



Evaluation of Different Sowing Methods and Varieties on Performance and Agro-Meteorological Indices of Wheat

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Abstract: The field experiment was conducted at Punjab Agricultural University, Ludhiana during the *rabi* season of 2022-23 to study the effect of different sowing methods on phenological development, agro-meteorological indices and wheat yield. Two wheat varieties viz. PBW-725 and PBW-869 were sown under three different sowing methods viz. conventional sowing, happy seeder sowing and super seeder sowing. Different phenological stages of wheat crop were recorded by visual observations. Crop sown with happy seeder required more number of days to progress through various growth stages (emergence to maturity) followed by those sown with the super seeder and conventional method. The happy seeder sown crop exhibited higher helio-thermal use efficiency, photo-thermal use efficiency, heat use efficiency and radiation use efficiency compared to crop sown with super seeder and conventional methods which contributed to more yield under happy seeder sowing. Linear relationships were established between various agro-meteorological indices and grain yield. The analysis revealed a positive correlation of growing degree days, helio-thermal units, photo-thermal units, and heat use efficiency with grain yield, indicating that increases in these agro-meteorological indices are associated with higher grain yields.

Keywords: Agro-meteorological indices, Microclimate, conventional sowing, Happy seeder sowing, Super seeder sowing

Wheat is widely adapted crop, thriving under diverse conditions ranging from temperate irrigated to dry and high rainfall areas, as well as warm humid to cold dry environments. Cultivating wheat following a rice crop presents a valuable opportunity to enhance productivity and effectively handle rice stubble management. The rice-wheat cropping system is widely adopted globally, particularly in Asia, covering an extensive area of 240 million hectares (Nawaz et al 2019). Asia contributes 826 million tons (Mt) to the total global rice residue production which is difficult to manage leading to challenges like residue burning, rising greenhouse gas emissions, soil health degradation, declining productivity and decreasing groundwater levels (Goswami et al 2019). In India, it covers an area of about 31.6 million hectares with a production of 106.41 million tonnes. The three most important wheat-growing states are Uttar Pradesh, Punjab and Haryana making up about 60% of the nation's total area and the issue of rice residue burning is particularly severe in these regions (Anonymous 2022). The combustion of crop residues leads to the emission of black carbon, a significant contributor to the warming of the lower atmosphere (Chaudhary et al 2021). Hence, retaining crop residues is crucial as it mitigates the release of black carbon, thereby providing environmental benefits and promoting the well-being of wheat crop. Currently, lot of efforts are going into the cultivation of wheat in retained residues of rice crop in the field. This approach aims to address the challenges

arising from the uncontrolled burning of paddy residues, particularly in the North-Western region of India which involves the sowing of wheat under resource conservation methods (happy seeder and super seeder). These resource conservation methods have many benefits to the crop as the addition of residues to the soil provides vital nutrients that aid in the growth of crops. In particular, it supplies roughly 31-42 kg N/ha (nitrogen), 8 kg P/ha (phosphorus), 34-61 kg K/ha (potassium), and 2.1-2.2 tonnes C/ha (carbon) every crop cycle (Hung et al 2019). Rani et al (2019) stated that the adoption of resource conservation practices is considered as a helpful tool for improving soil properties and mitigating the adverse effects of climatic changes.

Wheat is heat sensitive crop. Grain production in India was considerably reduced (25% in Punjab) by heat stress, which was exhibited by the occurrence of much higher than average temperatures for 15-25 days during the reproductive phase of wheat (Bal et al 2022). Hence, to eliminate the effects of higher temperature, there is a need for sowing the wheat under resource conservation methods as these methods influence the heat and water balance of the soil during the growing season (Sidhu et al 2020). Crop growth and yield are closely linked to temperature-based agro-meteorological indices like growing degree days (GDDs), helio-thermal units (HTUs), and photo-thermal units (PTUs). These indices, along with thermal efficiencies, are essential for understanding phenology and yield. Accumulated GDD can

estimate the timing of different crop developmental stages (Sidhu et al 2020). While extensive research exists on these indices for conventionally sown wheat crop, there is limited knowledge for crops sown with happy seeder and super seeder. Evaluating these methods can help to identify the practices to enhance heat units and manage the impacts of climate change on crop growth and productivity. Keeping this in view, the present study was planned to evaluate the agro-meteorological indices of wheat sown with happy seeder and super seeder (residues retained and incorporated).

MATERIAL AND METHODS

Experimental details: The field trial was conducted at Punjab Agricultural University, Ludhiana. It is situated at latitude of 30°54'N, longitude of 75°48'E and at an altitude of 247 m above mean sea level. Two wheat varieties (PBW-725 and PBW-869) were sown under three different sowing methods (conventional sowing, happy seeder sowing and super seeder sowing) during the *rabi* season of 2022-23. The experiment was laid out in a strip plot design with three replications. During the experiment, phenological stages such as tillering, booting, flowering, milk, dough, and physiological maturity were observed visually. Growing degree days, helio-thermal units and photo-thermal units were computed for the crop at various phenological stages. The helio-thermal use efficiency, photo-thermal use efficiency, heat use efficiency and radiation use efficiency were computed as for biomass and grain yield.

Computation of Agro-Meteorological Indices

Growing degree days (°C day): Growing degree days are used to predict plant growth and development during the growing season. Growing degree days (GDDs) were computed from complete emergence to physiological maturity, revealing an increasing GDD requirement throughout this period. GDDs were calculated (Nuttonson 1955):

$$\text{GDD (}^{\circ}\text{C day)} = \sum (T_{\max} + T_{\min}) / 2 - T_b$$

Where; T_{\max} = Maximum temperature ($^{\circ}\text{C}$), T_{\min} = Minimum temperature ($^{\circ}\text{C}$)

T_b = Base temperature (5°C for wheat crop) (Slafer 1995)

Helio-thermal units ($^{\circ}\text{C day hour}$): It is the product of GDD and actual sunshine hours for a given day (Rajput 1980).

$\text{HTU (}^{\circ}\text{C day hour)} = \sum (\text{GDD} \times \text{actual bright sunshine hours})$

Photo-thermal units ($^{\circ}\text{C day hour}$): Photo-thermal units are represented by the product of GDD and the day length of that particular day (Rajput 1980).

$$\text{PTU (}^{\circ}\text{C day hour)} = \sum (\text{GDD} \times \text{day length})$$

Helio-thermal use efficiency (kg/ha/ $^{\circ}\text{C/day hour}$): The quantity of dry matter or grain yield produced per unit of

accumulated helio-thermal units is known as helio-thermal use efficiency (Dar et al 2018):

$$\text{Helio-thermal use efficiency (kg/ha/}^{\circ}\text{C/day hour)} = \frac{\text{Grain or dry matter yield}}{\text{Accumulated helio-thermal units}}$$

Photo thermal use efficiency (kg/ha/ $^{\circ}\text{C/day hour}$): It is the ratio of grain yield to photo thermal units (PTU). It was computed by dividing the grain yield or total dry matter by the total photo thermal units (Major et al 1975):

$$\text{PTUE (kg/ha/}^{\circ}\text{C/day hour)} = \frac{\text{Grain or dry matter yield}}{\text{Accumulated photo-thermal units}}$$

Heat use efficiency (kg/ha/ $^{\circ}\text{C/days}$): It denotes the amount of dry matter produced per growing degree day and is calculated (Sastri et al 1985):

$$\text{HUE (kg/ha/}^{\circ}\text{C/days)} = \frac{\text{Grain or dry matter yield}}{\text{Accumulated growing degree days}}$$

Radiation use efficiency (kg/ha/MJ): Radiation use efficiency (RUE) is determined by biomass accumulation and the canopy's ability to intercept photosynthetically active radiation (IPAR) (Monteith 1977):

$$\text{RUE (kg/ha/MJ)} = \frac{\text{Grain or dry matter yield}}{\text{Accumulated intercepted PAR}}$$

RESULTS AND DISCUSSION

Crop phenology: Different residue management practices affect the phenology of wheat sown with happy seeder, super seeder and conventional method. The temporal progression to physiological maturity varied among wheat crop sown using different techniques. Notably, crop sown with the happy seeder exhibited an extended period to attain physiological maturity, while the conventional sown crop exhibited the shortest duration. Specifically, for variety PBW-869, the physiological maturity phase required 161 days when sown with happy seeder, 157 days with super seeder and 154 days with conventional sowing. Similarly, variety PBW-725 took 158 days with happy seeder, 155 days with super seeder and 150 days with conventional sowing to reach physiological maturity (Table 1). The observed prolongation in the time required for physiological maturity in crop sown with the happy seeder and super seeder methods can be attributed to an elongated vegetative growth phase as compared to conventional sowing. Sidhu et al (2020) documented an extended duration for wheat crop sown with happy seeder method to attain physiological maturity in comparison to those sown conventionally. Singh et al (2023) also reported an increased temporal requirement for physiological maturity in wheat crop sown with the happy seeder method compared to conventional sowing.

Growing degree days (GDDs): Wheat sown with the happy seeder exhibited the highest accumulation of growing degree days (GDDs) at various phenophases. Specifically, variety PBW-869 demonstrated the highest GDD accumulation (1971.8°C days), followed by variety PBW-725 (1902.2°C days) when sown with happy seeder. In contrast, GDD accumulated by super seeder sown varieties PBW-869 and PBW-725 were 1861.6 and 1842.8°C days, respectively. The increased time taken by crops sown with the happy seeder to reach physiological maturity implies that these crops experience more days with temperatures conducive to GDD accumulation, contributing to the observed higher GDD values. Under conventional sowing, variety PBW-869 and

variety PBW-725 accumulated 1825.1 and 1756.7°C days of GDD, respectively, which are lower as compared to happy seeder and super seeder (Table 2). Kaur et al (2016) also reported a positive relation between the accumulated growing degree days and the time taken to reach maturity in wheat varieties. The varieties with an extended duration to maturity, as observed by Kaur (2022), demonstrated higher GDD accumulation.

Helio-thermal units (HTUs): The highest accumulation of HTU (°C day hours) occurred in wheat sown with the happy seeder (Table 3). This increased accumulation of HTU can be attributed to extended duration which exposes the crop to a greater cumulative amount of heat, contributing to the higher

Table 1. Phenological behaviour of wheat varieties under different methods of sowing during *rabi* 2022-23

Phenological stages	Conventional		Happy seeder		Super seeder	
	PBW 725	PBW 869	PBW 725	PBW 869	PBW 725	PBW 869
Complete emergence	6	7	8	9	7	8
CRI	19	20	22	23	19	21
Maximum tillering	41	43	47	49	43	45
Jointing (Start)	56	58	65	68	59	62
Flag leaf initiation	70	71	79	83	73	77
Booting (Start)	81	84	92	96	85	89
Heading (Start)	95	97	106	111	99	103
Anthesis (Start)	102	104	114	120	107	110
Milking (Start)	113	115	125	130	117	121
Soft dough (Start)	123	126	136	141	129	132
Hard dough (Start)	137	140	146	151	142	145
Physiological maturity	150	154	158	161	155	157

Table 2. Effect of sowing methods and varieties on accumulated growing degree days (°C day hour) of wheat under different irrigation treatments during *rabi* (2022-23)

Phenological stages	Conventional		Happy seeder		Super seeder	
	PBW 725	PBW 869	PBW 725	PBW 869	PBW 725	PBW 869
Complete emergence	125.1	139.0	153.9	167.2	139.0	153.9
CRI	297.3	309.1	334.3	345.9	297.3	322.3
Maximum tillering	547.9	582.4	598.4	609.6	566.2	598.4
Jointing (Start)	658.7	665.2	694.7	710.4	671.4	682.0
Flag leaf (Start)	727.0	734.5	786.2	821.7	747.8	770.1
Booting (Start)	803.1	813.4	903.9	947.4	837.4	873.3
Heading (Start)	947.4	957.7	1068.0	1143.8	984.5	1022.9
Anthesis (Start)	1010.8	1037.4	1186.7	1278.5	1083.5	1130.4
Milking (Start)	1186.7	1202.9	1356.9	1443.3	1231.5	1263.8
Soft dough (Start)	1324.4	1373.4	1539.8	1616.0	1425.7	1481.6
Hard dough (Start)	1553.9	1616.0	1698.6	1773.2	1630.8	1679.3
Physiological maturity	1756.7	1825.1	1902.2	1971.8	1842.8	1861.6

HTU accumulation. The slower progression through growth stages allows for more days with temperatures conducive to HTU accumulation, resulting in the observed higher values of HTU in happy seeder sown crop followed by super seeder sown crop and conventional sown crop. Variety PBW-869 accumulated the highest helio-thermal units accumulation (14222.5°C day hours) followed by variety PBW-725 (13461.1°C day hours) sown with happy seeder. In case of super seeder sowing, variety PBW-725 accumulated 12780.0°C day hours helio-thermal units, while variety PBW-869 accumulated 13009.4°C day hours helio-thermal units. On the contrary, conventional sowing resulted in a lower accumulation of HTU because conventional sown crop required less number of days to complete various phenophases. Variety PBW-869 accumulated 12564.1°C day hours and variety PBW-725 accumulated 11769.9°C day hours. Singh (2019) observed that HTU requirement was highest in wheat sown with happy seeder as compared to conventional sowing. Singh et al (2023) also reported similar results and observed more accumulation of HTU in wheat sown with happy seeder due to delayed physiological maturity.

Photo-thermal units (PTUs): Under happy seeder sowing, variety PBW-869 exhibited the highest photo-thermal units (21801.3°C day hours) followed by variety PBW-725 (20922.3°C day hours) as it showed delayed maturity. In happy seeder sowing, the crop undergoes a prolonged vegetative period and takes more days to reach maturity. This extended duration exposes the crops to a greater cumulative amount of heat and light, contributing to higher PTU accumulation. The combination of increased thermal

time (due to more days) and enhanced light exposure under happy seeder sowing conditions results in higher PTU. In super seeder sowing, variety PBW-869 and variety PBW-725 accumulated 20416.0°C day hours and 20182.2°C day hours, respectively. Conventional sowing, which required less number of days to reach maturity, resulted in the lowest accumulation of PTU. Variety PBW-869 and variety PBW-725 accumulated 19962.3 and 19115.8°C day hours, respectively, under conventional sowing (Table 4). Singh (2019) observed similar findings of high PTU requirement in happy seeder sown wheat as compared to conventional sowing.

Heat use efficiency for total biomass: HUE reveals a progressive increase from conventional sowing to super seeder sowing, with the highest HUE observed in happy seeder sowing (Table 5). Specifically, the happy seeder sown crop exhibited a notable HUE of 8.9 kg/ha/°C/day, surpassing the HUE values of 8.8 kg/ha/°C/day for super seeder sowing and 8.6 kg/ha/°C/day for conventional sowing. The higher efficiency in converting heat units into biomass under the happy seeder sowing method may be attributed to the positive influence of residues which is responsible for increased biomass production, leading to the observed higher HUE. Gupta et al (2020) also reported that crops with extended growth duration tend to produce higher biomass.

Helio-thermal use efficiency for total biomass: The happy seeder sowing method exhibited the highest HTUE for total biomass (1.3 kg/ha/°C/day hours), followed by super seeder sowing and conventional sowing (Table 5). This observed pattern in HTUE values suggests that the crop sown with the happy seeder exhibits higher efficiency in utilizing both solar

Table 3. Effect of sowing methods and varieties on accumulated helio-thermal units (°C day hours) of wheat during *rabi* (2022-23)

Phenological stages	Conventional		Happy seeder		Super seeder	
	PBW 725	PBW 869	PBW 725	PBW 869	PBW 725	PBW 869
Complete emergence	186.0	218.0	352.1	462.5	86.0	352.1
CRI	1399.4	1493.8	1699.0	1795.3	1399.4	1599.4
Maximum tillering	3364.0	3586.2	3589.1	3605.2	3502.7	3589.1
Jointing (Start)	3768.5	3773.7	3822.4	3822.4	3788.0	3808.4
Flag leaf (Start)	3843.9	3896.4	4244.5	4350.6	4014.1	4108.0
Booting (Start)	4307.5	4307.5	4965.5	5355.8	4501.6	4703.5
Heading (Start)	5355.8	5364.1	6133.8	6693.5	5516.2	5886.5
Anthesis (Start)	5771.6	5989.5	7130.0	7885.2	6259.4	6549.4
Milking (Start)	7130.0	7287.1	8701.3	9546.5	7450.1	7727.9
Soft dough (Start)	8376.3	8866.3	10113.6	10721.5	9351.1	9929.7
Hard dough (start)	10247.5	10721.5	11468.3	11959.7	10885.8	11339.0
Physiological maturity	11769.9	12564.1	13461.1	14222.5	12780.0	13009.4

radiation and thermal time for biomass production compared to crops sown using super seeder and conventional methods. The likely contributing factor to this higher HTUE in the happy seeder sown crop is the delayed maturation compared to super seeder and conventional sowing. Dar et al (2018) also reported higher helio-thermal use efficiency in crops with delayed maturity.

Photo-thermal use efficiency for total biomass: Photo-thermal use efficiency for total biomass indicated that wheat sown with the happy seeder had the highest value (0.8 kg/ha/°C/day hours) followed by super seeder and conventionally sown crops. The highest PTUE observed under happy seeder sowing can be attributed to the extended duration required to reach maturity, leading to increased biomass compared to super seeder and conventional sowing methods. The prolonged growth period under happy seeder sowing enables the crop to capture more solar radiation and accumulate thermal time, leading to a more efficient conversion of these resources into biomass. Sidhu et al (2020) also observed higher PTUE in wheat sown with the

happy seeder due to the longer duration required for growth.

Radiation use efficiency for total biomass: RUE exhibited a distinct pattern, with happy seeder sown crop recording the highest value (4.0 kg/ha/MJ) followed by super seeder sown crop and conventional sowing method (Table 5). This observed trend in RUE values can be attributed to the superior performance of wheat sown with the happy seeder characterized by enhanced photosynthetically active radiation (PAR) interception and leaf area index (LAI), followed by the super seeder and conventional sowing methods. The greater interception of PAR and higher LAI in the happy seeder sown crop contributed to higher RUE. Priadkina et al (2020) also reported a positive correlation between higher PAR and LAI values and increased radiation use efficiency in wheat.

Heat use efficiency for grain yield: The crop sown using the happy seeder method exhibited the highest HUE (3.1 kg/ha/°C/day) followed by super seeder sown crop and conventional sowing method (Table 5). The higher HUE observed in the happy seeder sown crop may be attributed to

Table 4. Effect of sowing methods and varieties on accumulated photo-thermal units (°C day hours) of wheat under different irrigation treatments during *rabi* 2022-23

Phenological stages	Conventional		Happy seeder		Super seeder	
	PBW 725	PBW 869	PBW 725	PBW 869	PBW 725	PBW 869
Complete emergence	1309.6	1464.0	1609.4	1747.6	1464.0	1609.4
CRI	3089.3	3210.3	3468.2	3586.8	3210.0	3345.5
Maximum tillering	5635.8	5983.7	6144.5	6257.4	6056.0	6144.5
Jointing (Start)	6752.7	6818.4	7117.0	7276.7	6907.0	6988.2
Flag leaf (Start)	7445.9	7522.4	8052.9	8419.4	7887.0	7887.1
Booting (Start)	8227.2	8333.6	9276.3	9734.5	8956.0	8956.2
Heading (Start)	9734.5	9843.3	11056.3	11901.6	10310.0	10555.8
Anthesis (Start)	10422.0	10716.4	12384.4	13424.1	11597.0	11752.1
Milking (Start)	12384.4	12567.2	14320.3	15315.0	13072.0	13256.9
Soft dough (Start)	13947.8	14509.7	16467.7	17391.4	15111.6	15766.8
Hard dough (Start)	16638.1	17391.4	18401.6	19319.6	17756.0	18165.0
Physiological maturity	19115.8	19962.3	20922.3	21801.3	20182.2	20416.0

Table 5. Heat use efficiency, helio-thermal use efficiency, photo-thermal use efficiency and radiation use efficiency of wheat varieties under different sowing methods during *rabi* (2022-23)

Treatments	Heat use efficiency (kg/ha/°C/day)		Helio-thermal use efficiency (kg/ha/°C/day hours)		Photo-thermal use efficiency (kg/ha/°C/day hours)		Radiation use efficiency (kg/ha/MJ)	
	Total biomass	Grain yield	Total biomass	Grain yield	Total biomass	Grain yield	Total biomass	Grain yield
Conventional sown wheat	8.6	3.0	1.2	0.4	0.7	0.2	3.2	1.2
Happy seeder sown wheat	8.9	3.1	1.3	0.5	0.8	0.3	4.0	1.4
Super seeder sown wheat	8.8	3.0	1.3	0.4	0.7	0.2	3.9	1.3

the presence of remaining residues in the field, contributing to a higher grain yield. The residues left in the field under happy seeder sowing are likely to enhance the efficiency of heat energy utilization, leading to higher HUE. Singh (2019) also observed that treatments involving the retention or incorporation of straw in the field tend to use heat energy more effectively compared to treatments without residue retention.

Helio-thermal use efficiency for grain yield: HTUE was highest in the crop sown with the happy seeder (0.5 kg/ha/°C/day hours) followed by super seeder and conventional method (Table 5). This may be due to the longer growth duration associated with wheat sown using the happy seeder sowing followed by super seeder and conventional sowing. Attri and Sandhu (2023) also noted higher helio-thermal use efficiency in crops exhibiting a longer growth duration.

Photo-thermal use efficiency for grain yield: The crop sown with happy seeder exhibited the highest PTUE (0.3 kg/ha/°C/day hours) followed by super seeder sowing crop and conventional sowing (Table 5). The relatively lower grain yield observed in the conventional sowing method compared to the happy seeder and super seeder methods which contributed to the decreased photo-thermal use efficiency in conventional sowing. The positive correlation between delayed maturity and higher PTUE, leading to increased grain yield, was also observed by Gupta et al (2020). This indicates that the prolonged growth duration associated with happy seeder and super seeder methods enhances the efficient utilization of solar radiation and thermal time, leading to elevated PTUE and consequently, augmented grain yield.

Radiation use efficiency for grain yield: The happy seeder exhibited the highest RUE (1.4 kg/ha/MJ) followed by super seeder and conventional sowing (Table 5). This may be due to the reason of more favourable micro-environment under happy seeder sown wheat followed by super seeder and conventional sowing. The improved RUE in the happy seeder sown crop could be attributed to factors such as enhanced soil moisture retention likely facilitated by residue retention. Zhou et al (2021) reported increased RUE in plots with higher moisture retention due to residue retention. The presence of residues in the field, particularly under happy seeder sowing may contribute to improved soil conditions, fostering a micro environment conducive to higher RUE.

Relationship between different agro-meteorological indices and grain yield: Linear regression equation was developed to establish the relationship of GDD, HTU, PTU and HUE with grain yield across different sowing methods (pooled data). The analysis revealed a positive correlation of

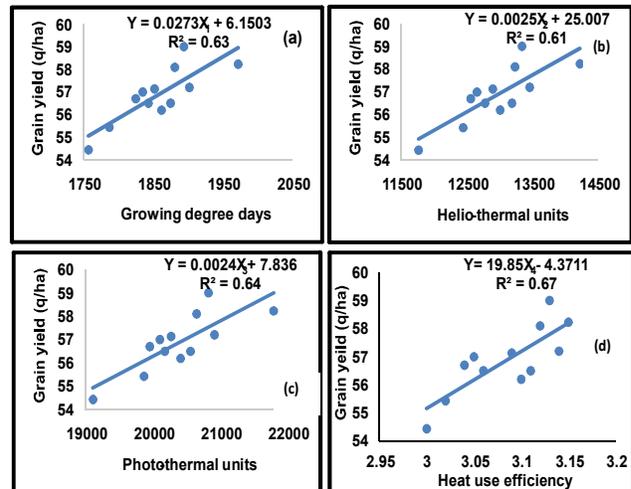


Fig. 1. Relationship between different agro-meteorological indices (GDD (a), HTU (b), PTU (c) and HUE (d)) with grain yield under different sowing methods during *rabi*2022-23

GDD, HTU, PTU, and HUE with grain yield. This positive association suggests that an increase in growing degree days, helio-thermal units, photo-thermal units, and heat use efficiency is associated with higher grain yields (Fig. 1). The coefficient of determination (R^2) values indicated that 63, 61, 64, and 67% of the variation in grain yield can be attributed to growing degree days, helio-thermal units, photo-thermal units, and heat use efficiency, respectively. The linear regression equations derived for different treatments further demonstrated that improvements in accumulated growing degree days (AGDD) and heat use efficiency during various growth stages corresponded to an increase in wheat crop grain yield. Kaur et al (2016) reported a highly significant and linear relationship between grain yield and AGDD. Gupta et al (2020) identified a linear relationship between AGDD and heat use efficiency with grain yield, emphasizing the positive impact of a longer duration taken by wheat to complete phenophases on grain yield. Kaur (2022) also observed a positive relationship between growing degree days and grain yield in wheat. The regression equation developed between different agro-meteorological indices and grain yield is as under:

$$Y = 0.0273X_1 + 6.1503 \quad (R^2 = 0.63)$$

$$Y = 0.0025X_2 + 25.007 \quad (R^2 = 0.61)$$

$$Y = 0.0024X_3 + 7.836 \quad (R^2 = 0.64)$$

$$Y = 19.85X_4 - 4.3711 \quad (R^2 = 0.67)$$

Where;

Y – Grain yield (q/ha)

X_1 – Growing degree days (°C days), X_2 – helio-thermal units (°C day hour), X_3 – photo-thermal units (°C day hour), X_4 – heat use efficiency (kg/ha/°C/days)

CONCLUSION

Wheat sown with happy seeder took more number of days to reach physiological maturity followed by super seeder and conventional sowing. Happy seeder sown crop accumulated the highest GDD, HTU, PTU, HTUE, PTUE, HUE, RUE followed by super seeder and conventional sowing which might be attributable to more number of days taken to reach maturity under happy seeder sown wheat. Variety PBW-869 is a longer duration variety as compared to variety PBW-725, hence it accumulated more agro-meteorological indices. The relationship between different agro-meteorological indices and grain yield were found to be positive which showed that with an increase in GDD, HTU, PTU and HUE, the grain yield also increases. Based on this study, farmers are recommended to adopt the happy seeder sowing method and consider using the PBW-869 variety for higher yields, as this method accumulates more agro-meteorological indices positively correlated with grain yield. Regular monitoring of these indices and integrating this practice with other crop management strategies can enhance wheat productivity and mitigate climate change effects.

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