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Heat use efficiency of winter crops in Haryana

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ABSTRACT

Field experiments were conducted at Reaserch Farm, HAU, Hisar during winter seasons of 1993-94 and 1994-95 with wheat and mustard and 1992-93 and 1993-94 with chickpea. Experimental results indicated highest heat use efficiency (HUE) in wheat in terms of seed yield (2.56 kg ha^{-1} day^{-1} in 1993-94 and 2.18 kg ha^{-1} day^{-1} in 1994-95) as compared to mustard and chickpea crops in that order. HUE values varied between two seasons within dates of planting in three crops. The HUE in terms of dry matter accumulation (DMA) was highest in mustard followed by chickpea and wheat and decreased when planting was delayed after recommended time of sowing for these crops.

Key words: Winter crops, Heat use efficiency, Haryana

Temperature is the prime weather variable which affects plant life. Regardless of how favourable moisture and light may be, plant growth ceases when temperature drops below a critical minimum or exceeds a certain maximum value. Agronomic application of temperature effect on plants is the heat unit concept which had been variously applied to correlate phenological development in crops to predict maturity dates (Nuttonson, 1955 ; Gilmore and Rodgers, 1958 ; Major *et al.*, 1975). Apart from this, heat use efficiency (HUE) i.e., efficiency of utilization of heat in terms of dry matter accumulation is another important aspect which has practical utility as reported for soybean and pigeonpea (Balakrishanan and Natarajaratnam, 1986). Even under best agroclimatic conditions the total heat energy available during crop season is never converted to dry matter. Efficiency of heat energy conversion for dry matter production depends upon genetic factors, crop and sowing time. This study was planned to determine heat use efficiency of winter crops (wheat, mustard and chickpea) in the Hisar region under different sowing dates.

MATERIALS AND METHODS

Experiments were conducted at Research Farm, Haryana Agricultural University, Hisar during winter seasons of 1993-94 and 1994-95 with wheat and mustard and 1992-93 and 1993-94 with chickpea. The crops were grown under non-limiting cultural conditions except for variation in planting dates (Table 1) to provide differential crop growth environments. Air temperature data used in this study were recorded at Agromet Observatory situated within 50 m of the experimental site. Growing degree days (GDD) were calculated by simple arithmetic accmulation of daily mean temperatures above a base temperature value of 5 °C considered for winter crops (Nuttonson, 1955). Thus, GDD is represented as

$$GDD = \frac{Tmax + Tmin}{2} - \text{Base temperature}$$

HUE has been defined in terms of dry matter production as ratio of amount of above ground biomass produced per plant at maturity and accumulated heat units during crop

season. It was calculated as follows:

$$HUE = \frac{\text{Dry matter accumulation (g plant}^{-1})}{\text{Accumulated GDD (}^{0}\text{days)}}$$

HUE in terms of economic yield (seed yield, kg ha^{-1}) was also calculated.

RESULTS AND DISCUSSION

Wheat

Grain yield was the highest in 28th November sown crop and delay in sowing beyond this resulted in significant reduction reflected by poor yield attributes (Table 2). Accumulated dry matter per plant (DMA), accumulated growing degree days (GDD) and heat use efficiency (HUE) at harvest in wheat for two crop seasons have been presented in Table 3. In general, DMA was higher in first three sowing dates during 1993-94 as compared to 1994-95 but was almost similar in the 4th sowing date in two crop seasons. It may be seen that HUE was more consistent in 2nd sowing date as compared to other sowing dates. The low HUE in case of late sown wheat can be expected because of accumulation of higher GDDs since both maximum and minimum temperatures shoot up rapidly in the region during late February and March. The higher temperature during reproductive phase caused enormous deleterious effect on DMA, more so on seed yield of the crop (Table 3 and4). HUE (kg ha^{-1} ^{0}day^{-1}) in terms of economic yield followed the trend observed for DMA except for certain contradictions. The highest (2.56 kg ha^{-1} ^{0}day^{-1}) and lowest HUE (1.67 kg ha^{-1} ^{0}day^{-1}) were recorded with 2nd and 4th seeding dates, respectively in 1993-94 crop season (Table 4). The reason for this variation can be sought in almost equal number of GDDs accumulated in two seasons but a wide gap in

Table 1: Date of sowing and harvest of three crops in different crop seasons

	Season-1		Season-2	
	Sowing	Harvest	Sowing	Harvest
Wheat				
1	08-11-93	03-04-94	08-11-94	31-03-95
2	28-11-93	17-04-94	28-11-94	11-04-95
3	21-12-93	25-04-94	21-12-94	16-04-95
4	08-01-94	28-04-94	08-01-95	20-04-95
Mustard				
1	28-09-93	19-02-94	-	-
2	10-10-93	05-03-94	-	-
3	25-10-93	16-03-94	25-10-94	13-03-95
4	-	-	09-11-94	25-03-95
Chickpea				
1	29-09-92	22-04-93	29-09-93	13-04-94
2	08-10-92	29-04-93	12-10-93	14-04-94
3	25-10-92	05-05-93	28-10-93	17-04-94

Table 2 : Yield and yield attributes of mustard, chikpea and wheat in different crop seasons

Date of sowing	No of Silique m^{-2}	No of seeds siliqua^{-1}	1000-seed wt. (g)	Seed yield (g m^{-2})	Seed yield (q ha^{-1})
Mustard					
28-09-93	4153	11.5	6.3	223.1	21.08
10-10-93	3950	11.4	6.7	201.4	19.82
25-10-93	3541	10.4	5.9	161.7	15.18
CD at 5%	435	NS	NS	20.5	1.56
25-10-94	3308	11.7	6.5	198.4	19.79
09-11-94	2665	10.3	5.3	155.3	15.82
CD at 5%	302	NS	0.6	37.7	2.07
Chikpea					
	No. of pods m^{-2}	No. of seeds pod^{-1}	100-seed wt (g)	Seed yield (g m^{-2})	Seed yield (q ha^{-1})
29-09-92	236	0.94	24.7	52.6	9.71
08-10-92	259	1.00	21.2	57.0	11.89
25-10-92	237	0.67	20.9	53.8	10.93
CD at 5%	11	0.10	1.0	1.9	1.16
29-09-93	210	1.41	17.0	50.3	8.92
12-10-93	211	1.55	17.3	52.6	9.97
28-10-93	182	1.60	17.5	49.5	8.78
CD at 5%	NS	NS	NS	NS	NS
Wheat					
	No.of panicles p^{-1}	1000-seed wt(g)	Seed yield p^{-1} (g)	Seed yield (kg ha^{-1})	
08-11-93	4.4	56.4	8.1	36.19	
28-11-93	4.3	56.9	8.6	38.95	
21-12-93	4.0	55.2	7.9	29.00	
08-01-94	3.9	54.7	7.6	25.12	
CD at 5%	NS	NS	0.8	2.19	
08-11-94	4.5	39.4	7.4	28.92	
28-11-94	4.6	41.2	8.2	32.27	
21-12-94	4.6	36.6	7.1	28.73	
08-01-95	3.8	35.1	6.3	26.86	
CD at 5%	NS	1.2	1.2	2.33	

Table 3 : Heat use efficiency (g plant^{-1} ^{0}day^{-1}, 10^{3}) in terms of dry matter production at maturity of wheat, mustard and chickpea

		Date of sowing											
		1st			2nd			3rd			4th		
Crop	Year	GDD ^{0}days	DMA g plant^{-1}	HUE	GDD ^{0}day	DMA g plant^{-1}	HUE	GDD ^{0}days	DMA g plant^{-1}	HUE	GDD ^{0}days	DMA g plant^{-1}	HUE
Wheat	1993-94	1607	25.3	15.7	1522	23.7	15.6	1570	22.8	14.5	1506	19.2	12.7
	1994-95	1633	23.2	14.2	1478	22.8	15.4	1391	21.7	15.6	1424	20.1	14.1
Mustard	1993-94	1992	1046.9	525.6	1800	954.7	530.4	1634	835.8	511.6	-	-	-
	1994-95	-	-	-	-	-	-	1566	762.1	486.6	1452	696.6	479.4
Chipkea	1992-93	2775	69.0	24.9	2678	61.8	23.1	2507	55.8	22.3	-	-	-
	1993-94	2443	76.5	31.3	2326	63.1	27.1	2122	59.3	27.9	-	-	-

Table 4 : Heat Use efficiency (kg ha^{-1}) in terms of economic yield of wheat, mustard and chickpea

		Date of wowing											
		1st			2nd			3rd			4th		
Crop	Year	GDD ^{0}days	Yield kg ha^{-1}	HUE	GDD ^{0}days	DMA kg ha^{-1}	HUE	GDD ^{0}days	DMA kg ha^{-1}	HUE	GDD ^{0}days	DMA kg plant^{-1}	HUE
Wheat	1993-94	1607	3619	2.25	1522	3895	2.56	1570	2900	1.84	1506	2512	1.67
	1994-95	1633	2892	1.77	1478	3227	2.18	1391	2873	2.07	1424	2686	1.89
Mustard	1993-94	1992	2108	1.06	1800	1982	1.10	1634	1581	0.97	-	-	-
	1994-95	-	-	-	-	-	-	1566	1546	0.99	1452	1045	0.72
Chickpea	1992-93	2775	971	0.35	2678	1189	0.44	2507	1093	0.44	-	-	-
	1993-94	2443	892	0.37	2326	997	0.43	2122	878	0.41	-	-	-

seed yield of two dates. The reduction in seed yield is due to extended vegetative phase because of low temperature initially encountered by late sown crop and exceptionally high temperatures during reproductive and maturity phases resulted in poor sink source development and forced maturity.

Mustard

Initially the experiment was planned with three seeding dates but seeding was not possible in first two dates due to waterlogging in the field. The seed yield in mustard decreased with successive delay in sowing (Table 2). GDDs for various growth intervals were highest in September sown crop and subsequent delay in sowing resulted in reduced GDDs irrespective of crop season (Table 3). Initially low tempertures extended the growing phase in late sown crop and it was particulary true for vegetative phase, where the gain in dry matter was less and slow. Higher temperatures during reproductive phase in late sown crop also curtailed the reproductive phase both in terms of duration and dry matter production per plant which resulted in lower HUE as compared to sowing in September and early October. Obviously the late sowing of mustard resulted in reduced seed yield and decreased HUE in terms of economic yield (Table 4). The highest HUE (2.1kgha^{-1} ^{0}day^{-1}) was recorded with seeding of crop in early October and lowest (0.72 kg ha^{-1} ^{0}day^{-1}) when it was sown in November.

Chickpea

In 1992-93, yield and yield attributes of chickpea were significantly influenced by date of sowing (Table 2). However, no significant influence of sowing date was observed in second crop season. Crop accumulated more GDDs during 1992-93 as compared to 1993-94 (Table 3). HUE (g plant^{-1} ^{0}day^{-1}) at maturity of crop was also higher in first crop season as compared to the latter, this was partly due to lower GDDs in first season and partly due to higher DMA at harvest in the latter crop season (Table 3). HUE in terms of economic yield was highest (0.44kg ha^{-1} ^{0}day^{-1}) in second seeding date (Table 4). In general, HUE in terms of economic yield was the highest in wheat followed by mustard and chickpea (Table 4). Among the crops, chickpea accumulated highest GDDs and recorded lowest yield. On the other hand, wheat was able to produce highest yield while accumulating minimum GDDs.

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