was recorded in happy seeder sowing method irrespective of varieties followed by super seeder and conventional sowing. The co-efficient of correlation among the yield and tillers/meter in wheat under different methods of sowing showed significant positive correlation (r = 0.81). The spike length (cm) and grain per spike also showed significant correlation (r = 0.88). The results indicated that the variety BWL-8855 performed better under happy seeder technology as compared to Super seeder and conventional method.

Keywords GDD, HTU, PTU, HUE, Grain yield.

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important *rabi* crop of North-western plains of India. It occupies prime positions in modulating the economy of India. Yield of wheat is the final product of complex system

consisting of several sub-systems, involving weather, soil production technology. Wheat is a widely adapted crop it is grown from temperate irrigated to dry and high rainfall areas, and from warm humid to dry cold environments. Undoubtedly this wide adaptation has been possible due to the complex nature of its genome, which provides a fantastic plasticity to the crop. Wheat is a C_3 plant and as such it thrives in cool environments. It is grown under diverse agro-climatic conditions on 29.2 million hectares area in India with a production of 85.9 million tonnes during the season 2010-11 (Anonymous 2011). Phenological development from seeding to maturity is related to the accumulation of heat or temperature units above a threshold or base temperature below which no growth occurs. Development is orderly and predictable (Rickman and Klepper 1995). Growing of suitable variety with suitable technologies is essential for ensuring optimum productivity. Being a thermo-sensitive crop, choice of suitable variety for different sowing methods happy seeder, super seeder and conventional method further gets prime importance. Temperature is an important environmental factor influencing the growth and development of crop plants. Influence of temperature on phenology and yield of crop plants can be studied under field condition through accumulated heat units' system (Bishnoi *et al*. 1995). Based on phenology, growing degree days and heat use efficiency BAW-1170 was comparatively heat tolerant genotype whereas E22 was heat sensitive genotype and other two were moderate heat tolerant genotypes (Roy *et al.* 2018). Plants have a definite temperature requirement before they attain certain phenological stages though accumulation of degree-days for each development stage is relatively constant and independent of sowing date, crop variety may modify it considerably. (Hossain 2006) reported that plating method exhibits an important role in better emergence and subsequent crop growth (Mamta *et. al.* 2015). The impact of high temperature on wheat productivity can be minimized by adoption of various management practices. Recent interest in assessment of the effects of climate changes has a direct bearing on agriculture: How will even minute changes in temperature influence crop growth. Therefore, an experiment was planned to determine the phenology and heat unit requirement of promising wheat varieties under different crop growing environment with different method of sowing in southwestern Punjab.

MATERIALS AND METHODS

The present study was under during the year 2020-21 at the fields of KVK, Faridkot and at village Machaki Kalan (Farmers' field) of district Faridkot. For these two novel technologies namely; happy seeder and super seeder versus conventional method were taken, for three wheat cultivars (HD-3226, BWL-8855 and HD 3086). All the cultivars were sown on same date with all three practices on 30-10-2020. Crop was cultivated as per the package and practice of Punjab Agriculture University, Ludhaina. All parameters were recorded in three replications and accordingly the data was statistically analyzed.

The experiment was conducted in Randomized Block Design with three method of sowing, viz., happy seeder (HS), super seeder (SS) and Conventional method (CM and three varieties of wheat, viz., 'HD-3086', 'HD-3226'and 'BWL-8855', with three replications. Wheat crop was sown with the row spacing of 22.5 cm as per treatments. Four irrigations (75 mm water in each irrigation) were applied at four critical phonological stages. In regards to fertilizer application of the crop, 150 kg N, 62.5 kg P_2O_5 and 30 kg K_2O were applied. Out of which, 1/3rd N and full dose of P_2O_5 and K_2O were applied as basal dose at the time of sowing by broadcasting method. The remaining 2/3rd dose of N was applied in two splits at CRI and late tillering stages. Total tillers and ears recorded from one meter row length and presented as per square meter. Five ears were randomly selected and threshed manually, grains counted and data presented as grains per ear. The sample of 1000-grains collected from each plot, weighed and presented as gram. Total bundle weight was recorded from each plot at the time of harvesting. The crop was threshed and grain were weighed and presented as quintal per hectare. Meteorological data, viz., rainfall, relative humidity, maximum and minimum temperature, bright sunshine hours, day length were recorded from Agrometeorological observatory, Punjab Agricultural University, Ludhiana. The agro-meteorological indices were computed using the daily meteorological data. The dates of occurrences of different phonological events, viz., earing and maturity were recorded when 75% of

the plants in each replication reached the respective stages. Emergence count m^{-2} one m^2 area was marked in each replication of all plots. Emergence count from one m^{-2} area of each replication was recorded after the completion of germination. Tiller/m was marked in each replication of all plots. Number of tiller count in meter rows for each replication. Inflorescences the stage was noticed when terminal spikelet of the spike becomes visible. Heading continues till the complete spike has emerged. Data was recorded in three replications.

Accumulated heat uints

Helio Thermal Unit (HTU) and Photo-Thermal Units (PTU), Heat Use Efficiency (HUE) were calculated using following formulas.

GDD (°C day) = Σ(Tmax+ Tmin)/2 - 4.5 (base temperature)

PTU (°C day hour) = Σ (GDD × D)

HTU (°C day hour) = Σ (GDD × SS)

Heat Use Efficiency = Yield (Grain)/ Growing degree days accumulation (Kg/ha/°C) (Sahu *et al.* 2007).

RESULTS AND DISCUSSION

Growing degree days (GDD)

Growing degree days were found to be significant both at earing and maturity of different dates of sowing (Table 1). The crop sowing with super seeder method of took maximum growing degree days (120.4°C days) for seed emergence (m^{-2}) followed by happy seeder (105.2 °C days) and Conventional method (93.7 °C days) of sowing. The growing degree days to earing took maximum (977.1 °C days) in conventional method minimum (895.3 °C days) by happy seeder method of sowing. Similarly, days taken to maturity maximum in conventional method therefore maximum growing degree days (2064.7 °C days) followed by happy seeder (2021.93 °C days) and super seeder method (1977.67 °C days) of sowing.

Table 1. Effect of sowing method and varieties on days taken to emergence, earing and maturity, growing degree days (GDD), helio thermal unit (HTU), photo thermal units (PTU) and Heat Use efficiency (HUE).

Variety	Days taken to emergence			Growing degree days (°C day)			Photo thermal units (°C day hour)			Helio thermal units (°C day hour)		
	HS	SS	CM	HS	SS	CM	HS	SS	CM	HS	SS	CM
HD-3226	7.0	8.0	6.0	105.6	120.7	90.5	1165.1	1331.5	998.7	654.7	734.7	647.1
HD-3086	6.6	7.6	6.3	99.7	114.8	95.1	1106.0	1273.5	1055.7	618.1	772.5	680.0
BWL-8855	7.3	8.3	6.3	110.3	125.7	95.5	1223.6	1381.8	1055.4	684.1	801.7	679.8
Mean	7.0	8.0	6.2	105.2	120.4	93.7	1164.9	1328.9	1036.6	652.3	769.6	669.0
LSD (0.05)		0.0075			0.0012			0.2894			0.0124	
Variety	Days taken to earing			Growing degree days (°C day)			Photo thermal units (°C day hour)			Helio thermal units (°C day hour)		
HD-3226	94.6	99.3	101.0	902. 3	955.3	972.6	9293.6	9839.2	10591.9	3672.3	3887.9	3900.2
HD-3086	93.6	98.6	101.0	877.5	948.5	972.6	9038.2	9769.9	10591.9	3571.4	3860.5	3900.2
BWL-8855	95.0	98.2	102.4	906.1	944.7	986.1	9332.9	9730.2	10738.8	3687.9	3844.9	3954.3
Mean	94.4	98.7	101.5	895.3	949.5	977.1	9221.3	9779.8	10640.9	3643.9	3864.4	3918.2
LSD (0.05)		0.324			0.047			0.0087			0.2578	
Variety	Days taken to maturity			Growing degree days (°C day)			Photo thermal units (°C day hour)			Helio thermal units (°C day hour)		
HD-3226	168.1	161.3	168.4	2047.5	1956.6	2037.6	22481.1	21541.8	22454.8	9615.2	9567.6	9964.1
HD-3086	164.3	163.3	168.6	1993.0	1974.3	2062.0	21962.4	21756.8	22826.1	9745.6	9654.3	10186.2
BWL-8855	165.6	165.6	172.0	2025.3	2002.1	2095.0	22419.9	22063.2	23002.7	10004.9	9790.3	10202.5
Mean	166.0	163.4	169.6	2021.9	1977.6	2064.8	22287.8	21787.2	22761.2	9788.5	9670.7	10117.6
LSD (0.05)		0.2540			0.0047			0.0193			0.514	

HS=Happy seeder, SS= Super seeder and CM= Conventional method.

Table 2. Heat use efficiency (kg/ha/°C) for straw and grain yield at maturity in different sowing method.

Methods	Heat use efficiency (Biological yield kg/ha/°C)			Mean	Heat use efficiency (Grain yield kg/ha/°C)			Mean
	HS	SS	CM		HS	SS	CM	
HD-3226	5.32	4.66	5.27	5.08	2.49	2.55	2.48	2.50
HD-3086	5.44	4.52	5.11	5.14	2.48	2.40	2.32	2.40
BWL-8855	5.66	4.92	5.40	5.34	2.68	2.54	2.53	2.58
Mean	5.44	4.78	5.26	5.18	2.55	2.50	2.44	2.49
LSD (0.05)		0.0013				0.247		

Temperature is the most important climatic variables which affects the plants life in terms of its sowing time germination, growth, phonological development and quality of crop (Gill and Kingra 2007).

Accumulated photo-thermal unit (PTU)

The variation in accumulated photo-thermal units (PTU) in different treatments at earing and maturity has been presented in Table 1. Accumulation of accumulated photo-thermal units (PTU) at seed emergence (1328.9 ^{0}C days hour) in super seeder method of sowing. However, at earing conventional method of sowing took maximum photothermal units (10640.9 °C days hour). In maturity maximum accumulated photothermal units observed in super seeder sowing method followed by conventional method and happy seeder method of sowing.

Accumulated helio-thermal unit (HTU)

Among the genotypes for seed emergence (m^{-2}) BWL-8855 showed higher consumption of HTU (721.8 °C day hours) as compared to HD-3086 (690.2 °C day hours) and HD-3226 (679.1 °C day hours). The maximum accumulated helio-thermal units were observed in super seeder method of sowing (769.6 °C day hours) and minimum in happy seeder (652.3 °C day hours) method of sowing. The maximum accumulated helio-thermal unit in days to taken to earing in conventional method of sowing (3918.2 °C day hours) and minimum (3643.9 °C day hours) happy seeder method of sowing. In days taken to earing the accumulated helio-thermal units (3829.3 °C day hours), (3820.1 °C day hours) and (3777.3 °C day hours) respectively for BWL-8855, HD-3086 and HD-3226. The Table 1 showed that maximum accumulated helio-thermal unit observed in conventional method of sowing (10117.6 °C day hours) followed by Happy seeder (97688.5 °C day hours) and in super seeder (6970.3 °C day hours) method of sowing.

Heat use efficiency

The interaction of sowing method and genotype significantly influenced the heat use efficiency of biological yield (kg/ha) and grain yield (kg/ha) Table 2. All the genotypes used more heat use efficiency of biological yield in happy seeder method of sowing (5.32kg/ha/°C), (5.44 kg/ha/°C) and (5.66 kg/ha/°C) for HD-3226, HD-3086 and BWL-8855 respectively, whereas less heat use efficiency was observed in super seeder method of sowing for the genotypes i.e., (4.66 kg/ha/°C), (4.52 kg/ha/°C) and (4.92 kg/ha/°C) for HD-3226, HD-3086 and BWL-8855 respectively. Under happy seeder method of sowing, genotype BWL-8855 had significantly highest heat use efficiency (5.66 kg/ha/°C). Heat use efficiency for grain yield maximum for the genotypes BWL-8855 (2.68 kg/ha/°C) in happy seeder and minimum for HD-3086 (2.32 kg/ha/°C) in conventional method of sowing. Among the methods of sowing happy seeder showed 2.4% higher heat use efficiency than the super seeder and 4.1% higher than the conventional method of sowing.

Yield attributes

The plant height (cm), Tiller/meter, 1000grain weight spike length (cm) grain per spike, biological yield and grain yield (q/ha) were significantly influenced by sowing method and varieties (Table 3). The maximum plant height (cm) was recorded in crop sown with happy seeder technology was statistically at par with that of super seeder and conventional methods. Among different methods of sowing the tillers per

Table 3. Effect of sowing method and varieties on plant characters, yield attributes and biomass of wheat.

Variety	Plant height (cm)				Tiller/m				1000 grain weight			
	HS	SS	CM	Mean	HS	SS	CM	Mean	HS	SS	CM	Mean
HD-3226	95.7	93.2	94.3	94.40	107.3	101.3	104.3	104.30	48.3	39	45.5	44.27
HD-3086	92.7	88.4	90.6	90.57	100.6	110.6	97.6	102.93	43.4	42.1	42.6	42.70
BWL-8855	100.4	93.9	96.4	96.90	91.7	84.3	88.3	88.10	47.5	45.1	45.9	46.17
Mean	96.27	91.83	93.77	93.96	99.87	98.73	96.73	98.44	43.73	42.07	42.67	44.38
LSD (0.05)	0.325				0.928				0.201			

Table 3. Continued.

Variety	Spike length (cm)				Grain per spike				Yield (q/ha)			
	HS	SS	CM	Mean	HS	SS	CM	Mean	HS	SS	CM	Mean
HD-3226	11.2	10.4	10.9	10.83	42.3	39	38	39.77	51.15	50	50.7	50.62
HD-3086	9.6	9	9.3	9.30	36	32	34	34.00	49.5	47.5	48	48.33
BWL-8855	11.9	10.6	10.4	10.97	46.2	36	36	39.40	54.3	51	53	52.77
Mean	10.57	9.8	10.2	10.37	38.67	35	36.67	37.72	51.65	49.5	50.57	50.57
LSD (0.05)	0.527				0.816				0.545			

meter recorded in happy seeder were significantly more than super seeder and conventional method. The crop sown with happy seeder gave significantly higher 1000 grain weight which was statistical at par with super seeder and conventional method. Among the different varieties 1000 grain weight varieties BWL-8855 were significantly more than HD-3226 and HD-3086. Number of grains per being statistically at par among three methods of sowing were significantly more than HS, SS and CM. Regarding the different varieties, number of grains ear^{-1} was significantly more in BWL-8855, however it was at pat with variety HD-3226 and HD-3086.Happy seeder method of sowing recorded maximum spike length (cm) as compared to SS and CM of sowing. Wheat variety BWL-8855 produced significantly more spike length than HD-3226 and HD-3086. The biological yield was significantly higher in crop sown with HS method of sowing. The wheat variety BWL-8855 recorded significantly higher in biological yield as compared to other varieties. The higher value of yield attributing parameters and yield in case of HS over the SS and CM could be attributed to availability of microclimate and optimum environmental conditions for growth and development of crop which might enhance accumulation and translocation of photosynthates from source to sink.

Grain yield

The crop sown with happy seeder recorded (51.65q/ha) the highest grain yield which was statistically at par with super seeder (49.50q/ha) and conventional method (50.57q/ha) of sowing (Table 3). The maximum grain growth duration (71.6 days) was found in happy seeder sowing method followed by conventional method (68.17 days) and super seeder method (64.7 days). The genotype BWL-8855 had longest grain duration (68.7 days) followed by HD-3226 and HD-3086. Dry mass was also highest under reduced tillage as compared to conventional and no till system (Akbarian *et al.* 2010). It might be due to higher yield attributes. The detrimental effect of heat at later stages of crop development and earing in different method of sowing had remarkable effect on grain yield. Temperature, day length and vernalization are the main environmental factors that govern the rate of development in wheat, and determine the duration of different phenological phases (Slafer and Rawson 1994). The variety BWL- 8855 recorded highest grain yield which was statistically on par with HD-3086. It might be due to potential of different varieties. The interaction between methods of sowing and wheat varieties was also found to be significant (Table 3). The variety BWL-8855 sown with happy seeder method

Table 4. Coefficient of correlation among yield and physiological traits in wheat under different methods of sowing.

Traits	Plant height (cm)	Tiller/meter	1000 grain weight	Spike length (cm)	Grain per spike	Yield (q/ha)
Plant height (cm)	1					
Tiller/meter	-0.75136	1				
1000 grain weight	0.42129	-0.91502	1			
Spike length (cm)	0.79193	0.19208	0.22014	1		
Grain per spike	0.42138	0.28184	0.64495	0.88745	1	
Yield (q/ha)	0.99459	0.81582	0.71320	0.72423	0.32492	1

at par with conventional methods and super seeder. A significant difference in yield with method of sowing in all the genotypes maximum yield in BWL -8855 (52.77q/ha) followed by HD-3226 (50.62q/ha) and HD-3086 (48.33q/ha). This might be because of biomass partitioning of reproductive organ was the main attribute responsible for grain yield. The correlation and coefficient in (Table 4) showed that plant height significantly related with the plant height (r = 0.7919), grain spike with tiller /meter with (r = 0.8158) and 1000grain weight with grain yield (r = 0.7132), spike length and grain per spike (r = 0.8845).

CONCLUSION

The crop sown with happy seeder method sowing took optimum growing degree days, accumulated photo-thermal units, accumulated helio-thermal units and heat use efficiency to obtained maximum grain yield as compared super seeder and conventional method. Among the genotypes BWL-8855 showed maximum yield in happy seeder method of sowing. Therefore, the performance of genotype BWL-8855 under happy seeder method of sowing is at par.

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