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Recent Fog trends and its impact on wheat productivity in NW plains in India

S. Singh and D. Singh

Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar-125004, India
(surendersd@yahoo.com / Fax: +91-1662-234952)

Abstract

Observations on fog events recorded at Agrometeorological Observatory at Hisar, India (Lat: 29°10'N, Long: 75°41'E and Alt: 209.1 m amsl) representing North-west plains in India during winter season for the recent period 1993 to 2008 have been analyzed. The study period was so chosen because of significant climatic aberrations reported by IPCC[1]. In the region, the fog season is generally considered from November to February, with the months of December and January witnessing the longest durations of dense fog. The cumulative foggy days in the region ranged between 18 to 52 during the winter/rabi seasons (1992-93 to 2007-08). The maximum (52) and minimum (18) numbers of foggy day were observed during winter/rabi season 2007-08 and 1997-98, respectively. On an average, the dense fog was witnessed for just 3-5 hours during the months of November and February while December and January experiences about 95 per cent of dense fog durations under reference. The conditions became conducive for formation of dense fog as there was little difference between day and night temperatures with no winds. Interestingly, an increasing trend (@ ~ 2 day/season) in occurrence of fog events was seen during the period under report. Maximum foggy events (25) in a month were recorded in December, 1998. Average maximum foggy events (12) recorded in a month were observed in January. All the Niño years (SST>0.5°C) received above normal rainfall (50.0 mm) in fog season, but the deficient rainfall was recorded during Niña years (SST<-0.5°C); though, there seems no direct correlation between seasonal rainfall and teleconnections but the foggy events prevailed during/after the passage of WDs. The seasonal rainfall's associated weather system i.e. Western Disturbances (WDs) coming over NW plains in India from far west countries Afganistan & Pakistan. The WDs and fog events showed strong relation over the region. The growth and development of winter wheat was adversely affected due to reduced or no PAR available for photosynthesis, cold stress and congenial conditions for diseases and insect-pest development in the region.

1. Introduction

Fog season is generally considered from November to February, with the months of December and January witnessing the longest durations of dense fog in North-west plains of India[2, 3]. Fog is nothing but cloud at ground level condensation of invisible water vapor in air into visible droplets of water. Fog occur most of the time during cold and nearly calm conditions when the air is saturated (a RH around 100 %). Fog plays an important role in the earth's ecosystem being a medium for the exchange of water and pollutants between the atmosphere and the biosphere[4]. The feasibility of a fog water collection system depends on the availability of a site where relatively large amounts of water can be collected and fog may be measured on top of canopy to estimate its impact on the crop beneath[5]. Fog which often occurs in the winter time during stable weather situations plays an important role in tropics affairs and air quality all over the world. Fog climatology based on satellite remote sensing using time series data is important because long term knowledge of regional changes in fog frequency and fog properties are of over all importance for Global Circulation Model simulations dealing with global climate change[6]. The frequency of occurrence of fog is so high that the foggy conditions persist for number of days together over a larger area in winter season (November through February). The study of fog intensity and its continuity over NW plains is of paramount importance as being sensitive indicator of regional climate change. Therefore, an attempt has been made here to characterize the fog events and their impact on winter wheat productivity in semi-arid NW plain region in India.

1.1 Study domain and data base

Systematic meteorological records during the winter seasons (November to February) for period 1992 to 2008 for Hisar (Latitude 29°10'N. Longitude 75°41'E and Altitude 209.1 meters) representing semi-arid NW plain region of India have been considered for aforementioned study. The fog data were taken from CWS 27 (b) format of India Meteorological Department recorded at Agrometeorological Observatory at Research Area of Department of Agricultural Meteorology, Chaudhary Charan Singh Haryana Agricultural University, Hisar, India. Daily records on maximum and minimum temperature, relative humidity, bright sun-shine hours and number of foggy days and their duration have been taken for calculating monthly and seasonal values. The relevant data on teleconnections, WDs and wheat productivity were taken from e-resources of BOM, Darwin, IMD and Statistical Abstract of Haryana, respectively.

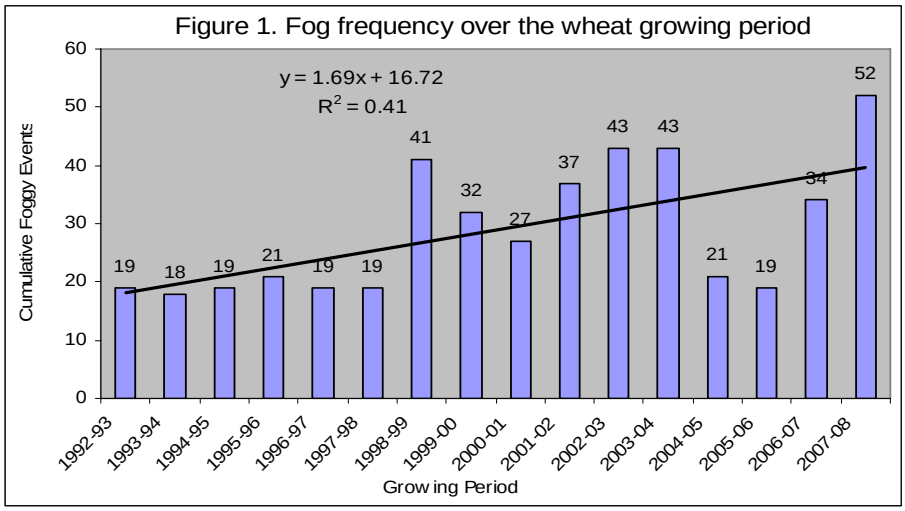
2. Foggy events and associated weather variables

During the entire winter season (wheat growing season), the more number of foggy events were observed in coolest months (December and January) and minimum events in comparatively warmer (November and February) months. However, the range of foggy events was highest (4 to 25) in January month (Table 1). The foggy days in entire winter season ranged between 18 to 52 during the whole growing period under study. Maximum foggy events (25) in a month were recorded in January, 2003. Average maximum foggy events (12) too were recorded in the month of January. In a particular winter season, the highest foggy events (52) were recorded during 2007-08 and the minimum (18) during 1993-94 (Figure 1). Interestingly, an increasing trend (@ ~ 2.0 day/season) in occurrence of fog events was noticed.

Table 1. Foggy events and associated weather variables

Events /Variable (s)	November	December	January	February
Foggy Days	3 (1-16)	9 (3-20)	12 (4-25)	4 (2-9)
T_{max} (°C)	28.4 (26.2-30.6)	21.3 (17.1-24.3)	18.6 (14.4-23.2)	21.5 (16.2-23.8)
T_{min} (°C)	9.3 (2.9-11.5)	5.0 (2.2-6.7)	3.8 (0.9-5.8)	4.8 (2.7-7.8)
RH_{mor} (%)	88	92	90	86
BSS (hrs)	6.3	5.9	5.7	7.2

About 41 per cent of variability in foggy events can be explained over the time due to regional climatic variability. {$y = 1.69 x + 16.72$ (R^2=0.41)}. Such occurrence in foggy events may be attributed to sharp fall in temperatures and above 95 per cent relative humidity along with calm conditions in the atmosphere. Satellite based remote sensing monitoring of the region showed continued prevalence of foggy conditions (3-4 weeks) for days together (Figure 2) which helped considerably in weather forecasting and impact assessment of such events on crop productivity. The minimum temperature during winter season ranged between 2.9 to 11.5°C as against normal range of 4.6 to 9.6°C. Similarly, maximum temperature ranged between 14.4 to 30.6°C and bright sun-shine hours ranged between 5.7 to 7.2 hours as against normal range of 20.5 to 28.7°C and 7.3 to 8.5 hours, respectively during the winter seasons of study period (Table 1). These wide ranged fluctuations in weather variables too indicted regional climatic variability in global climate change perspectives.



2.1 Teleconnections and their impact

All the Niño years (SST>0.5°C) received above normal rainfall (50.0 mm) in fog season, but the deficient rainfall was recorded during Niña years (SST<-0.5°C); though, there seems no direct correlation between seasonal rainfall and teleconnections but the foggy events prevailed during/after the passage of WDs. The seasonal rainfall's associated weather system i.e. Western Disturbances (WDs) coming over NW Indian region from far west countries Afganistan & Pakistan. The WDs and fog events showed strong relation over the region.

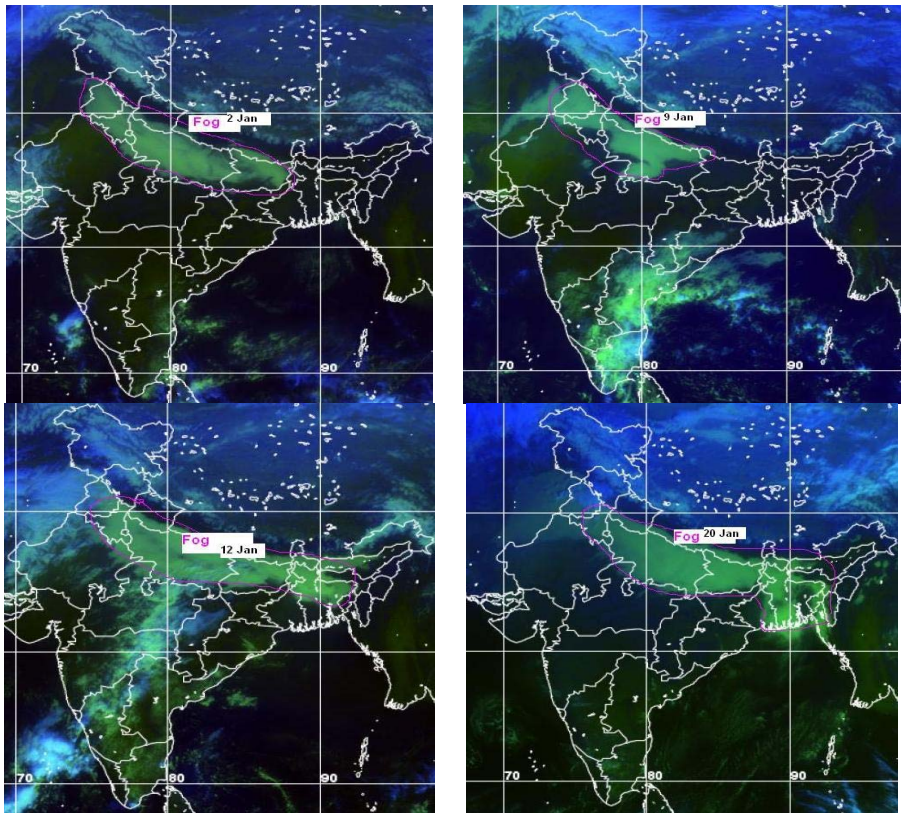


Figure 2. Recent Persistence Foggy conditions (January, 2010) in the NW plains

3. Summary and Conclusions

Frequency and duration of foggy events have increased in winter season of 1993 through 2008 as compared to long term normals at Hisar, India. Such type of continued and varied climatic situations in the region affecting the agricultural productivity adversely and symbolized the shift in local climates due to global climatic changes. Continued foggy conditions for days together especially more than a week caused considerable damage to field crops like wheat The growth and development of winter wheat was adversely affected due to reduced or no PAR available for photosynthesis, cold stress and congenial conditions for diseases and insect-pest development in the region. Simple and multiple regression equations using fog events explained 45 to 60 per cent variations in wheat productivity. It may be concluded that the regional climatic variability may be the reason of increased duration and frequency of foggy events in the region and thus, the meteorological variables need to be monitored carefully for better predicting of ensuing foggy conditions and to negotiate these conditions up to some extent particularly for crop production operations for sustainable agricultural development. Thus, strategies are needed to predict the sustenance of foggy conditions over the region using remotes sensing technology viz., satellite monitoring of the region[7] which may provide a better approach in getting useful information essential for fog forecasting and dew research for water trapping/collection in continued foggy weather for sustainable wheat production in otherwise moisture deficit semi-arid region of NW plains in India.

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