Indian J. Genet., 74(4) Suppl., 568-571 (2014)
DOI: 10.5958/0975-6906.2014.00891.8

Climate change and maize productivity in north-western plains regions of India

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(Received : September 2014; Revised : November 2014; Accepted: November 2014)

Abstract

The full season maturity group grown during the monsoon (*kharif*) season in 'All India Coordinated Maize Improvement Project' trials from 1991 to 2012 in north-western plains zone was analysed for grain yield for the best check and best entries. The rainfall trends were simultaneously analyzed in each month over years through Mann and Kendall approach. The increase or decrease in rainfall over years is not significant but the fluctuations in rainfall in each month over years were significant in all the months. In spite of rainfall fluctuations, there was continuous improvement in the new genotypes developed at 'All India Maize Improvement Project' especially in past two decades in 'zone II' as well as Punjab state. The performance of maize in AICMIP was higher in Punjab state than in overall 'zone II'. The new and improved hybrids developed in the program every year were suitable for changing climatic conditions.

Key words: Monthly fluctuations, rainfall, temperature, Punjab, yield, zone

Introduction

Maize in India is primarily grown in monsoon (*kharif*) season throughout the country. In winter (*rabi*) season, maize is sown in some part of the country, while the spring maize is also gaining importance in last few years. At national level, there is a constant increase in the national productivity of maize especially from early nineties [1]. The maize area, production and productivity for 2011-12 were 8.782 million hectare, 21.759 million tons and 2.478 ton per hectare, respectively [2]. Organized research on improvement of maize started in India in 1957 under the auspices of 'All India Coordinated Research Project' and was the first in a series of coordinated projects under the ICAR system. Based upon agro-climatic conditions, the maize growing area in the country is broadly classified into five zones [3]. Among them, Zone II includes Punjab, Haryana, Delhi and West Uttar Pradesh; The full season maturity group in maize is grown in all parts of the Indian sub-continent except in Himalayan hills where extra-early, early and medium maturity group maize are grown so as to fit in their cropping system. Historical data on climatic parameters as well as yield data on maize are important to look into past setbacks and achievements. In north-east region which is a high rainfall area, the rains are affected [4]. There was a shift in peak of rainfall, reduction in peak of total rainfall during the rainiest months and low rainfall in the initial months of the maize crop season was observed. In maize, the hybrid checks like 'Seed Tech 2324', days to anthesis and silk have decreased by 0.31 and 0.11 days per year, respectively, while in 'Bio 9681' days to anthesis and silk decreased by 0.27 and 0.07 days per year, respectively. Concomitantly, there is an increase in yield by 0.29 per cent and 0.10 per cent per year. Over the years, the check genotypes showed change in days to anthesis, days to silk and yield suggesting the importance of crop genetic background in adaption. 'Seed Tech 2324' and 'Bio 9681' are more fit to climate change as compared to 'HIM 129' and 'Surya'. Suitable genotypes like 'Seed Tech 2324' and 'Bio 9681' showed increase in yield in changing favourable conditions in Himalayan region [4]. Based on the past data, the genetic progress was studied at Netherlands, UK and France [5-8]. The paper aims to study climate change and to assess the change in trend of maize yield and other traits since early nineties in zone II with special reference to Punjab.

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Published by the Indian Society of Genetics & Plant Breeding, F2, First Floor, NASC Complex, PB#11312, IARI, New Delhi 110012
Online management by indianjournals.com

Materials and methods

The maize hybrids along with checks were used every year in Advance Evaluation Trial 2nd year (AET II) to select the superior/best hybrid at zone level in 'All India coordinated trials'. These hybrid entries in 'AET II' had already been tested for two years i.e. 'Initial Evaluation Trial' (IET) and 'Advance Evaluation trial 1st year' (AET I), in multi-location testing. The data on the 'AET II' the best entry and the best check in the final (third) year of testing in full season maturity group for 22 years from year 1991 to 2012, of 'AICMIP trials' was used for monsoon (*kharif*) season with an emphasis on Punjab [9]. The testing locations covered in 'zone II' were Jammu, Dhaulakuan, Ludhiana, Karnal, Delhi, Kanpur and Pantnagar. The grain yield data analyzed for moving averages of the best check and best entries. The rainfall trends of one of the center were analyzed in each month over years. Rainfall characteristics like mean, standard deviation (SD) and coefficient of variation were computed month-wise for 'zone II'. Both parametric test (linear regression) and non-parametric (Mann-Kendall) method [10, 11] were used to detect the precipitation and yield trends in time series.

Results and discussion

The total rainfall of the season averaged over 22 years for the maize crop season (July to October) in 'zone II' was from 511.2 mm. In 'zone II', the monthly fluctuations in rainfall during maize cropping season are high during maize crop season and the trend was numerically decreased in all the months except for the month of September (Fig. 1). Even though the increase or decrease in rainfall over years is not significant but the fluctuations in rainfall in each month over years was significant in all the months. In another study, in north-east region of India, which is a high rainfall area, there was a shift in peak of rainfall, reduction in peak of total rainfall during the rainiest months and low rainfall in the initial months of the maize crop season was observed [4]. In north-western Himalayas, the fluctuations in maximum temperature and rainfall in last 25 years were found significant, while that of minimum temperature were non-significant with a linear trend [12]. They also observed that monthly rainfall trends showed increase

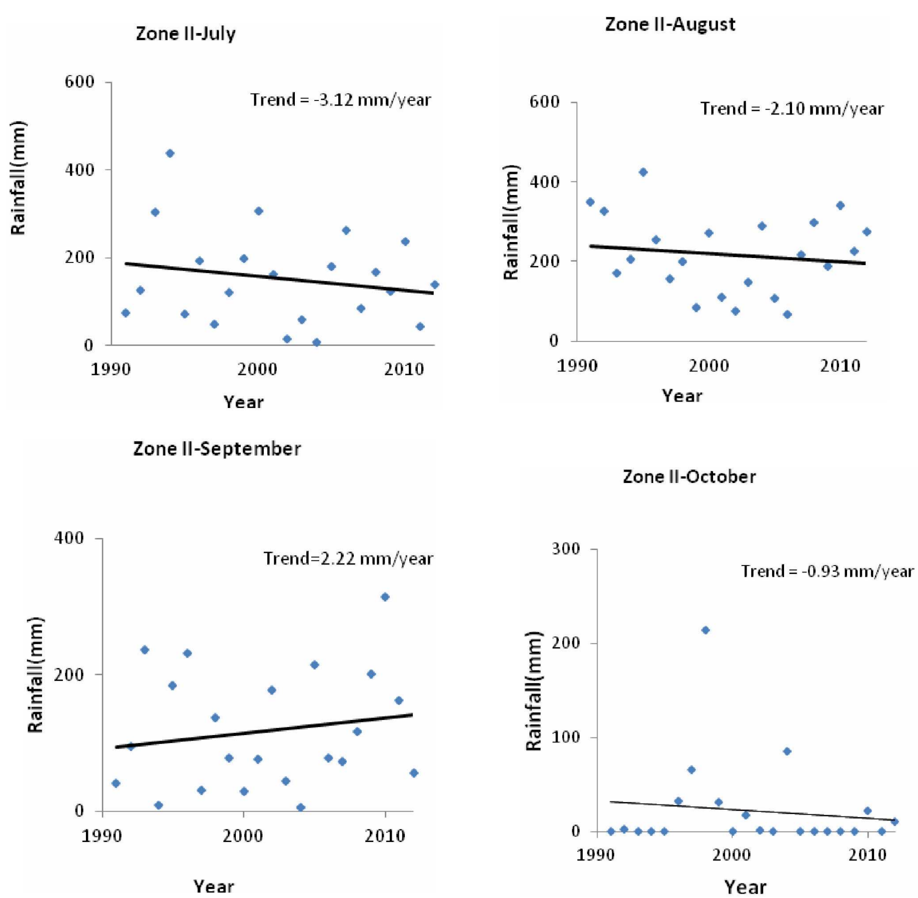

Fig. 1. Rainfall trends in Zone II (North-Western Plains Zone) from July to October

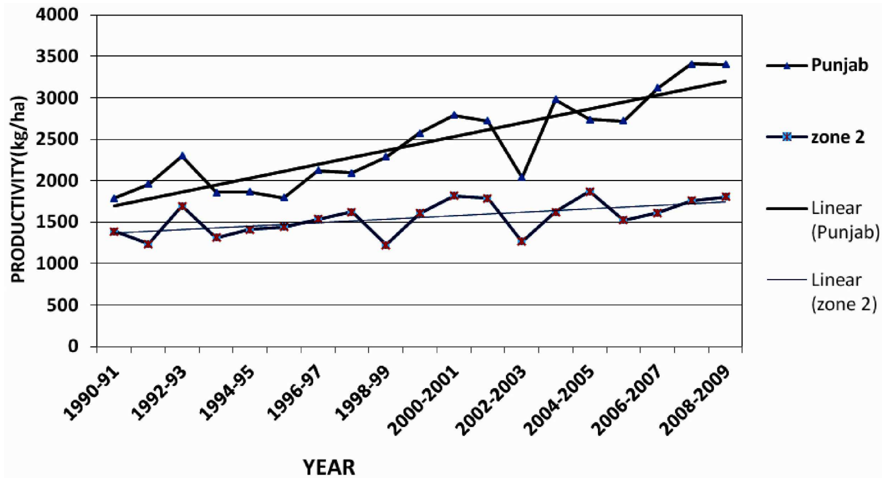

Fig. 2. Average productivity (kg/ha) of Punjab and Zone II (1990-91 to 2008-09)

in high rainfall month (August) from 1989 to 2003 later decreased uptil 2013.

The yield performance of best test entry was *at par* or higher than the best check with significant and positive strong correlation with each other. In addition, there was increasing trend for maize yields since 1991 in 'zone II' as well as in Punjab state (Fig. 2). The new maize hybrids from AICMIP are superior even though there were wide and significant fluctuations in rainfall over years. In spite of rainfall fluctuations, there was continuous improvement in the new genotypes developed at AICMIP especially in past two decades in 'zone II' as well as Punjab state. The performance of maize in AICMIP was higher in Punjab state than in overall 'zone II'. Hence, AICMIP had an important contribution in overall increase in zonal yields of 'zone II' as well as Punjab state. There was an increase in yield from 1994 to 2000 and 2002 to 2007. In north-western Himalayas, which is a part of 'zone I' and adjacent to 'zone II' there was constant increase in productivity in last 25 years in spite of high fluctuations in climatic parameters *vis-a-vis* grain yield [12].

The initial grain yield in zone II was higher than that in other zones but the yield gain was less in this zone in comparison to other zones. The yield gains in 'zone II' as expressed through trend was low i.e., 110.8 kg/ha/year. The yield fluctuation expressed for the best check was R^2=0.384 and the best check was R^2=0.469 in 'zone II'. In addition, the yield for the best entry was 6237.8±251.9 kg/ha and best check was 5798.7±248.7 kg/ha. On the other hand, the actual fluctuations and yield gains in Punjab and 'zone II' was given in Fig. 2.

There is need of more in order to achieve higher innovative technology in maize programme so as to break through in yield barrier in 'zone II' including Punjab state.

There are many factors that affect the actual zonal yields computed over states and in future, new innovative technology with more active maize improvement programme has a major impact in view of unpredictable rain patterns and changing climatic conditions. The new and improved hybrids developed every year were suitable for changing climatic conditions. We believe that there is lot more that need to understand in this historical dataset and its full value is yet to come.

Acknowledgements

The authors are grateful to all the Project Directors, Directorate of Maize Research, New Delhi for providing the data of All India Maize Improvement Project trials of different zones of the country. We are also grateful to Dr. Ravinder Singh, Head, Department of Agricultural Physics from IARI, New Delhi, for providing the weather data for use in the present article.

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