Journal of Agrometeorology 22 (4) : 524-527 (December 2020)

Short Communication

Assessing the effect of weather parameters on wheat yield of Nadia district of West Bengal

SARATHI SAHA*, SAON BANERJEE and ASIS MUKHERJEE

Department of Agricultural Meteorology and Physics, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, India
**Corresponding Author:sarathisaha94@gmail.com*

Wheat (*Tritium aestivum* L.) is an extensively consumed food grain with greatest trade worldwide. It is one of the most popular and major cereals grown in India. India produced 103.60 million tonne of wheat during 2018-19 and has achieved a bumper production of 106.21 million tonne in 2019-20 as per the government record (Business standard, 2020). West Bengal ranks 10th among the Indian states in terms of production with 8.744 lakh metric tonne of wheat produced from more than 3 lakh hectares of land. Wheat productivity of West Bengal is about 2700 kg ha^{-1} (Jegede, 2020). Appropriate time of cultivation of wheat in India as well as in West Bengal is from November to March. However, the growing period of wheat differs in different regions due to climatic variations that directly impact the vegetative and reproductive stages leading to yield variation. Like all other crops, wheat production is also influenced by the collective effects of climate, genetical traits and management practices. Among them, climatic factor is the uncontrollable one. Crop performance is greatly dependent on the behaviour of weather elements like solar radiation, air temperature, relative humidity and bright sunshine hours. Ambient temperature and rainfall are the most essential parameters during grain filling stage for higher production of wheat. Excessive heat stress during reproductive stages may lead to severe crop loss by damaging grain filling of wheat (Kumar *et. al.,* 2013). Sufficient rainfall assures yield enhancement of the crops. According to the second estimate of foodgrain production released by Agriculture Ministry, the 10 per cent higher cumulative rainfall during the monsoon season (June-September 2019) than the Long Period Average (LPA) helped to attain higher than their normal production for most of the crops including wheat in the year 2019-20 in the country (Business standard, 2020).West Bengal is a non-conventional wheat growing state and comparatively fewer documents are available on the impacts of weather parameters on the wheat production of this state. The present study aims at describing the complex relationship of weather parameters with yield of wheat in Nadia District of West Bengal. As per Statistical Abstract of2015,Nadia is the highest producer of wheat in West Bengal in terms of percent distribution of yield. It has contributed 7.24% of total yield of the state (Government of India, 2017). Here we have considered maximum temperature, minimum temperature, bright sunshine hours and rainfall as prime weather parameters for wheat-weather relationship study.

The weather data was collected from the Agromet-observatory of Bidhan Chandra Krishi Viswavidyalaya, (Latitude: 22p 58' N; Longitude: 88p 31' E; 9.75 m above mean sea level) Kalyani, West Bengal. Kalyani being a part of Nadia district, the measured parameters from the observatory represent the average weather condition of the entire district on real time basis. This location comes under the new alluvial zone of lower Gangetic West Bengal. The detailed information on wheat yield of Nadia district for 18 seasons (1996-1997 to 2013-2014) was collected from Government of West Bengal for carrying out the study (Govt of West Bengal, 2015). Among the said 18 seasons, some seasons were identified either as season of good yield or poor yield. The values of yield exceeding "mean + SD" values were considered as good yield where as poor yield was having values less than "mean – SD" values. Thus, the seasons 2010-2011 to 2013-2014 were denoted as good yield seasons with 3078, 3320, 3366 and 3406 kg ha^{-1} yield respectively and the season 2003-2004 had a poor yield of 1882 kg ha^{-1}(Table 1). Weather data of wheat growing season of the 18 seasons were also collected. Then the correlation values between yield and weather parameters were worked out. The identification of prevailing weather parameters responsible for good yield was also done. Thus, impact of weather on wheat yield was evaluated through the present study. As per the wheat growing condition in West Bengal, the entire crop growth period was divided into eight fortnightly (FN) sections starting from November 2nd Fortnight (2FN) to March 1st fortnight (1FN) for convenience of the study. The vegetative stage, consisting of germination, CRI, tillering and jointing, continues during Nov 2FN to Jan

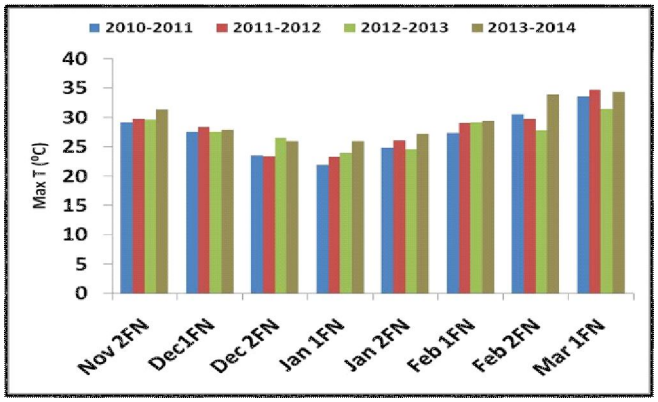

Fig. 1: Variation of maximum temperature throughout the growth period of wheat during seasons of good yield

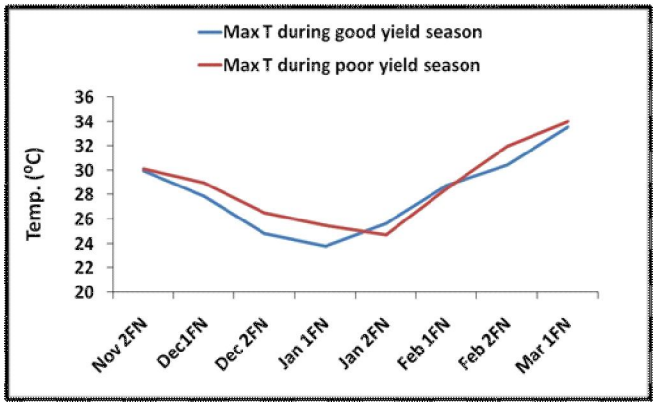

Fig.3: Prevailing max. temp. during different growth stages of wheat for the seasons when good and poor yield were obtained

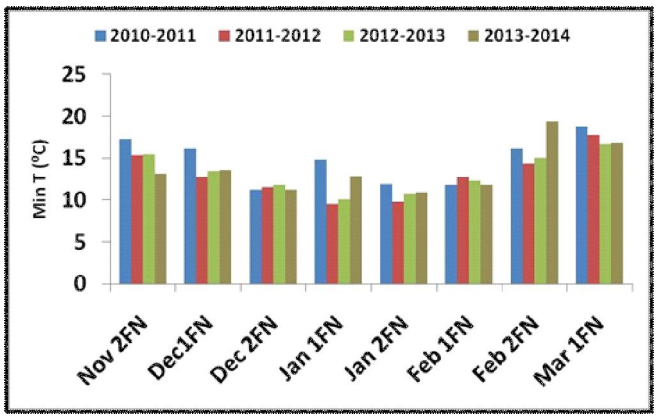

Fig.2: Variation of minimum temperature throughout the growth period of wheat during seasons of good yield

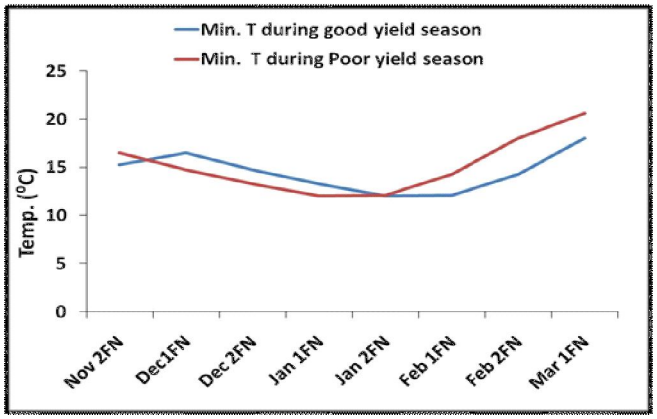

Fig.4: Prevailing Min. T during different growth stages of wheat for the seasons when good and poor yield were obtained

Table1: Year wise yield data of wheat

Season	Wheat yield(kg ha^{-1})	Season	Wheat yield(kg ha^{-1})
1996-1997	2256	2005-2006	2188
1997-1998	2158	2006-2007	2328
1998-1999	2301	2007-2008	2348
1999-2000	2458	2008-2009	2549
2000-2001	2014	2009-2010	2536
2001-2002	2172	2010-2011	3078
2002-2003	2292	2011-2012	3320
2003-2004	1882	2012-2013	3366
2004-2005	2135	2013-2014	3406

mean Mean=2488,SD= 475.85 "mean + SD" =2964 "mean – SD" = 2012Seasons with good yield: 2010-2011, 2011-2012, 2012-2013 and 2013-2014 Seasonwith poor yield: 2003-2004

1FN in the study region. Reproductive stage, covering both flowering and grain formation, is observed during Jan 2FN and Feb 1FN. The last two fortnights covered ripening and maturity phases of the crop.

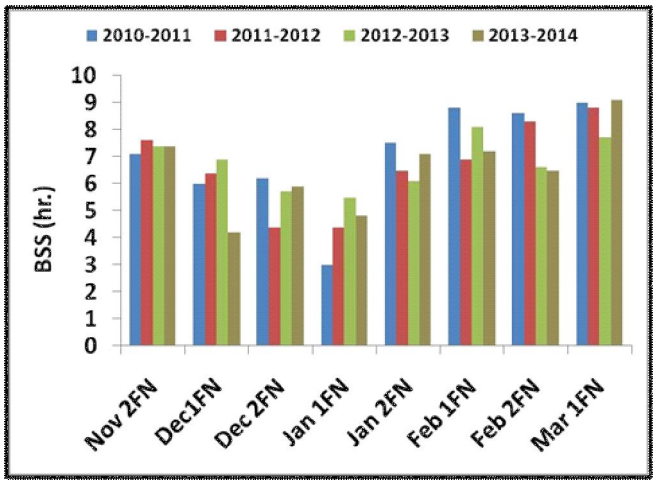

Fig.5: Variation of bright sun shine hour through out the growth period of wheat during seasons of good yield

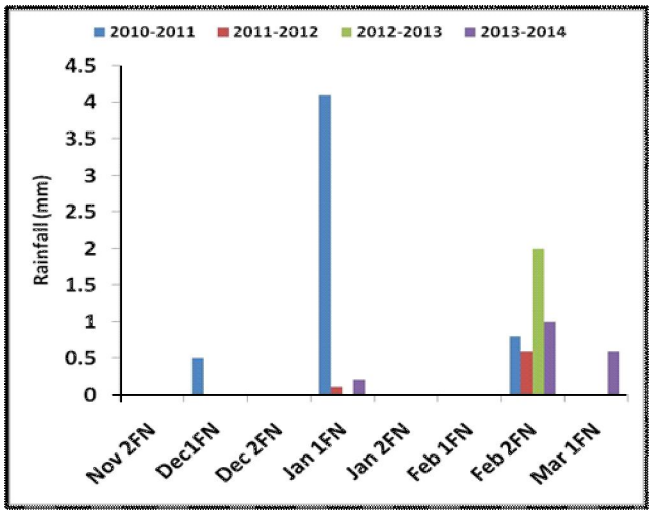

Fig.6: Variation of rainfall through out the growth period of wheat during seasons of good yield

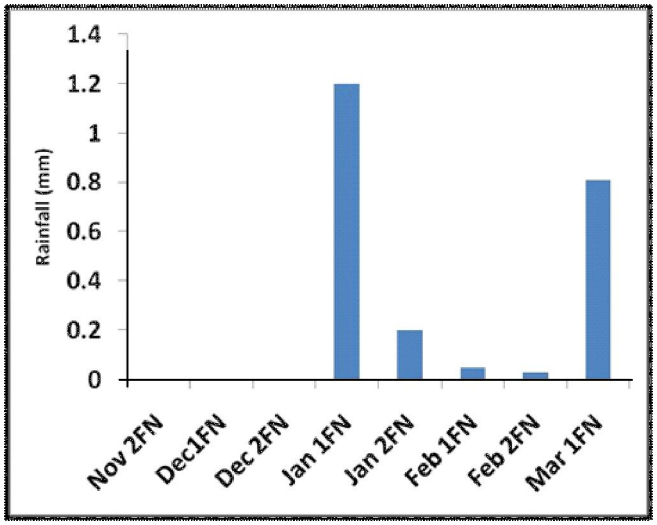

Fig.7: Variation of rainfall through out the growth period of wheat during season of poor yield(2003-2004)

It was observed that wheat production was good when maximum temperature was little bit high (around 30 to 33°C) during initial and lateral growth stages and lower (near about 23 to 24°C) in the mid-season (Fig.1). Higher yield was obtained from wheat when the maximum temperature prevailed between 27 to 32 °C during germination and CRI stages. Emami (2007) observed that 20 to 22 °C maximum temperature was effective for good germination of wheat but the range was found to be little higher for the study region. During reproductive stage the range of maximum temperature was around 22 to 26 °C. The seasons with good yield experienced about 30 to 35 °C of maximum temperature in the maturity stage. Similar trend was found in case of minimum temperature also (Fig.2). The variation of minimum temperature throughout the wheat growing period showed that comparatively lower minimum temperature ranging between 9.5 to 13 °C during reproductive stage was responsible for better growth and higher yield of wheat. On the other hand, ranges of minimum temperature conducive for good yield during vegetative and maturity phases were 13 to 14°C and 16 to 17°C, respectively. Overall distribution of maximum and minimum temperatures during the wheat growing season was compared between good and poor yield seasons. It was noted that the range of maximum temperature was slightly higher (2.5%) in the season of poor yield(Fig.3). This 2 to 3 % higher temperature especially during vegetative and maturity phases respectively became constraint for better growth and biomass production of wheat. It was also seen that, persistence of higher range of minimum temperature persisted for consecutive 6 to 9 days during grain formation; ripening and maturity stages reduced wheat production drastically (Fig.4). The wheat productionof the poor yield season (2003-2004) was 35% less than the average of good yield seasons (2010-2011, 2011-2012, 2012-2013 and 2013-2014). Higher temperature might have deteriorated the mean rate of photosynthesis. It became one of the reasons of poor biomass. Reduction of the length of growing period, number of tillers and increased heat stress were the other causes of poor yield due to high temperature condition. Satyanarayana *et al*. (2009) conducted a study to quantify the reduction in growing period of wheat as a result of temperature rise for climate change under the ICAR-AICRPAM project and they reported from their future projection that increased temperature could reduce the wheat yield by curtailing the crop duration. Kushwaha *et al.* (2011) mentioned about the negative effect on wheat yield and biomass imposed by greater temperature range. Yield reduction was more when higher temperature prevailedduring reproductive phase. Bright sun shine (BSS)

hour is extremely important for the photosynthetic activity and biomass accumulation of the crop. Though BSS hour is not a limiting factor for *Rab*i crops, range of BSS hours favourable for wheat growth in the region has been evaluated in the present study. It has been observed that around 7 hours of bright sun shine resulted in excellent germination and seedling growth of wheat that ultimately helped to achieve handsome yield. On the other hand, 4 to 5 BSS hour was found to be suitable for the rest of the vegetative stage. After a healthy vegetative growth of the crop 6 to 7.5 hours with bright sun shine boosted the grain formation and more than 8 hours of bright sun shine was crucial for the proper ripening and maturity of the crop (Fig.5). Wheat is generally grown under irrigated condition in this region. So, rainfall during the growth period is not responsible for fulfilling the water requirement of the crop but may hamper the growth and development processes in a number of ways like delaying maturity or causing pest and disease infestation. The seasons with good yield had very little amount of rainfall during the growing season. Only, the second half of February, when there was beginning of maturity, only 0.5 to 2 mm of rainfall was received in all of the four seasons of good yield. This amount was too little to cause any harm to the crop (Fig.6). But during 2003-2004season, which was marked with poor yield, had continuous occurrence of very little amount of rainfall from jointing to maturity (Fig.7).In general, the rainy days for the months of February and March are only two in Nadia District and probability of getting 75 to 100 mm rainfall is zero (Mukherjee *et al*., 2015). So, rainfall at maturity is not the limiting factor for wheat growth in the study region.

Summarising the entire study, the following points can be concluded. Seasons with good yield were observed to have higher maximum and minimum temperatures in the initial and later stages of wheat growth. Maximum temperature around 24 to 29 ^{o}C in flowering and grain formation stages is conducive for good yield. Likewise, maximum temperature between 28 to 34^{o}C at maturity stage is favourable for higher production of wheat. Bala and Kaur (2013) found similar results for Punjab. The temperature ranges mentioned as weekly thumb rule model for predicting potential yield of wheat for different stations of Punjab in their work were quite matching with finding of this study. Higher maximum and minimum temperatures resulted in reduction of yield. BSS in between 4 hr and 8 hr upto grain formation and above 8 hr during maturity is favourable for good wheat yield. Rainfall was poorly correlated with yield and the study revealed that rainfall was not a critical factor for wheat production in this region.The critical behaviour of thermal regime on wheat growth and yield for the study location is observed through this work. The present study is useful for the policy makers to prepare appropriate policies and plans regarding wheat cultivation.

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Received : May 2020; Accepted: September 2020