

GOVERNMENT OF PAKISTAN

PAKISTAN METEOROLOGICAL DEPARTMENT

Study on:
WEATHER AND WHEAT DEVELOPMENT IN
TANDO JAM REGION
2013-2014

BY

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ABSTRACT

Agriculture still plays a predominant role in future in order to produce earnings to meet rapidly increasing food demands and to increase foreign exchange earnings by accrued agricultural commodity export. Any changes in agricultural productivity send a ripple effect through out the rural population of any country. Rapid agricultural growth can stimulate and thus sustain the pace of industrial growth, thus setting into motion a mutually reinforcing process of sustained economic growth.

This report is an effort on the part of author to make an analysis of both Meteorological & Phenological observation along with the soil moisture at different phonological stages of wheat crop. Air temperatures (Min & Max), pan evaporation, soil temperatures at different depth and heat units/ degree days were also incorporated at different stages during the crop growth period.

It is unassailable verity that soil temperature plays a crucial role from germination to maturity and was recorded during the crop growing period from 5 cm to 110 cm depth. Soil temperature suffered sharp diurnal changes and seasonal variations. However, the soil temperatures n the major rooting depth remained in normal limits supporting optimal growth and development in Hyderabad division.

From table-4 it is evident that the crop accumulated 2205 heat units during its life cycle.

INTRODUCTION

Agriculture has an important direct and indirect role in generating economic growth. The importance of agriculture to the economy is seen in three ways, first it provides food to consumers and fibers for domestic industry, second it is source of scarce foreign exchange earnings and third it provides market for industrial goods. Besides other requirements for standard yield like better genotypes of any crop for growers, low prices of input which include fertilizers and weedicides, timely irrigation and fertilizer, suitable range of various meteorological parameters is essential for the enhancement of crop yields.

Wheat is major food cereal crop in Pakistan. It is essentially better from nutritional point of view than the most cereals and other food staples. In Pakistan, spring wheat is grown as Rabi crop in Sindh, Punjab, N.W.F.P and Balochistan provinces. In the northern parts of Balochistan, some winter wheat is cultivated on a small scale. It is grown on an area of about 8.5 million hectares in Pakistan.

For the last few years, Pakistan has become self sufficient in wheat production. The situation must be improved by adopting crop management and modern technology in agriculture. This task must be accomplished by the joint efforts of agriculturists and meteorologists. In Pakistan wheat is the most important food crop. The largest cropped area is devoted to wheat, which is about 8.5 million hectares and quantity produced is more than that of 2.9% to GDP.

The life cycle of wheat crop in the plains of Pakistan approximately covers the period October – November to March – April. After the moon soon, the sowing of wheat is regulated by the point reached in the slow cooling of seed –bed. Towards harvest, when the crop has to ripen under a rapidly ascending temperature when the hot dry winds are frequent. At both – ends, therefore, the growth period is temperature limited, a fact which not only restricts the choice of the varieties to early maturing types, which grow rapidly, but also influences the geographical distribution of the crop. The wheat season become shorter in the direction north to south in correspondence with the duration of winter, which decreases in the same direction? The crops take 140 -160 days to mature in northern region, 120 – 140 days in the central region and 100 – 120 days in the southern part. The yield per unit area and spread of the crop are lower in the southern region than in the northern region.

This study was conducted during 2013 -2014 in the Experimental field of plant physiology section of Sindh Agriculture Research Institute Tando Jam, located in the north- east at about 50 m of Agro met Observatory of R.A.M.C Tando Jam. The study permits the wheat variety TD-1 which was sown on 20-11-2013. The study will provide a base to estimate the optimum ranges of various meteorological parameters for getting highest yield of the particular crop variety grown under different Agro- climate conditions.

Table - the basic details about the cultivar.

FOCAL OBJECTIVES OF THE REPORT

- To investigate the impact of various meteorological parameters on crop growth and development
- To manage to increase yield parameters of wheat crop in the irrigated area of Pakistan
- To find the water satisfaction sensitivity of crop in Tando Jam region
- To find the relationship between weather parameters and crops life cycle

- To determine the onset of pests and diseases related to weather elements
- To prepare data for the development of crop wheat – weather model
- To make an attempt for formulation of Yield estimation mechanism

MATERIALS AND METHOD

This study was conducted during 2013-2014 in Experimental field of plant physiology section of Sindh Agriculture Research Institute Tando Jam located in the north–east 50m of Agro met Observatory of R.A.M.C Tando Jam. The study permits the wheat variety TD-1 which was sown on 20-11-2013.

For this purpose both meteorological and crop data were recorded during the crop season. In order to compile the data of each development stage, careful, precise and timely recording of the following parameters were undertaken at 0300, 0900 and 1200 (UTC) as routine practice.

Crop data including Phonological and soil moisture observation were collected according to World Meteorological Organization (WMO). The seeding rate was 50 Kg/acre.

1.1 METEOROLOGICAL PARAMETERS

Following meteorological parameters were recorded and observed which are listed in Table -1.

Table -1: OBSERVED METEOROLOGICAL PARAMETERS

1.	Air temperature (°C)
2.	Maximum and Minimum Temperature (°C)
3.	Soil Temperature (°C)
4.	Relative Humidity (%)
5.	Precipitation (mm)
6.	Pan Evaporation at (0300 & 1200 UTC)
7.	Bright Sunshine Hours.
8.	Wind speed (Km/Hr) & Wind Direction
9.	Soil Moisture (%)

1.2 PHONOLOGICAL STAGES

Generally the field selected for Phonological observation should be of one hectare size. The area of field selected for observation was one acre and it was divided into 4 replications. Over all 10 plants were selected from each replication (pheno–phase trials). These plants were tagged in a row in each replication. Thus Phonological observations were recorded on 40 plants and continued throughout the

period on the same plants. Following Phonological phases were particularly identified from the observed data.

1. Emergence
2. Third Leaf
3. Till ring
4. Shooting (Stem Extension)
5. Heading (Earring)
6. Flowering
7. Milk Maturity
8. Wax Maturity
9. Full Maturity

1.3 PHONOLOGICAL OBSERVATIONS

Number of plants in a particular Phonological phase at a time were observed from each replication on every Monday, Wednesday and Saturday and recorded on the prescribed Performa.

When 10% of the selected plants were in certain phase, that particular phase was considered to be started. If 50% of the selected plants displayed a certain phase, that phase was considered to be in full swing. Similarly, 75% occurrence of a certain phase displayed by the selected plants was considered as completion of that particular phase and next Phonological phase observations were started at their proper time. Thus next phonological stage is not bound to appear after the completion of first one. It has been observed that at a time two phases exist.

Table -2: PHASE WISE REFERENCE CROP EVAPOTRANSPIRATION (ETO) DURING GROWING SEASON

Station: R.A.M.C Tando Jam **Season:** Rabi (2013 –14) **Crop Variety:** TD -1

Observed Phonological Stage	Period (75%) Occurrence	Days	Mean Temp: Range	Mean R.H (%)	Mean Wind Speed (m/s)	Pan Evap: (mm) day	ET0 mm /day	Total ET0 (mm)	Total Bright Sun shine Hours
Sowing	20-11-2013		23.7	51	0.4	3.6	***	***	
Germination	22-11-2013 to 30-11-2013	09	22.0-23.5	56	0.5	3.0	***	***	78.8
Emergence	03-12-2013 to 07-12-2013	05	20.7-22.0	53	0.8	2.1	***	***	44.6
Third Leaf	10-12-2013 to 25-12-2013	16	12.5-21.7	62	0.7	2.5	***	***	133.3
Tillering	28-12-2013 to 07-01-2014	11	10.0-14.5	44	1.0	2.6	***	***	99.5

Shooting	10-01-2014 to 23-01-2014	14	12.5-16.5	53	3.2	2.5	***	***	121.9
Heading	26-01-2014 to 04-02-2014	10	17.0-20.7	54	0.7	2.8	***	***	78.5
Flowering	07-02-2014 to 17-02-2014	11	14.7-19.0	45	0.9	3.4	***	***	93.6
Milk Maturity	20-02-2014 to 01-03-2014	10	18.0-20.7	50	1.1	3.5	***	***	91.8
Wax Maturity	03-03-2014 to 09-03-2014	07	20.0-24.5	61	0.9	4.0	***	***	58.3
Full Maturity	12-03-2014 to 23-03-2014	12	20.5-26.7	45	1.3	4.5	***	***	116.5
Harvesting	10-04-2014								

Table – 3: SOIL MOISTURE AT DIFFERENT PHENOLOGICAL STAGES (%)

Date	05cm	10cm	20cm	30cm	40cm	50cm	70cm	90cm	110cm
02-12-0213	28.9	26.9	24.1	22.0	24.6	27.4	27.4	25.1	29.5
07-12-2013	24.2	25.5	25.6	25.9	21.5	24.2	25.9	26.6	25.4
17-12-2013	25.0	27.4	22.4	25.4	23.8	27.3	27.5	26.0	23.3
27-12-2013	Not Attached due to Wet field								
07-01-2014	26.1	25.8	24.0	27.4	25.2	26.8	26.4	27.4	23.4
17-01-2014	26.2	26.8	25.1	26.5	22.6	28.0	28.3	28.4	27.9
27-01-2014	Not Attached due to irrigation								
07-02-2014	25.2	22.5	27.9	25.2	27.0	27.5	27.3	28.1	25.0
17-02-2014	Not Attached due to irrigation								
26-02-2014	24.8	28.2	23.9	22.6	22.5	26.0	24.7	24.6	22.3
07-03-2014	Not Attached due to Wet field								
17-03-2014	26.6	26.4	29.2	23.5	25.1	28.8	26.1	23.8	24.5
27-03-2014	26.7	23.4	28.3	22.1	23.2	26.0	28.9	27.2	24.2

1.4 SOIL MOISTURE OBSERVATIONS

The soil samples were taken on 7th, 17th and 27th of each month next day the soil samples were also taken if some anomalous event occurred in any month in four replications at 5, 10, 20, 30, 40, 50, 70, 90 and 110 cm depths. The soil samples were taken with the help of auger and then weighed and dried in the oven for about 8 hours. Thus soil moisture present in the soil was calculated by the difference of wet and dry weights of soil. Moisture contents of the soil varied by the dry and wet spells throughout the season. These fluctuations were more prominent in the shallow layers of the soil from surface to 50cm. After each effective irrigation or rain the moisture level increased in the shallow layers as compared to deep layers of the soil. Followed by somewhat dry spell, the soil moisture slightly decreased in shallow layers.

2 - THERMAL REGIME

2.1 HEAT UNITS REQUIREMENTS OF DIFFERENT PHASES FROM 5C THRESHOLDS

The idea of degree days has been used to calculate heat units requirements of different phases from 5c threshold level which is biological zero for wheat .Biological zero is the temperature below which growth of plant ceases. This concept assumes that a given variety (cultivar) of a plant requires the same summation (K) of the daily mean temperature fore-going from one Phonological stage to next stage, regardless of temperature, distribution. Generally, only positive values above the biological zero (Tb) are considered. The period of negative value is termed as dormant because no growth of crop takes place under such situation.

Inter phase period for wheat crop during 2013-14 and corresponding heat units at Tando Jam observed at different phonological stages. Heat unit requirements of different phases and cumulative heat units for the crop have been worked out are shown in Table-4. Maximum heat units 2205 were accumulated from wax maturity to full maturity.

Table – 4: HEAT UNITS ACCUMULATION AND INTER PHASE PERIOD FOR WHEAT CROP

S.No	Inter phase	Period	No. of Days Taken	Cumulative Total	Degree Days (T-5C)	Cumulative Frequency $\Sigma (T - 5)$
1.	Sowing – Emergence	20-11-2013 to 02-12-2013	13	13	296	296
2.	Emergence - Third leaf	03-12-2013 to 31-12-2013	17	30	185	481
3.	Third leaf – Tillering	01-01-2014 to 20-01-2014	20	50	267	748
4.	Tillering – Shooting	21-01-2014 to 02-02-2014	12	62	174	922
5.	Shooting – Heading	03-02-2014 to 10-02-2014	10	72	172	1094

6.	Heading – Flowering	11-02-2014 to 02-03-2014	17	89	310	1404
7.	Flowering-Milk maturity	03-03-2014 to 20-03-2014	13	102	244	1648
8.	Milk maturity – Wax maturity	21-03-2014 to 01-04-2014	12	114	261	1909
9.	Wax maturity – Full maturity	02-04-2014 to 08-04-2014	12	126	296	2205
10.	Date of Harvesting	10-04-2014				

Table -5: MEAN MONTHLY SOIL TEMPERATURE IN DEGREE CENTIGRADE DURING 2013-14 FOR WHEAT VARIETY TD-1 AT R.A.M.C TANDO JAM (DEPTH IN CM)

Month	5 cm	10cm	20 cm	30 cm	50 cm	100 cm
Nov- 13	25.2	27.7	25.3	25.4	26.8	*
Dec- 13	20.2	21.5	20.6	21.3	23.5	*
Jan-14	16.7	16.9	16.7	17.4	18.7	*
Feb-14	21.1	20.3	19.8	20.2	20.8	*
Mar-14	27.1	26.4	24.4	24.3	24.0	*
April-14	34.8	32.9	31.0	30.0	29.2	*

3.1 SOIL TEMPERATURES (°C) DURING RABI SEASON 2013 -14

Soil temperature plays an important role in crop growing period, right from the germination to maturity.

To measure soil temperatures, the soil thermometers were installed at different depths to monitor the thermal regime of the soil. The soil temperatures in c were recorded three times a day at 0300, 0900 and 1200 (GMT) time lags Pakistan Standard Time (PST) by 5 hours. The depth at which the soil temperatures were observed on daily basis includes 5 cm, 10 cm, 20 cm, 30 cm, 50 cm and 100 cm depths. It was observed that major root concentration centered between 30 cm to 4 cm depth which is just close to the rooting depth of wheat in such soils. Mean monthly temperature from November, 2013 to April, 2014 are shown in Table - 6 given below.

Table -6: MEAN MONTHLY TEMPERATURE DURING RABI SEASON 2013-14 AT R.A.M.C TANDO JAM

MONTHS	TEMPERATURE (°C)			ABSOLUTE		Mean Temp ≤ 0	Mean Temp ≥ 5°C R.H ≤ 30%	Max: Temp ≥ 40°C R.H ≤ 30%	Rainfall (mm)
	Mean	Mean Max	Mean Min	Max	Min				
NOV – 13	22.8 (24.6)	30.8 (31.9)	14.8 (17.3)	35.5 (41.0)	12.0 (6.0)	0	0	0	(00) (2.1)
DEC -13	18.0 (19.8)	25.9 (26.3)	10.3 (12.5)	32.0 (35.6)	1.5 (3.0)	0	0	0	(00) (2.0)
JAN -14	15.1 (18.1)	23.4 (25.0)	7.0 (11.1)	31.0 (35.0)	2.0 (-1.0)	0	0	0	(00) (1.2)
FEB -14	18.2 (20.9)	26.5 (28.1)	10.0 (13.6)	29.0 (39.0)	5.0 (2.0)	0	0	0	(00) (3.9)
MAR -14	23.8 (26.2)	32.0 (33.9)	15.6 (18.5)	37.0 (47.0)	11.0 (5.0)	0	0	0	(00) (5.1)
April-14	30.0	39.2	21.1	44.5	15.0	0	0	0	(3.0)
Date of Harvesting	10-04-2014								

3.2 AIR TEMPERATURE DURING RABI SEASON 2013-14 AT R.A.M.C TANDO JAM

Detail of Mean monthly Air Temperature, Monthly Mean Maximum and Minimum Temperature and absolute Max and Min Temperatures in °C is presented in Table-6.

Here we see that the mean air temperature during the crop life varied between 15.1 to 23.8°C, mean max 23.4 - 32.0°C and mean minimum from 7.0 - 15.6°C . The highest temperature was recorded in the month of March 37.0°C where as the lowest temperature was recorded in the month of December 1.5°C.

Number of moderate ($\geq 35^{\circ}\text{C}$ & $\text{R.H} \leq 30\%$) and severe ($\geq 40^{\circ}\text{C}$ & $\text{R.H} \leq 30\%$) hygrothermal stress days has also been noted for each month during the entire crop growth period. No day of moderate hygrothermal stress and severe hygrothermal stress has been registered during the crop life cycle.

OTHER METEOROLOGICAL PARAMETERS

Monthly total precipitation (mm) data and monthly mean reference crop Evapotranspiration (ET_o) (mm/day), solar radiation, wind speed (Km/ hr), Direction & Relative Humidity (%) are also given in Table -7 below. The frequency of occurrence of very wet days with relative humidity $\geq 80\%$ is also included, Normal values of each meteorological element are also shown in parenthesis.

Table -7: SUMMARY OF METEOROLOGICAL PARAMETERS

Months	Precipitation (mm)		Wind		Mean R.H %	No of days with mean R.H ≥80 %	Bright Sun Shine Hours	Solar Radiation MJ/M2/day	ETo Mm /day
	Total	Rainy days	Speed Km/hr	Direction					
Nov-13	00 (2.1)	00	0.8 (5.1)	N (N)	52 (47)	00	262.0 (279.5)	***	***
Dec-13	00 (2.0)	00	1.3 (4.9)	NE (N)	56 (49)	01	267.4 (271.1)	***	***
Jan-14	00 (1.2)	00	1.6 (5.2)	N (N)	52 (48)	00	272.8 (270.6)	***	***
Feb-14	00 (3.9)	00	1.2 (5.7)	N (N)	50 (45)	00	238.6 (253.9)	***	***
Mar-14	00 (5.1)	00	2.2 (5.7)	N (W)	49 (43)	00	277.5 (286.0)	***	***
Apr-14	3.0	02	2.7	SW	43	00	301.6	***	***

4- AGRO METEOROLOGICAL SUMMARY OF CROP CYCLE AT PHONOLOGICAL STAGES

Mean air temperature & relative humidity were recorded at various phases of wheat crop during 2013-14. The mean air temperature range and mean relative humidity & soil temperature at seed depth were favorable for germination and emergence of seedlings. The temperature regime at different phonological stages of wheat crop is discussed below.

EMERGENCE

Emergence phase was distinguished by the appearance of cotyledons. When plant emergence stage was completed, the field was divided into four replications. The mean relative humidity was 53% at the time of emergence. Mean air temperature during emergence was found to be 20.7-22.0°C. However optimum ranges vary generally for all varieties of wheat crop. Soil temperature at the sowing depth was 25.2 – 26.8°C.

THIRD LEAF

In third leaf phase, with 75% occurrence, mean relative humidity was about 62% and mean air temperature ranges between 12.5 – 21.5°C. This phase ended up to 25-12-2013.

TILLERING

This stage of crop growth started on 28-12-2013 and 75% occurrence was completed on 07-01-2014. The mean air temperature ranged between 10.0 – 14.5°C and mean relative humidity was 44%. This phase was considered as the active period of tillering process, although it continued during shooting also.

SHOOTING

This is the most important growth period of plant development. During this stage stem extension occurred in the crop. For the wheat crop, mean air temperature ranged between 12.5-16.5°C the soil temperature at the sowing depth remained 16.7-18.7°C at 5cm depth, while the relative humidity remained 53%.

HEADING

It was the initiation of reproductive stage of wheat crop. Heading stage started on 26-01-2014 and was completed 04-02-2014. The mean air temperature was about 17.0- 20.7°C, During this stage, soil temperature was 19.8-20.8°C at 5cm depth and mean relative humidity was 54%.

FLOWERING

Flowering started in the first week of February and completed till second week of February. Mean air temperature was recorded 14.7 – 19.0 C and mean relative humidity was 45%.

MILK MATURITY

Wheat has varying requirements for temperature and soil moisture during seed formation. This phase started on 20-02-2014 and ended on 01-03-2014. The mean air temperature was recorded as 18.0 – 20.7 C and mean relative humidity was 50%.

WAX MATURITY

This started on 03-03-2014 and ended on 09-03-2014. The mean air temperature ranged 20.0 – 24.5 C. The mean relative humidity during this phase was 61%.

FULL MATURITY

Wheat requires high temperature at this stage. The mean relative humidity at this stage was 45%, mean air temperature recorded was 20.5 – 26.7 C. The highest temperature recorded at this stage was 37.0 C. The crop was matured for harvesting 10-04-2014.

6- RESULTS & DICUSSIONS

Pakistan is a land of tremendous development possibilities by virtue of its unique geographical location and richness of natural and cultural resources. There are two growing seasons of crops in Pakistan i.e., Kharif and Rabi. The Rabi season starts in Pakistan from the mid of October and remains up to the end of November. The crop under discussion TD-1 is a late variety and it is sown up to mid of December.

It is evident from Table-7 that the mean air temperature during the crop life varied from 15.1°C to 23.8°C.

Mean Max: from 23.4°C to 32.0°C and mean Min: from 7.0°C to 15.6°C. The highest temperature was recorded in the month of March and was noted 37.0°C whereas the lowest temperature was recorded in the month of December and was noted 1.5°C .All these values of temperature are near to normal values. Because of these factors the of wheat crop in Tando jam as well as in adjoining areas remains satisfactory compared to last two years.

CONCLUSION

It is concluded from result that from the result that the crop from germination to full maturity, all the meteorological parameters remained normal. No rainfall observed from Emergence to full maturity. All these factors resulted into satisfactory yield of wheat during the Rabi season 2013-14.

Table -8: SUMMARY OF INFORMATION ABOUT WHEAT TD - 1 CULTIVAR

RAMC: TANDOJAM Latitude: 25°40' Longitude: 68°43' Elevation: 19.5m

Farm: A.R.I. TANDOJAM (Plant physiology Field)

1.	Field Size	4.5 Acre
2.	Crop Variety	Wheat- TD 1
3.	Date of Sowing	20-11-2013
4.	Pesticide used	Nil
5.	Quantity of seed per acre	50-kgs /acre
6.	Row spacing	30 cm
7.	Type of irrigation	Tube well + Irrigation water
8.	Recommended and supply dose of fertilizer quantity	1 bag of DAP/ acre 1 bag urea @ first irrigation 1 bag urea @ second irrigation 1bag urea @ third irrigation.
9.	Irrigation scheduling	1 st 20-11-2013, 2 nd 06-12-2013, 3 rd 07-01-2014, 4 th 25,26-01-2014, 5 th 05-02-2014, 6 th 06-03-2014
10.	Total days from sowing to harvest	118 days
11.	Date of harvesting	10-04-2014
12.	Yield	1200 Kg/acre (30 Man)
13.	Maximum yield of variety	1200 to 1400 Kg / acre (30 to 35 Man)
14.	Chemical spraying information (no. of practices)	Nil
15.	Date of any severe bad weather event like wind storm/heavy rain fall	Nil
16.	Information about any pest attack on the crop including date of commencement and duration	Nil
17.	Information pre-sowing practices	1-Soaking doze on 23-04-2013 2-Two deep ploughing with leveling. 3-Two shallow ploughing after soaking doze