Environment & Ecology 27 (4A) : 1818—1820, 2009
 ISSN 0970-0420

Impact of Climate Changes on Wheat Yield in Haryana

URMIL VERMA, D. S. DABAS, MANOJ YADAV, R. S. HOODA
AND M. H. KALUBARME

Department of Mathematics & Statistics, CCS Haryana Agricultural University
Hisar 125004, India
E-mail : Vermas21@hotmail.com

Abstract

This study attempts to answer the question whether observed climate changes have had an impact on wheat yield in Haryana. Trend-agromet wheat yield models in various districts of Haryana state were developed using trend predicted yield, agrometeorological indices like Growing Degree Days (GDD), Temperature Difference (TD) and weekly Accumulated Rainfall (ARF) over critical growth phases of wheat. Weather indices obtained were integrated over seven growth and developmental stages of wheat viz., crown root initiation stage, tillering stage, jointing stage, flowering stage, milking stage, dough stage, and maturity stage. Stepwise regression analysis was carried out for getting the suitable yield relationships. Agromet parameters turned out to be significant predictor variables contributing towards crop yield.
Key words : Agrometeorological indices, Temperature difference, Growing degree days, Rainfall, Trend yield.

Food is an essential daily requirement of each one of the human and animal being of the world. Therefore, food and nutritional security of its human and animal population is important for any state/nation. This leads India to chart a course of state led improved technological inputs and favorable policy environment which has increased its food production by over four times since independence. The state of Haryana has witnessed even a more spectacular progress in even a shorter period on this front. Planning and decision making in this regard have profound implications not only for the governments but also for business and human institutions and organizations.

Importance

Reliable and timely forecasts of agricultural production is important for informed planning and decision making relating to storage and distribution logistics, pricing, marketing and import/export. The validated state government estimates become available only several weeks after the crop is harvested. Therefore, these estimates can hardly be used for advance planning and timely decision making. The traditional official advance estimates of area and production of crops are only guestimates and not the objective estimates (1). This makes reliable and verifiable pre-harvest estimates of crop production crucial for several of the government, institutional and trading agencies.

Historical Background

Agrometeorological models and trend extrapolation have been proved to be usefull tools for yield and production forecasting in various continents and under various climatic conditions. During the last decade, considerable work has been carried out in India in the spectral response and yield relationships of different crops at Space Application Center, Ahmedabad, under Crop Acreage and Production Estimation (CAPE) project. One of the first attempts directed towards wheat production forecast using remote sensing based acreage estimates and yield from Crop Cutting Experiments (CCE) was in Patiala Tehsil (Punjab state) during 1984-85 cropping season (2). Studies have been carried out to develop suitable forecast models for various crops using multiple regression technique (3—6). (5); Sarkar (4); Ramakrishna et al. (3); Verma et al. (6).

Study Area and Data Used

The Haryana state comprising of 20 districts is situated between 74^0 25′ to 77^0 38′ E longitude and 27^o 40′ to 30^o55′ N latitude. The total geographical area of the state is 437,861 ha. Department of Agriculture (DOA) yield estimate, published by Bureau of Economics and Statistics have been used for computing trend based yield. The meteorological data like daily minimum and maximum temperatures, rainfall for past 22 years (1978-79 to 1999-2000) were collected from different meteorological stations in Haryana and IMD, Delhi.

Quality weather data from adequate number of stations for each district in the state are not available; the districts having equable climatic conditions and physiography have been assigned with the climate data of neighboring districts where meteorological sub-station is available.

Crop Productivity

There are several approaches to the estimation of the pre-harvest productivity of a crop. The productivity of a crop is determined mainly by the availability and adoption of appropriate crop production technologies, availability and use of quality inputs like fertilizer, irrigation, available soil moisture etc; appropriate management strategies like selection of proper variety and seed, timely cultural operations including the plant protection, sowing, harvesting and the weather. This can be analyzed in the form of long term trend analysis in the time series yield data over a period of several years.

Modelling of Pre-Harvest Crop Productivity

Weather plays a dominant role in crop growth, development and yield. Thus the impact of weather and climate on food production is quite high. Weather indicators thus can be conveniently used as variables in crop yield modeling. The effect of weather parameters on crop productivity is not uniform throughout the crop life. Different weather parameters affect a crop differently during its different growth and development stages. Therefore, it is not only the aggregated magnitude of weather parameters but also their periods of occurrence or the temporal distribution pattern which is important. For this purpose, the different weather parameters are aggregated (averaged or accumulated) for short periods coinciding with semi-empirical crop growth and development stages of the crop.

Average wheat yield statistics of various districts in Haryana were used with time (year) as an independent variable and had been regressed against yield to get the trend equation. To account for the effect of temperature on wheat yield, the derived meteorological indices i.e. Growing Degree Days (GDD) and Temperature Difference (TD) were computed as; $TD = \sum [T_{max} - T_{min}]$ and $GDD = [\{\sum (T_{max} + T_{min})/2\} - T_b]$, where; T_{max} = Maximum Temperature, T_{min} = Minimum Temperature, T_b = Base Temperature5°. The weekly Accumulated Rainfall (ARF) was also computed to study its effect on yield. To integrate GDD, TD over different growth phases, wheat period was divided into seven phenological stages, viz. crown root initiation stage (meteorological week numbers 44—46), lillering stage (meteorological week numbers 47—49), jointing stage (meteorological week numbers 50—52), flowering stage (meteorological week numbers 1—3), milking stage (meteorological week numbers 4—6), dough stage (meteorological week numbers 7—9) and maturity stage (meteorological week numbers 10—14). This helps in identifying critical growth phases and meteorological parameters influencing the final wheat yield.

Meteorological indices	Growth stages	Phase
Temperature Difference (TD	1. Crown Root Initiation	Vegetative (1, 2, 3)
Growing Degree Days (GDD)	2. Tillering	
Accumulated Rainfall (ARF)	3. Jointing	
	4. Flowering	Reproductive (4, 5)
	5. Milking	
	6. Dough	Maturity (6, 7)
	7. Maturity	

Trend-Agrometeorological Yield Relationships

Bhiwani

$$Y = 29.30 + .759 * \text{Year}$$
$$R^2 = .48, \ n = 22$$

$$Y = 45.72 - .891 * GDD_7 + .1.105 * \text{Trend}$$
$$R^2 = .71, \ SEOE = 2.133, \ n = 16$$

Sirsa

$$Y = 34.92 + .698*Year$$
$$R^2 = .69,\ n = 22$$
$$Y = 9.46 - .074*ARF_3 - .076*ARF_6 + .796*Trend$$
$$R^2 = .88,\ SEOE = 0.983,\ n = 16$$

Jind

$$Y = 31.89 + .713*year$$
$$R^2 = .74,\ n = 22$$
$$Y = -5.92 + .119*TD_3 + 1.019*Trend$$
$$R^2 = .87,\ SEOE = 1.338,\ n = 16$$

Kaithal

$$Y = 34.54 + .765*Year$$
$$R^2 = .42,\ n = 22$$
$$Y = 22.84 - .0704*AR_6 + .388*TD_7$$
$$R^2 = .79,\ SEOE = 1.73,\ n = 16$$

Karnal

$$Y = 35.74 + .513*Year$$
$$R^2 = .33,\ n = 22$$
$$Y = -14.47 + .394*TD_2 + .880*Trend$$
$$R^2 = .84,\ SEOE = 1.243,\ n = 16$$

Kurukshetra

$$Y = 34.14 + .886*Year$$
$$R^2 = .68,\ n = 22$$
$$Y = -28.16\ .574*GDD_1 + .870*Trend$$
$$R^2 = .87,\ SEOE = 1.366,\ n = 16$$

Yamunanagar

$$Y = 25.12 + 1.872*Year$$
$$R^2 = .86,\ n = 22$$
$$Y = 15.91 - .219*GDD_4 + .065*ARF_1 + .704*Trend$$
$$R^2 = .88,\ SEOE = 1.693,\ n = 16$$

Panipat

$$Y = 36.48 + .360*Year$$
$$R^2 = .13,\ n = 22$$
$$Y = 1.49 + .247*TD_1 - .237*TD_5 - .244*ARF_1 + .889*Trend$$
$$R^2 = .89,\ SEOE = .406,\ n = 16$$

Sonipat

$$Y = 30.88 + .871*Year$$
$$R^2 = .59,\ n = 22$$
$$Y=39.03-.660*GDD_7-.550*ARF_1+1.030*Trend$$
$$R^2 = .92,\ SEOE = 1.066,\ n = 16$$

Rewari

$$Y = 34.22 + .567*Year$$
$$R^2 = .52,\ n = 22$$
$$Y=16.49+.036*ARF_4-.046*ARF_6+.581*Trend$$
$$R^2 = .80,\ SEOE = 1.312,\ n = 16$$

Mahendergarh

$$Y = 35.77 + .650*Year$$
$$R^2 = .82,\ n = 22$$
$$Y = .81+.033*ARF_3+.031*ARF_4+ .965*Treand$$
$$R^2 = .83,\ SEOE = .994,\ n = 16$$

Faridabad

$$Y = 28.37 + 1.075*Year$$
$$R^2 = .77,\ n = 22$$
$$Y=-28.95+ .195*TD_6+.489*GDD_4+.154*ARF_7+ 1.089*Trend$$
$$R^2 = .89,\ SEOE = 1.698,\ n = 16$$

References

1. Agrawal R. and V. Ramasubramanian. 2007. Forecasts of agricultural production. Fert. Market. News Aug. 7 : 1—9.
2. Kalubarme M. H. and R. K. Mahey. 1986. *Wheat acreage and production estimate in Patiala Tehsil (Punjab State) using Landsat MSS digital data of March, 1985.* Scientific Note, Space Applications Center, Ahmedabad, IRS-UP/SAC/CPF/SN/06.
3. Ramakrishna Y. S., H. P. Singh and R. G. Nageswra. 2003. Weather based indices for forecasting food grain production in India. J. Agromet. 5 : 1—11.
4. Sarkar J. 2002. Forecasting rice and wheat yields over different meteorological sub-divisions of India. *In Symp. on crop weather models in agriculture.* 56th Ann. Conf. of Indian Soc. Agric. Stat. Dharwad, India.
5. Singh D., H. P. Singh and P. Singh. 1976. Pre-harvest forecasting of wheat yield. Indian J. Agric. Sci. 46 : 445—450.
6. Verma U., D. S. Ruhal, M. Yadav, A. P. Khera, R. S. Hooda, C. P. Singh, M. H. Kalubarme and I. S. Hooda. 2003. Wheat production forecast using Remote sensing and agromet variables in Haryana State. J. Indian Soc. Rem. Sens. 31 : 141—144.