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Effect of weather parameter on growth and yield of wheat under different growing environment in bastar plateau zone

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Abstract
The IGKV funded research work was carried out during *Rabi* 2016 at Instructional cum Research Farm of Shaheed Gundadhoor College and Agricultural Research Station, Kumhrawand, Jagdalpur (C.G.). It comes under bastar plateau of Chhattisgarh which comprises of large plateau having elevation of 553 m above mean sea level and lies between 17°46' N and 20°34' N latitudes and 80°15' and 82°15' E longitudes. The treatments consisted of three different date of sowing viz., D_1- 1st December, D_2- 10th December and D_3- 20th December 2016 and three wheat varieties viz., V_1- Ratan, V_2- GW273 and V_3- GW366, in factorial randomized block design with three replications.
These results lead to conclusion that wheat optimum sowing date for bastar region is first fortnight of December. The date of sowing treatment D_1-1st December registered 4250 kgha-1, followed by D_2-10th December 4070 kg ha-1 of grain yield. The verities did not influenced yield statistically.

Keywords: weather parameter, growing environment, bastar plateau

Introduction

Wheat is the world's number one cereal crop after rice, grown under diverse agro- climatic conditions, contributing nearly one-third of total food grains production. This grown is not only in the temperate zone but also in tropical and sub-tropical zones. Major wheat producing countries of the world are China, India, United States of America, France, Russia, Canada, Germany, Turkey, Australia, Ukraine, and Pakistan. In India crop is grown in an area of 302.27 lakh ha. With the production 93.50 million tons and productivity of 3093 kg ha-1.
Anonymous 2015 [4]. Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Graur, 1995) [6]. Temperature is an important climatic factor which has profound effects on the yield of *rabi* crops. Changes in temperature affect the grain yield, mainly through phenological development processes. Winter crops are especially vulnerable to high temperature during reproductive stages and differential response to temperature change (rise) to various crops has been noticed under different production environments. The productivity of wheat is largely dependent on the magnitude of temperature change. In Chhattisgarh, wheat is sown in an area of 0.171 million hectares out of which 0.063 Million hectare area is irrigated and 0.108 million hectare area is unirrigated, with the total production of 181000 metric tons and productivity 1140 kg ha-1 (Anonymous, 2014) [3]. In Bastar, wheat is grown mostly under irrigated conditions in a rice based cropping system. The sowing of wheat is often delayed due to delay in harvesting of medium and late duration rice varieties. Late sown wheat crop faces high temperature during grain filling and ripening phases which is one of the major causes of stunted growth and low productivity of wheat in this area. Time of sowing is one of the most important factors which govern the crop phenological development and total biomass production along with the efficient conversion of biomass into economic yield. Delayed sowing of the wheat crop is exposed to sub- optimal temperatures at the establishment and supra-optimal temperatures at reproductive phases resulting into reduction of not only crop duration but also the yield (Sardana *et al*., 1999) [13]. Temperature based agro meteorological indices such as growing degree days (GDD), photo thermal units (PTU), helio thermal units (HTU), Radiation use efficiency (RUE) and heat use efficiency (HUE) can be quite useful in predicting growth and yield of crops. Growing degree days are based on the concept that real time to attain a phonological stage is linearly related to

temperature in the range between base temperature (Tb) and optimum temperature (Monteith, 1981). Heat use efficiency (HUE), i.e. efficiency of utilization of heat in terms of dry matter accumulation is an important aspect, which has great practical application. The total heat energy available to any crop is never completely converted to dry matter under even the most favorable agro climatic conditions. The efficiency of conversion of heat energy into biomass depends upon genetic factors, sowing time and crop type (Rao *et al*., 1999) [11]. A lot of work has been done on dates of sowing in India. However, very little work has been done in Bastar on the effect of weather parameters particularly temperature during crop growing season. Considering all above fact the experiment was conducted to study the "Effect of weather parameter on growth and yield of wheat under different growing environment".

Materials and Methods

The IGKV funded research work was carried out during *Rabi* 2016 at Instructional cum Research Farm of Shaheed Gundadhur College and Agricultural Research Station, Kumhrawand, Jagdalpur (C.G.). It comes under Bastar plateau of Chhattisgarh which comprises of large plateau having elevation of 553 m above mean sea level and lies between 17°46' N and 20°34' N latitudes and 80°15' and 82°15' E longitudes. The treatments consisted of three different date of sowing viz; D_1- 1stDecember, D_2- 10thDecember and D_3- 20thDecember 2016 and three wheat varieties viz., V_1- Ratan, V_2- GW273 and V_3- GW366,in factorial randomized block design with three replications. The experimental soil was *Vertisol*. The available nitrogen, phosphorus and potash 245, 12 and 338 kg ha-1 respectively, low in nitrogen & phosphorus and high potash contents. Seed rate of 120kg ha-1 was used with spacing 20cm in all treatments. The crop was fertilized with N: P: K (100: 60:40) kg ha-1 respectively. The Following formulas were used to calculate the agro-meteorological indices which are as given below:

1. Growing degree days

Growing degree days (GDD) concept assumes that there is a direct and linear relationship between growth and developments of plants and temperature and the growth is dependent on the total amount of heat units to which it is subjected during its life time. The growing degree days was computed by using following formula:

$$GDD = \Sigma\ [(TX + TN)/2 – \text{Base temperature}]$$

Where, Tx = Daily maximum temperature, Tn = Daily minimum temperature The base temperature which is considered 5oC for *rabi* crops.

2. Photo thermal unit (PTU)

PTU is calculated by multiplying GDD with maximum possible sunshine hours (N).

$$PTU = GDD\ X\ N$$

Where, N = maximum possible sunshine hours.

3. Helio Thermal Unit (HTU)

HTU is calculated by multiplying GDD with actual sunshine hours (n).

$$HTU = GDD\ X\ n$$

Where, n = actual sunshine hour.

4. Heat use efficiency (HUE)

Heat use efficiency (HUE) for total dry matter was obtained with help of following formula.

HUE (g/m2 / 0 day) = Biomass (g m-2) / GDD (0days)

5. Radiation Use Efficiency (RUE)

RUE (gMJ-1) = Biomass (g m-2) / IPAR (M J m-2day-1)

Where, IPAR is cumulative intercepted photo synthetically active radiation. The photo synthetic active radiation can be calculated by using the following formula

$$PAR = Rs\ X\ 0.5$$

Where, Rs = incoming solar radiation (MJm-2)

The incoming solar radiation can be calculated by the formula

$$Rs = Rs0\ (a + b * n/N)$$

Where, Rso= Extra-terrestrial radiation (MJm-2)

n = Bright sunshine hours, N = Possible sunshine hours, a = 0.18, b = 0.5

Result and Discussion

Yield attributes, yield and harvest index

The data on yield attributes, yield and harvest index as influenced by different growing environments are presented in Table 1. The parameters viz., number of ear head m-2, length of ear, number of grains ear -1 and harvest index were not influenced by different sowing dates. However, significantly highest test weight and yield registered under treatment D_1 (1st December), which was at par with treatment D_2 (10th December). Further, the number of ear head m-2, yield and harvest index were found non-significant for varieties. The variety GW- 273(V_2) found significantly superior and registered highest number of ear head m-2 (50.0) over rest of the treatments**.** However**,** number of grains ear -1 and test weight were significantly highest under treatment variety GW-366 (V_3). Wheat is thermo- sensitive, photo-insensitive and long day plant. The best wheat is produced with the cool moist weather during the major portion of the life cycle followed by dry warm weather during grain filling and maturity period. In Bastar the duration of cool periods is very less. Winter wheat generally complete their life-cycle most rapidly when given low temperatures during the early stages of growth but a long day and high temperature during the later stages of growth. (Bobade 2010) [5].

Heat Units

Growing degree day (GDD): The data on growing degree days accumulated by variety under various growing environment from emergence to harvesting are presented in Table 2. The highest value of accumulated GDD was recorded under treatment D_1 (1 December) (Fig 1, 2 & 3) by all three tasted varieties. Rajput *et al* 1987 [12] and Agrawal *et al* 1999 [2] were also reported similar finding.

Photo Thermal Unit (PTU): Different varieties responded differently in terms of accumulated photo thermal units (PTU) from sowing to harvest stage are presented in Table 3. The value of photo thermal unit computed during the course of investigation indicated that it was highest under D_1 (1st December) for all three varieties tested followed by D_2 (10th December) and D_3 (20th December) growing environment.

Overall highest value of PTU was (20338) recorded with variety GW-366 under D_1 sown crop followed by GW-273 (19097) and Ratan (18527).

Helio thermal unit (HTU): The calculated value of accumulated Helio Thermal units recorded (HTU) at various stages of crop for different varieties of wheat grown in different dates are presented in Table 4. The helio-thermal units observed highest in first date of sowing under all the varieties tested followed by D_3 and D_2 sowing date (Fig 1, 2, 3, 4 &5). In overall GW-366 recorded maximum value of HTU (13993) at harvest stage followed by GW-273 (13030) and Ratan (12680).

Heat use efficiency (HUE):- Heat Use Efficiency (HUE) for different varieties under different growing environments varied considerably Table 5. Highest HUE was observed with wheat variety Ratan D3 sown during (20th December).While, minimum HUE was observed with same variety sown during D1 (1st December) (Fig.1, 2, 3, 4 & 5).

Radiation Use Efficiency (RUE):- Radiation Use Efficiency (RUE) of different varieties recorded under different growing environments varied considerably Table 6. On the mean basis highest RUE value was observed under D_3 (20th December) with variety (V_1) Ratan while lowest with same date of sowing with variety V (3) GW-366 (Fig. 1, 2, 3, 4 & 5).
The values of accumulated GDD, PTU, HTU, HUE and RUE for each phenophase are relatively constant and independent of sowing date but vary in a crop from variety to variety (Phadnawis and Saini, 1992) [10].

Conclusion
These results lead to conclusion that wheat optimum sowing date for Bastar region is first fortnight of December. The date of sowing treatment D_1-1st December registered 4250 kg ha-1, followed by D_2-10th December 4070 kg ha-1 of grain yield. The varieties did not influenced grain yield statistically.

Table 1: Yield attributes, yield and harvest index of wheat as influenced by different growing environment

Treatment	No. of ears (m2)	Length of ear (cm)	No. of grains ear-1	Grain yield (kg ha-1)	Test weight (g)	Harvest index (%)
D_1- 1st December	104	48	249	4250	46	61.45
D_2- 10th December	109	44	233	4070	43	59.32
D_3- 20th December	129	46	227	3639	42	58.00
SE (m)	8.87	0.79	6.10	139	0.73	2.05
CD at 0.05%	N. S.	N. S.	N. S.	418	2.21	N. S.
V_1-Ratan	109	47	222	3782	41	62.93
V_2-GW-273	118	50	200	4044	40	57.22
V_3-GW- 366	115	40	286	4134	50	58.62
SEm±	8.87	0.79	6.10	139	0.73	2.05
CD (P=0.05	N. S.	2.37	18.3	N. S.	2.21	N. S.

Table 2: Accumulated growing degree days (GDD) at different growth stages of wheat varieties as influenced by different growing environments

Treatment	Emergences	CRI	Tillering	Ears emergences	50% flowering	Dough	Maturity
D1-1-12-2016							
V1-Ratan	112	330	394	818	1124	1522	1639
V2-GW- 273	96	330	412	802	1095	1539	1686
V3-GW- 366	96	313	412	818	1268	1555	1790
D2- 10-12-2016							
V1-Ratan	86	320	404	935	1142	1496	1588
V2-GW- 273	86	337	420	902	1060	1511	1602
V3-GW- 366	86	320	434	848	1125	1527	1708
D3- 2012-2016							
V1-Ratan	99	344	429	826	1058	1419	1567
V2-GW- 273	99	326	412	796	1023	1434	1581
V3-GW- 366	81	344	429	781	1109	1403	1606

Table 3: Accumulated Photo Thermal Units (PTU) at different growth stages of wheat varieties as influenced by different growing environment

Treatment	Emergences	CRI	Tillering	Ears Emergences	50% flowering	Dough	Maturity
D1-1-12-2016							
V1-Ratan	1055	3492	4213	8992	12486	17129	18527
V2-GW- 273	873	3492	4414	8812	12146	17324	19097
V3-GW- 366	873	3492	4414	8992	14164	17524	20338
D2- 10-12-2016							
V1-Ratan	964	3578	4536	10557	12958	17142	18237
V2-GW- 273	964	3777	4709	10171	12013	17319	18413
V3-GW- 366	964	3578	4874	9551	12766	17508	19683
D3- 2012-2016							
V1-Ratan	1106	3873	4830	9357	12048	16338	18118
V2-GW- 273	1106	3668	4636	9001	11644	16518	18276
V3-GW- 366	905	3873	4830	8838	12640	16150	18587

Table 4: Accumulated Helio thermal Units (HTU) at different growth stages of wheat varieties as influenced by different growing environment

Treatment	Emergences	CRI	Tillering	Ears Emergences	50% flowering	Dough	Maturity
D1-1-12-2016							
V1-Ratan	816	2169	2647	5817	8313	11785	12680
V2-GW- 273	695	2169	2778	5682	8056	11934	13030
V3-GW- 366	695	2046	2778	5817	9302	12075	13993
D2- 10-12-2016							
V1-Ratan	391	2099	2674	6886	8455	11557	12452
V2-GW- 273	391	2237	2768	6585	7816	11698	12562
V3-GW- 366	391	2099	2890	6151	8286	11860	13520
D3- 2012-2016							
V1-Ratan	732	2540	3106	6397	8289	11432	12732
V2-GW- 273	732	2399	2947	6131	7934	11576	12798
V3-GW- 366	601	2540	3106	6010	8772	11280	13015

Table 5: Heat use efficiency (HUE) at different growth stages of wheat varieties as influenced by different growing environment

Treatment	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
D1-1-12-2016							
V1-Ratan	0.007	0.007	0.014	0.009	0.024	0.019	0.019
V2-GW- 273	0.015	0.005	0.014	0.011	0.034	0.022	0.012
V3- GW- 366	0.016	0.002	0.017	0.011	0.021	0.027	0.015
D2- 10-12-2016							
V1-Ratan	0.003	0.003	0.0131	0.002	0.021	0.023	0.022
V2-GW- 273	0.005	0.005	0.842	0.006	0.024	0.025	0.025
V3- GW- 366	0.002	0.001	0.078	0.004	0.024	0.019	0.017
D3- 2012-2016							
V1-Ratan	0.008	0.003	0.018	0.013	0.050	0.017	0.016
V2-GW- 273	0.007	0.004	0.020	0.017	0.034	0.024	0.022
V3- GW 366	0.005	0.004	0.013	0.012	0.034	0.020	0.019

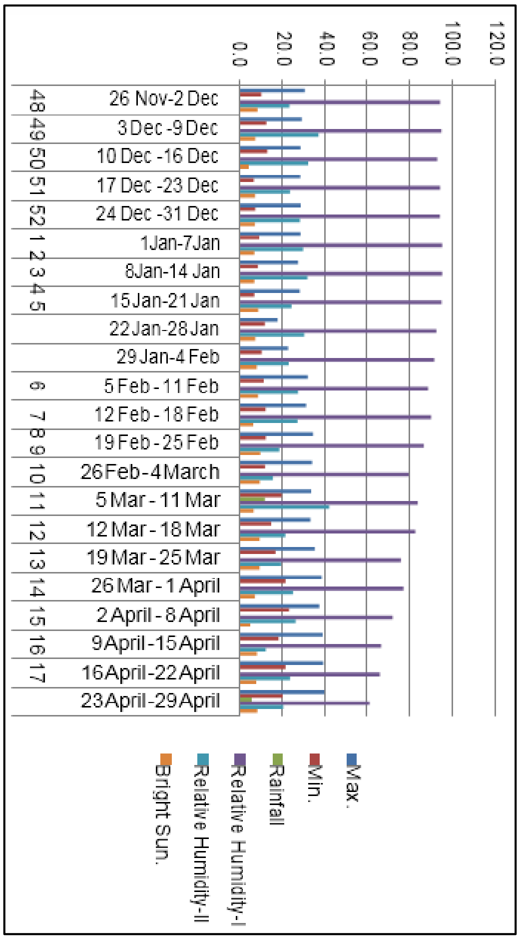

Fig 1: Weather condition during crop period.

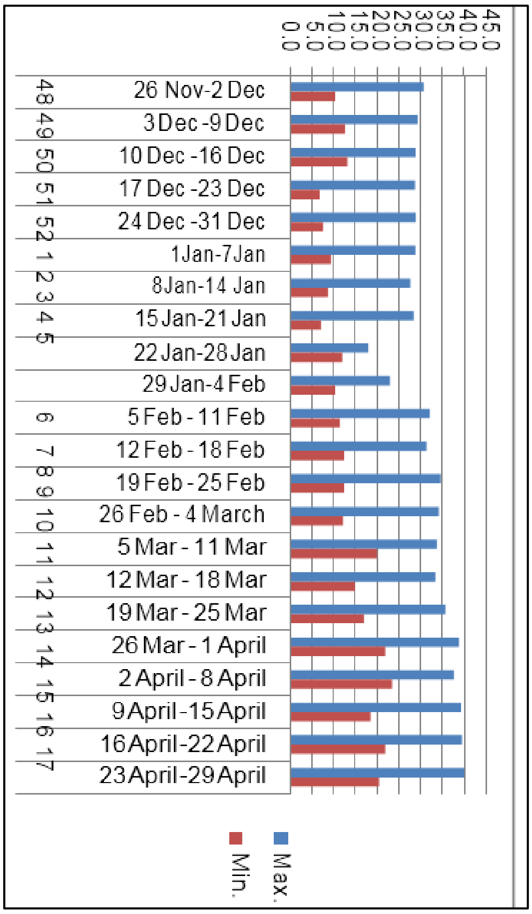

Fig 2: Max and Min temperature (^{0}C) during crop growth period.

Table 6: Radiation use efficiency (RUE) at different growth stages of wheat varieties as influenced by different growing environment

Treatment	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
D1-1-12-2016							
V1-Ratan	0.012	0.014	0.027	0.049	0.059	0.031	0.078
V2-GW- 273	0.015	0.024	0.036	0.050	0.073	0.041	0.097
V3-GW- 366	0.014	0.017	0.037	0.044	0.076	0.035	0.066
D2- 10-12-2016							
V1-Ratan	0.003	0.005	0.015	0.046	0.065	0.062	0.067
V2-GW- 273	0.007	0.022	0.020	0.071	0.064	0.055	0.070
V3- GW- 366	0.002	0.007	0.015	0.060	0.056	0.034	0.071
D3- 2012-2016							
V1-Ratan	0.011	0.018	0.031	0.042	0.048	0.038	0.140
V2-GW- 273	0.012	0.017	0.044	0.051	0.074	0.059	0.100
V3-GW- 366	0.008	0.018	0.021	0.037	0.051	0.041	0.101

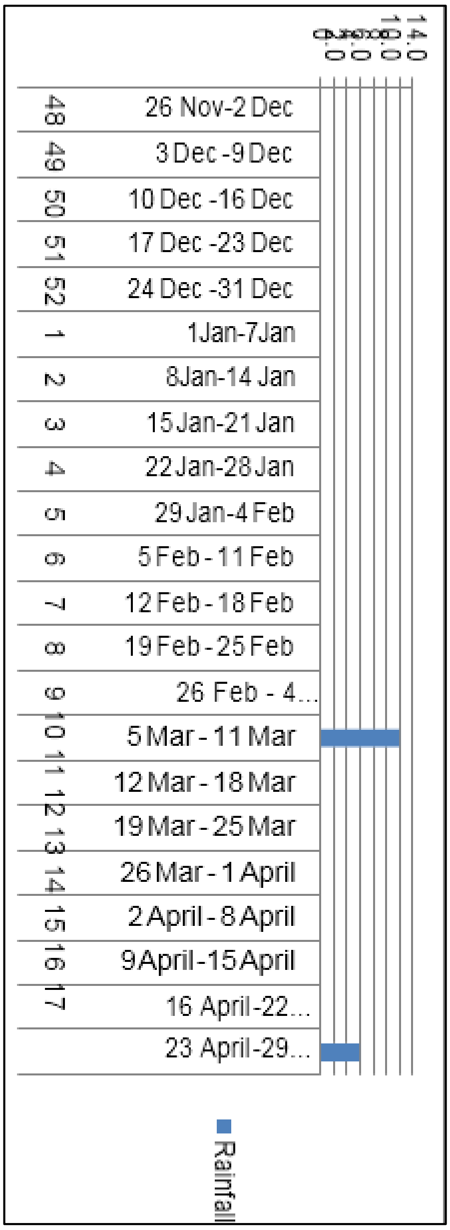

Fig 3: Rainfall (mm) during crop growth period.

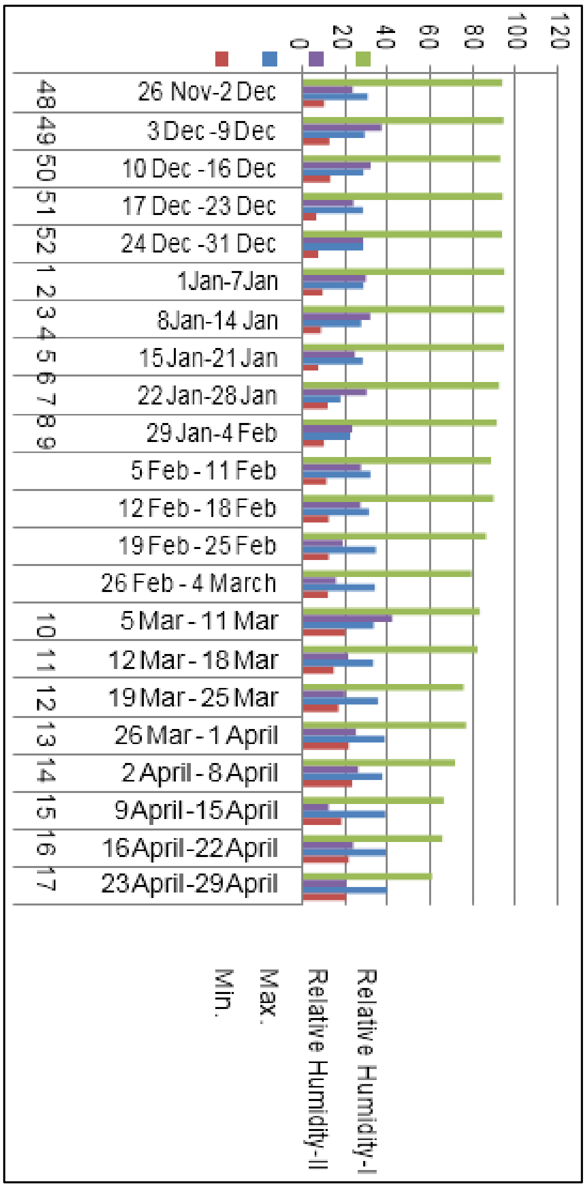

Fig 4: Relative humidity (%) during crop growth period.

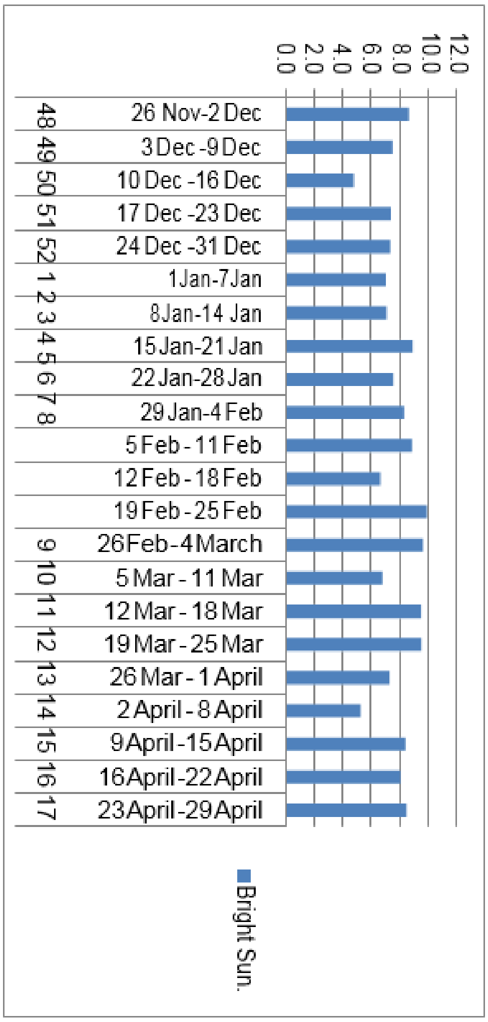

Fig 5: Bright sunshine hour during crop growth period.

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