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Effect of temperature variations on growth, dry matter and yield of Wheat *(Triticum aestivum L)* under Mid Himalayan Region of Uttarakhand

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Abstract

Uttarakhand is composed, in parts, of the Himalayan mountain ranges having different altitudes and orientations. Wintertime eastward-moving low-pressure synoptic weather systems (western disturbances) are modified by these orographic barriers. Therefore, advance and proper information of maximum and minimum temperature becomes important for assessing natural hazard threats. The trend analysis for both maximum and minimum temperature using 2-year moving averages was done for the period 2003-2012. It shows moving average trends indicate that maximum temperature is decreasing over the period, while little increasing trend was observed in case of minimum temperature during the period 2003-2012. The experiment was conducted in a two factors randomized block design (RBD) with four replications, three dates of sowing and two varieties viz. UP – 1109 and Sonalika (RR-21) recommended for different sowing environments. Seasonal trends of maximum temperature indicate decreasing trend throughout the year, while minimum temperature shows decreasing trend during rainy season whereas during other three seasons the trend was reverse. The maximum temperature during winter seasons was increasing during the first and last pentad. In general the maximum temperature has shown increasing trend during the last pentad in all the four seasons. Temperature play very important role in flowering and maturity of crops as well as quality parameters also. Due to increasing temperature at the time of vegetative stages, early flowering and maturity has been observed in wheat.

Keywords: dry matter, Himalayan region, temperature, variation

Introduction

Over the hilly areas of the western Himalayas, such as Jammu and Kashmir, Laddakh, Himachal Pradesh and Uttarakhand, knowledge of maximum and minimum temperatures during the winter months is very important for assessing human comfort, cold weather conditions, avalanche release, state of snow and frost. Maximum and minimum temperatures at a specific location depend upon the season, synoptic conditions and local parameters, including orography, land-use and vegetation cover. It is difficult to predict location-specific surface weather elements over complex mountainous regions by state-of-the-art numerical weather prediction (NWP) models, so statistical relationships are developed between a variable, which is to be predicted at the location of interest (predictand) and nearby observed values of surface and upper-air weather elements (predictors).

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Uttarakhand state has varied topographical features ranging from high hills to Tarai thereby the state experiences different climatic conditions. The plains and valleys are hotter in summers as compared to hills. The valleys are cooler in winters. The region has wide variations in topography as well as weather. Agriculture is mainly rainfed. Major problems are low temperature, erratic distribution of rainfall and short growing season. The major crops of the region are small millets, under-utilized crops like amaranth, rice bean, buck wheat etc. Irrigated rice is grown predominantly in valleys and upland rice is cultivated at higher elevations. The mid hill regions of the state supports off season vegetable crops (Murty *et al.* 2002). The temperatures fall rapidly during October and drops down to subzero temperature during winter in the region. The fall in temperature greatly influences the crop growth and agricultural production. In mid Himalayan region during grain filling stage of amaranth, even 1°C drop in minimum temperature in October, drastic yield reduction was observed (Murty and Singh, 2002).

The diurnal temperature variations in the region are small therefore, temperature plays and important role in crop production. Hence an attempt is made to study the temperature variation in mid Himalayas region. Such studies have attempted by different authors in different parts of the India (Pant and Hingane, 1988 Jain and Dubey, 1991, Samui and Gupta, 1992, Attri *et al.* 1995).

Material and Methods

The daily meteorological data of Ranichauri (longitude of 78^0 02' E, (latitude of 30^0 15, N and an altitude of 1950 m msl) in mid Himalayan region of Uttarakhand for the period 2003-2012 was utilized for the study. The daily maximum and minimum temperatures were converted to monthly, seasonal and yearly average for statistical analysis. The temperature trends were determined using 2-year moving averages. The soil moisture percentage measured at periodic interval of 15 days during the crop season .The growing degree days (GDD) and actual evapotranspiration (AEt) values derived from Thornthwaite method during different Phenological stages of crop growth and their dates of occurrence. The total dry matter (g/ m^2) and plant height (cm) were recorded at various growth stages of crop. The yield and yield contributing characters viz, 1000 seed weight, number of plants/m^2, number of spikelet/panicle were recorded at the time of harvesting.

Results and Discussion

The trend and moving average of both maximum and minimum temperatures were calculated and the results are as follows: The maximum and minimum temperature trends are presented in Table 1. The trend of minimum temperature from 2003-2012 indicates very little increasing trend while the moving average trends show slight decline in temperatures. Similar results were reported by Ram sing (2003). He was observed that in maximum number of months the minimum temperature departure was near normal followed by decrease in minimum temperature at Hisar. The maximum temperature (Fig.1) trend was decreased over the period of study. Compared to the minimum temperature the deviation of maximum temperature was decreased over the period of study. Compared to the minimum temperature the deviation of maximum temperature was less. The data is almost following the trend line. The trend line equations are presented in Fig.1.

The seasonal analysis indicates that the minimum temperature shows an increasing trend during, winter and post monsoon seasons while a sharp decline was observed during summer season. The temperature variation was more in rainy season and less in post rainy season. The standard deviation (SD) and Mean of maximum and minimum temperatures are presented in Table 2. The soil moisture percentage measured at periodic interval of 15 days presented in table 3. The soil moisture varied between 7.9 and 29.13% across different depths during the crop season. The growing degree days (GDD) and actual evapotranspiration (AEt) values derived from Thornthwaite method during different phonological stages of crop growth and their dates of occurrence are given in table 4.

Though wheat crop were sown on three different dates with an interval of 20 days, the crop sown on I^{st}, II^{nd} and III^{rd} dates germinated on 26/11/2012, 19/12/2012 & 06/01/2013 on receipt of rains of 2.4 mm on 22/10/2011 and 6.1 mm on 9 &10^{th} Dec 2011. Due to very low temperature prevailed in the region during winter season coupled with dew & no rainfall from October 23, 2011 to Dec 08, 2011, the germination and other phenological stages occurred on different dates in I^{st}, II^{nd} and III^{rd} date of sowing during the crop season. The growing degree days and actual evapotranspiration decreased as sowings were delayed. The growing degree days varied between 1352.95 & 1376.10 across the dates of sowing. The total dry matter (TDM) during different growth stages is presented in table 5. The total dry matter varied between 132.341 and 579.136 g/m^2 across dates of sowing and varieties. With first date of sowing, both the varieties produced highest biomass of 594.331 g/m^2, 570.778 g/m^2 respectively. The total dry matter and growing degree days were correlated. The correlation was found to be significant (r = 0.919). The plant height measured during different growth stages is presented in table 6. The highest plant height of 88.8 cm and 74.2 cm was observed with Second date of sowing in case of varieties UP-1109 and Sonalika with I^{st}date of sowing respectively. However, the plant height was decreased as the sowings were delayed. A correlation was found between plant height and growing degree days during different growth

stages. The correlation was found to be significant (r=0.971).The plant characteristics like 1000 seed weight, number of plants/m^2, number of spikelet/panicle etc. are presented in table 7. The average number of spikelet/panicle was 38 in both the varieties. The number of plants/ m^2 was 185, 179 and 168 in variety UP-1109 with respect to I^{st}, II^{nd} and III^{rd} date of sowing respectively. The number of panicles/m^2 varied from 144 to 162. Similarly, the number of grains/m^2 varied between 5242 and 7162. The 1000 seed weight was around 40.00 g across varieties and dates of sowing.The seed yield as influenced by different dates of sowing and varieties is presented in table 7. The highest seed yield of 1782.48 kg/ha was recorded with second date of sowing. Across dates of sowing, variety UP-1109 produced 1782.48 kg/ha while variety Sonalika produced 1489.55 kg/ha.

Table: 1: Seasonal Variation of Temperature °C (Maximum and Minimum)

S. No	Period	% Winter (Dec-Feb)		% Summer (Mar-May)		% Monsoon (Jun-Sep)		% Post Monsoon (Oct-Nov)	
		Max. Temp	Mini. Temp	Max. Temp	Mini. Temp	Max. Temp	Mini. Temp	Max. Temp	Mini. Temp
1.	**2003-04**	13.0	2.2	23.1	10.5	23.6	15.1	18.6	6.5
2.	**2005-06**	15.0	3.7	22.1	9.9	23.9	15.5	19.5	7.9
3.	**2007-08**	13.4	2.6	21.9	9.9	23.0	15.3	19.4	7.8
4.	**2009-10**	14.4	3.7	23.4	11.5	23.6	15.9	19.3	8.0
5.	**2011-12**	16.5	5.8	21.3	9.9	22.0	12.4	19.6	8.3

Table: 2: Seasonal variation of Temperature °C (Maximum andMinimum)

Seasons	Temperature °C			
	Maximum		Minimum	
	Mean	SD	Mean	SD
Winter	14.48	1.39	3.58	1.41
Summer	22.36	0.90	10.36	0.69
Rainy	23.22	0.74	14.48	1.41
Post rainy	19.28	0.41	7.70	0.68

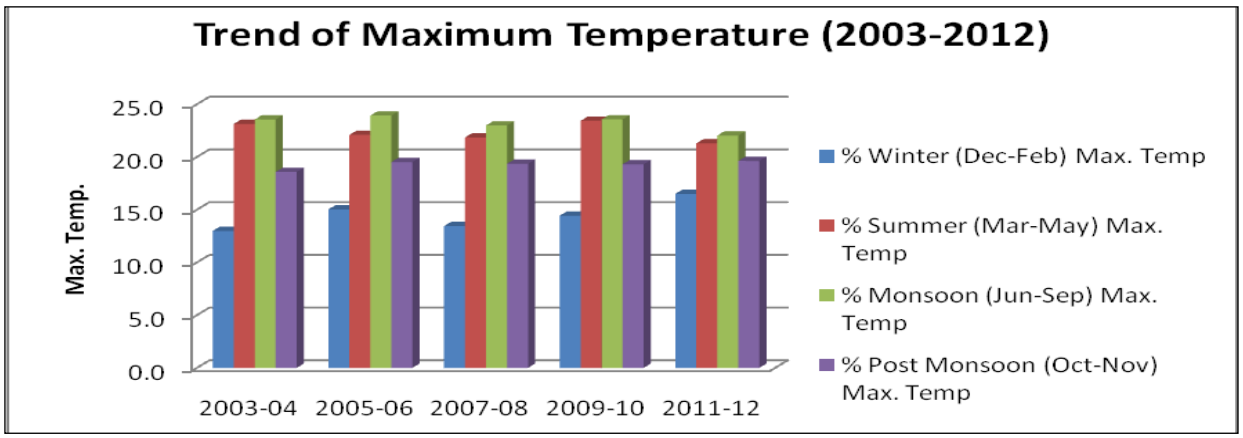
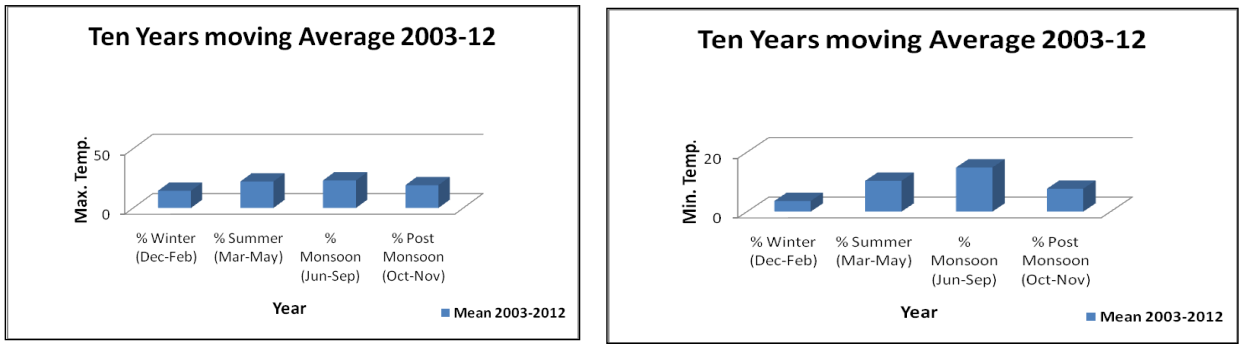


Fig. 1: Showing trend of maximum temperature

Fig. 2: Showing ten years moving average



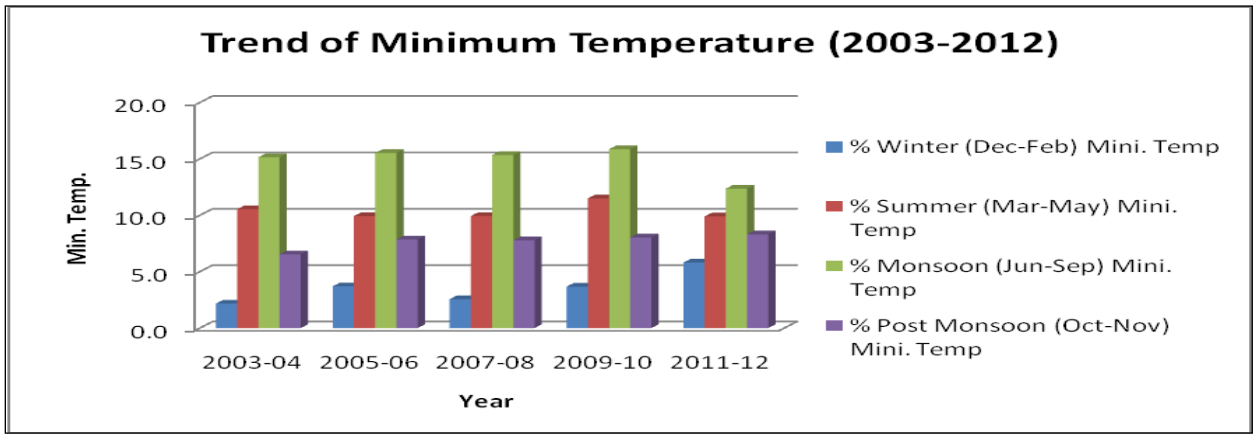


Fig. 3: Showing trend of minimum temperature

Table 3: Soil moisture (%) measured at different growth stages of crop

Date	Depth (cm)		
	0 – 15	15 – 30	30-45
30.10.12	16.6	28.7	29.1
20.11.12	14.1	16.5	15.8
10.11.12	17.6	18.6	20.1
26.12.12	17.0	14.8	19.8
11.01.12	22.6	24.4	21.9
29.01.13	22.1	22.1	21.65
10.02.13	26.7	25.1	27.9
25.02.13	18.9	22.7	24.6
10.03.13	21.4	24.8	22.6
25.03.13	19.3	21.4	20.5
10.04.13	10.6	12.8	16.9
25.04.13	12.3	14.5	14.9
10.05.13	7.9	11.1	12.4

Table 4: **GDD at different Phenological stages and date of its occurrence**

Phenological Stage		Date of occurrence	Growing degree days
Germination	D1	26.12.12	313.45
	D2	28.12.12	168.00
	D3	01.01.13	66.85
CRI Stage	D1	10.02.13	384.60
	D2	25.02.13	276.55
	D3	11.03.13	275.85
Tillering	D1	12.02.13	395.70
	D2	28.02.13	295.65
	D3	15.03.13	308.65
Jointing	D1	26.02.13	431.70
	D2	10.03.13	377.85
	D3	20.03.13	344.90
Anthesis	D1	11.04.13	814.45
	D2	14.04.13	700.60
	D3	17.04.13	624.40
Milking	D1	23.04.13	950.75
	D2	26.05.13	1280.95
	D3	01.05.13	791.85
Harvesting	D1	23.05.13	1376.10
	D2	30.05.13	1352.95
	D3	07.06.13	1366.75

Table 5: Total dry matter (g/m^2) during different growth stages of crop

	Dates of Sampling			
	30.03.12	**15.04.12**	**30.04.12**	**15.05.12**
I Date of Sowing				
UP – 1109	226.113	318.161	430.281	579.136
Sonalika	190.364	273.534	410.127	574.469
II Date of Sowing				
UP – 1109	191.361	276.610	419.193	480.185
Sonalika	189.183	279.130	454.567	540.237
III Date of Sowing				
UP – 1109	176.564	284.543	401.141	568.326
Sonalika	132.341	229.981	387.126	516.617

The significant difference in seed yield was observed due to different dates of sowing, the first date of sowing produced highest yield in case of UP-1109 while, Sonalika produce the highest yield in second date of sowing. Though, the yields due to varieties and interaction between dates & varieties were not significant. The performance of wheat during rabi season 2012-13 was found to be satisfactory with second and second dates of sowing only due to even distribution of rainfall during the crop season, even then the amount of rainfall was below normal the requirement of the crop/normal rainfall throughout the season.

Table 6: Plant height (cm) measured during different growth stages of crop

Treatments	Dates of Sampling			
	30.03.12	15.04.12	30.04.12	15.05.12
I Date of Sowing				
UP – 1109	46.6	58.5	76.7	81.1
Sonalika	44.4	54.3	73.0	85.2
II Date of Sowing				
UP – 1109	35.0	52.2	62.4	88.8
Sonalika	35.3	53.9	65.6	83.5
III Date of Sowing				
UP – 1109	32.1	43.1	54.5	76.1
Sonalika	30.6	41.6	52.2	74.2

Table 7: Yield and yield attributes of wheat

Treatment	No of Spikelet/Panicle	No of Grain/m^2	No of Panicle/m^2	1000 Seed Weight (g)	No of Plant/m^2	Mean Yield (kg/ha)
I Date of Sowing						
UP – 1109	41	5940	156	41.336	179	1729.13
Sonalika	38	5836	158	39.632	177	1308.15
II Date of Sowing						
UP - 1109	43	7162	162	41.963	185	1782.48
Sonalika	38	5880	158	40.113	176	1489.55
III Date of Sowing						
UP - 1109	36	5368	149	37.194	168	1579.20
Sonalika	35	5242	144	38.380	169	1160.80

Therefore, early and normal sowing of wheat crop is recommended under rainfed condition in mid Himalayan region. Late sowing of the crop is not recommended since it germinates late on receipt of rainfall followed by low temperature in Jan & Feb months and also low rainfall in March/April month coincides with peak growth period of the crop.

Early, normal and late sown crops in the Kharif season germinated well and thereafter the crops suffered slightly due to the excess moisture and high humidity prevailed in the region throughout the season due to the excess rainfall from July and August months coincides with grand growth stage. Thereafter seed setting stage of the most of the kharif crops, resulting into the performance of the kharif crops were not good and production below normal yields especially in underutilized crops. The performance of Rabi crops (2012-13) was in general not satisfactory due to dry condition attributed by low rainfall during Rabi season. However, the crops suffered from moisture stress during the terminal stages of the crop. The overall performance of rabi crops was satisfactory due to optimum temperature for proper growth, development, flowering, maturity and yield of wheat. From the above studies it can be concluded that the maximum temperature as shown decreasing trend while the minimum temperature is almost

stable during the period of study at College of Forestry & Hill Agriculture, Ranichauri. The seasonal variation of minimum temperature has indicated that the trends are increasing in all the seasons except rainy season.

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