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Effect of Drought on *kharif* Crop Production in Haryana During 1987-2016

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A B S T R A C T

The present study was carried out in the Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar. The aim of study was to find out the effect of drought on *kharif* crop production in Haryana during 1987 to 2016. Total 21 districts were selected *i.e.* 13 districts of eastern zone and 8 districts of western zone and the rainfall data of all districts were taken from India Meteorological Department for a period of 1987 to 2016.Haryana state lies in Trans-Gangetic plain and lies between 27^{0} 39' N to 30^{0} 55' N latitude and 74^{0} 27' E to 77^{0} 36' E longitude with an area of 44,212 km^{2}*i.e.* 1.3 per cent of the total area of the country. To identify the drought years, IMD criteria of rainfall deviation from normal was used. The effect of drought on *kharif* crops was analyzed by using correlation and scatter plot. Rice, Bajra, maize and cotton showed negative relationship with rainfall, whereas moong crop showed positive relationship with rainfall where these crops were grown. The adverse effects of drought on crop productivity were nullified by the assured irrigation facilities. The increased rainfall decreased the productivity by favouring the high incidence of pest and diseases except moong crop which were grown in summer season and relish the rainfall.

Introduction

Drought is a creeping natural disaster with long lasting effects on ecology as well as on the economy. Haryana state is considered the breadbasket of India, along with the Punjab state. The effects of drought (and mitigation of those effects) are therefore of considerable importance for the state. Haryana has a semiarid climate in the southwest and a Gangetic plain environment in the rest of the state. About 50 per cent of the state has moisture deficit. One of the reasons for adverse crop production in the state during June–September is the early withdrawal or late onset of monsoon rains, which contribute nearly 80 per cent of the state's annual rainfall.

During *kharif* season when at least four consecutive weeks receive less than half of the normal rainfall and six consecutive weeks in *rabi* season will recognised as an agricultural drought. India Meteorological

Department define meteorological drought when the seasonal rainfall received over the area is less than 75 per cent of its long term average value. In India agriculture sector adversely affected by drought during the monsoon period

With global climate change and uncertainties in precipitation patterns, food security may become more vulnerable than in the past (FAO, 2008). During the last few decades, major drought events have been recorded and were projected to intensify in many parts of Asia and beyond (Miyan, 2014), which could make farming exceedingly challenging in some countries.

Water deficit during drought spells is one of the most significant stress factors in crop production worldwide (Sivakumar *et al.*, 2005; Narasimhan and Srinivasan, 2005; Lobell and Field, 2007). It can lead to significant yield reduction or even crop failure. Beside the negative effects of water stress on the yield quantity, the quality can also be influenced (Jensen *et al.,* 1996; Ozturk and Aydin, 2004).

Despite ongoing breeding efforts to develop drought-resistant cultivars (Chapman *et al.*, 2012; Bennett and Jennings, 2013), prolonged droughts in the food-insecure regions may cause famine, epidemics, and deaths, generate water crisis due to drying up of perennial streams, impact agriculture-based livelihood systems, food security and overall economic development (Karim and Rahman, 2015). To fully understand the impact of drought on food security, it is necessary to elucidate the environmental variables and agronomic factors that determine the vulnerability of crop production to drought.

Hence, keeping the above points in view, the present study had been carried out to study the Effect of drought on *kharif* crop production in Haryana during 1987-2016**.**

Materials and Methods

Experimental site

Haryana state extends between 27^{o} 39’N to 30^{o} 55’N latitude and 74^{o} 27’E to 77^{o} 36’ E longitude covering geographical area of 44,212 km^{2} *i.e.* 1.3 per cent of the total area of the country. Haryana state fall under ‘Trans-Gangetic Plain region’ of agroclimatic zone of India divided by The Planning Commission of India and further divide in two agroclimatic zone *viz.* Eastern and Western Zone.

Districts selected for study

Eastern agroclimatic zone

Kalka (Panchkula), Ambala, Jagadhari (Yamunanagar), Thanesar (Kurukshetra), Kaithal, Jind, Karnal, Panipat, Sonepat, Gurgaon, Ballabgarh (Faridabad), Palwal and Nuh (Mewat).

Western agroclimatic zone

Sirsa, Fatehabad, Hisar, Bhiwani, Rohtak, Jhajjar, Narnaul (Mahendragarh) and Bawal (Rewari).

According to India Meteorological Department there are three categories of drought based on rainfall deficit from normal.

Mild drought	rainfall received <75% of normal
Moderate drought	rainfall received 75-50% of normal
Severe drought	rainfall received <50% of normal

Data used

District wise crop production data of past 30 years (1987-2016) for five main *kharif* crops *i.e.* rice, cotton, pearlmillet (bajra), maize and moong were collected from Statistical Abstracts of Haryana and State Agriculture Department.

Data analysis

Data was analysed by using simple statistical techniques like correlation and through scatter plot.

Results and discussion

Effect of drought on crop production

Correlation between rainfall and crop productivity of *Kharif* crops in Haryana during 1987 to 2016

The correlation analysis was carried out between rainfall and crop productivity of different *kharif* crops in different districts of Haryana and the correlation coefficients are presented in Table 1. The crops which occupied significant acreage in the district were considered for the analysis. Rice crop showed significantly negative correlation with rainfall in Ambala (-0.51), Gurgaon (-0.57), Karnal (-0.56), Kurukshetra (-0.67), Sirsa (-0.49) and Panipat (-0.47) while the remaining districts were found with non-significantly relationship.

In case of Bajra crop the significant and negative correlation was found in Karnal (-0.40), Rohtak (-0.52), Kaithal (-0.48) and Panchkula (-0.58), whereas, no significant relationship was established in remaining districts. The maize crop was shown in only four districts of eastern zone namely Ambala, Karnal, Yamunanagar and Panchkula and none of the district recorded significant relationship with rainfall. Similarly, in case of moong crop the rainfall couldn't significantly effected the production in all the districts where it was grown. Among the cotton growing districts the significant negative correlation was shown by Rohtak (-0.46), Kaithal (-0.51) and Rewari (-0.49) districts, while the remaining districts showed non-significantly negative correlation.

Relationship between rainfall and crop productivity in Haryana

The crop productivity was drawn on a scatter plot against the rainfall to find out the trends of crop productivity with the rainfall for both the zones and presented in Figs 1 to 9.

Rice growing districts of eastern zone of Haryana viz. Ambala, Faridabad, Gurugram, Jind, Karnal, Kurukshetra, Panipat, Sonipat, Kaithal, Yamunanagar and Panchkula were studied to find out the relationship between rice productivity and rainfall. As shown in figure 1 slightly decreasing trend in productivity was observed with increasing rainfall. Higher infestation of BPH and WBPH was observed in rice due to high relative humidity which reduces the rice yield which was observed by Win *et al.,* (2011). Contrast to above result, higher yield was observed with high rainfall due to more photosynthesis was recorded by Kumar *et al., (*2011) in their research. Subash *et al.,* (2011) also reported that excess rainfall reduce the rice yield due to high insect and pest infestation which support our findings.

Rice grown districts of western zone of Haryana viz. Bhiwani, Hisar, Rohtak, Sirsa, Jhajjar and Fatehabad were found with decreasing crop productivity trend with rainfall similar to the eastern zone with higher rate of decrease as compared to the other zone (Figure 2).

The Figures 3 and 4 depicts the bajra crop productivity with rainfall in eastern and western zone of Haryana, respectively. The crop productivity trend was decreasing in both the zones. The decreasing trend was slightly higher in eastern zone as compared to the western zone. Decrease in yield of bajra with increase in rainfall was observed in their finding by Gupta *et al.,* (2014). Gahukar (2008) also reported high infestation of gall midge, shoot fly in bajra due to high humidity in their research.

In eastern zone of Haryana the maize crop was grown in Ambala, Karnal, Yamunanagar and Panchkula districts and there was no significant area under maize crop in western zone of Haryana. The scattered plot between crop productivity and rainfall (pooled of all maize growing districts) are presented in Figure 5 which shows the decreasing productivity with increasing rainfall. Byjesh *et al.,* (2010) also reported that a 10 % increase in rainfall will offset the reduction in yield due to 1°C rise in temperature. Precipitation and temperature are individually found to have opposite effect on corn yield level and variability (Chen, 2004). The moong crop was grown Faridabad and Kurukshetra districts of eastern zone of Haryana, whereas in western zone the districts namely Bhiwani, Hisar, Sirsa and Fatehabad was the moong growing districts. The scatter plot analysis (Figures 6 and 7) showed that the moong crop production under both the zones has increasing trend with increasing rainfall. The findings of Pandey *et al.,* (1984) that the increment in the number of flower and seed with rainfall at critical stage in moong ultimately increase the yield are also in corroboration of our results. Kumar and Kumawat (2014) and Pandey *et al.,* (1984) observed increase in the moongbean yield because of adequate availability of moisture, the plants had absorbed more nutrients and produced higher yield (Table 2).

Table.1 Correlation coefficient between rainfall and crop productivity

Districts	***Kharif* crops**				
	Rice	Bajra	Maize	Moong	Cotton
Ambala	-0.51*	-	-0.27	-	-
Bhiwani	0.02	-0.13	-	0.09	-0.08
Faridabad	0.23	0.19	-	0.35	-
Gurgaon	-0.57*	-0.35	-	-	-
Hisar	0.21	0.12	-	0.35	-0.02
Jind	-0.09	-0.23	-	-	-0.35
Mahendergarh	-	-0.13	-	-	-0.06
Karnal	-0.56*	-0.40*	-0.24	-	-
Kurukshetra	-0.67*	-	-	0.1	-
Rohtak	0.29	-0.52*	-		-0.46*
Sirsa	-0.49*	-0.14	-	-0.04	-0.36
Sonipat	-0.28	-0.30	-	-	-0.12
Kaithal	-0.18	-0.48*	-	-	-0.51*
Panipat	-0.47*	-	-	-	
Yamunanagar	-0.27	-0.38	-0.38	-	-
Rewari	-	-0.20	-	-	-0.49*
Panchkula	-0.42	-0.58*	-0.33	-	-
Jhajjar	-0.35	-0.30	-	-	-0.36
Fatehabad	-0.09	0.03	-	0.1	-0.06

* Significant at 0.05 %

Table.2 Year wise percent area irrigated in different districts of Haryana

Districts	1985-86	1990-91	1995-96	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05 (P)	2005-06	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Ambala	46.6	56.8	76.1	78.8	80.3	86.4	90.4	88	83.5	95.5	86.6	89.6	86.3	85.6	88.9	100	100	100	100	100
Panchkula	*	*	40.5	36.6	45.5	41.9	45.5	48.1	25	33.3	17.4	20.8	33.3	66.7	46.2	56	65.2	100	100	100
Yamunanagar	*	72.6	79.8	83.2	83.9	82.4	87.2	88.8	89.6	90.4	90.4	88.7	100	92	92	92.8	93.6	95.1	100	100
Kurukshetra	94.3	95.9	99.3	100	100	100	99.3	100	100	100	100	100.7	100.7	100.7	100	100	100	100	100	100
Kaithal	*	98.4	98.5	99.5	100	99.5	99.5	99.5	100	99.5	99.5	99	99.5	99.5	99.5	100	100	100	100	99.5
Karnal	91.6	98.6	100	99.5	99.5	99.5	98.9	99.5	99.5	99.5	99.5	99.5	98.9	100	99.9	100	100	100	100	99.5
Panipat	*	97.3	98.9	100	99	100	98.9	100	100	100.5	100	100	100	100	100	99	100	100	100	100
Sonipat	77.2	99.1	98.8	94.9	94.9	99.4	100	95.8	97.6	98	95.9	97.3	96.1	99.3	100	100	100	100	100	100
Rohtak	59.1	69.1	68.7	67.6	82.7	77.5	89.4	97.2	79.9	87.4	93	93	76.1	80	79.8	80	80	81	100	100
Jhajjar	*	*	*	67.3	68.5	76	82.2	74.2	78.6	100	64.3	65.2	75.5	74.2	74	73.1	88.7	92.7	93.6	95
Faridabad	55.2	50.2	74.2	85.4	86.1	73.4	76.3	78.8	79.6	76.9	79.1	84.8	97.3	97.3	96.2	100	100	100	100	100
Palwal	*	*	*	*	*	*	*	*	*	*	*	*	85.6	90.4	98.4	91.7	100	100	99	100
Gurgaon	39.2	51.8	32.3	36.6	35.6	39.2	42.6	46.6	57.1	50.6	54.5	76.5	92.8	84.5	71.1	93.7	100	100	100	100
Mewat	*	*	*	*	*	*	*	*	*	*	*	59.6	63.6	62.6	28.6	41.9	100	29.5	31.2	60.4
Rewari	*	72.3	72.6	73	75	70	82.9	77.6	88	78.3	87.3	87.9	75.2	86.5	76.7	87.3	88	100	100	100
Mahendragarh	26.5	43.9	65.4	62.1	68.2	77.3	78.4	81.7	100	79.1	79.6	22.4	80.8	83.4	33.7	78.4	40.1	76.4	43.7	43.8
Bhiwani	31.6	39.8	55	47.4	54.1	52.1	55	60	65.8	70.2	72.8	71.1	31	54.5	54.4	67.6	64.5	28.3	28.3	28.3
Jind	78.9	95.5	88	91.2	84.8	93.2	94.4	88	94.9	85.7	86.8	94.9	88.3	97.1	90.4	99.2	100	100	97.9	100
Hisar	69.8	80.3	77.2	77.4	74.8	83.9	86.9	74.7	87	69.8	72.1	72.5	70.2	80.4	81.7	80.4	79.2	74.1	81.6	82.3
Fatehabad	*	*	*	86.6	88.7	94.5	96.3	93.7	96	96	94.9	94.2	94.6	99.1	99.6	96.9	96.8	96.8	100	100
Sirsa	62.9	71.4	82.3	78.9	78.6	90	90.2	84.6	83.4	81.7	85	86	86.8	93.9	89.7	92.1	92.9	91	93.9	92.9

Source: Statistical Abstracts of Haryana

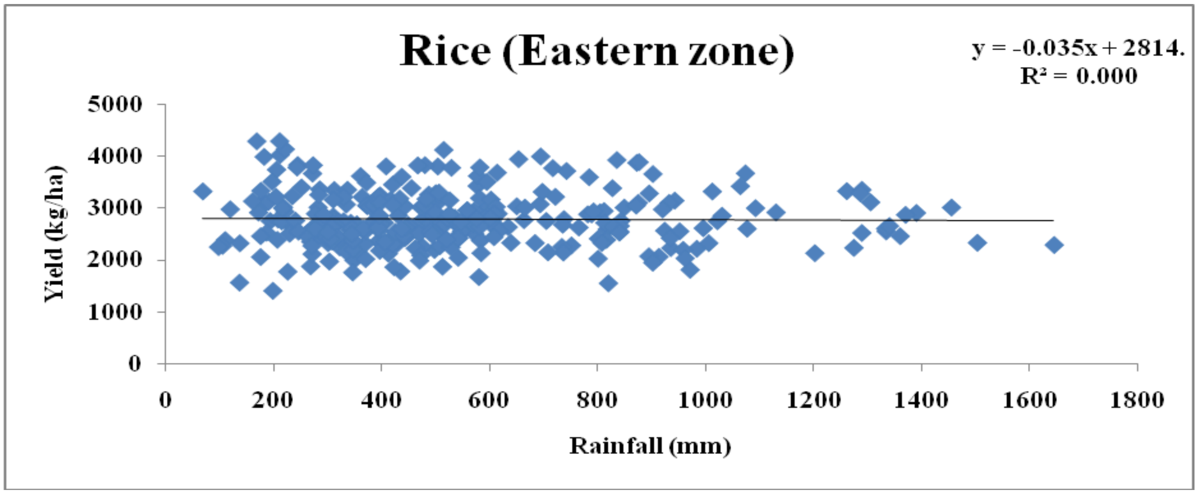

Figure.1 Relationship of rainfall (mm) and crop productivity (kg/ha) of rice crop in eastern zone of Haryana during *Kharif* season

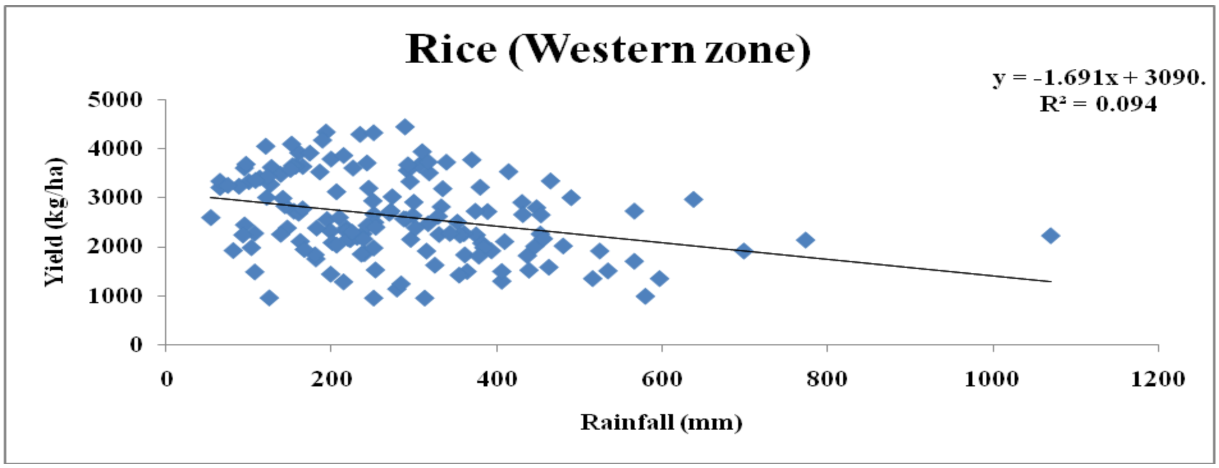

Figure.2 Relationship of rainfall (mm) and crop productivity (kg/ha) of rice crop in western zone of Haryana during *Kharif* season

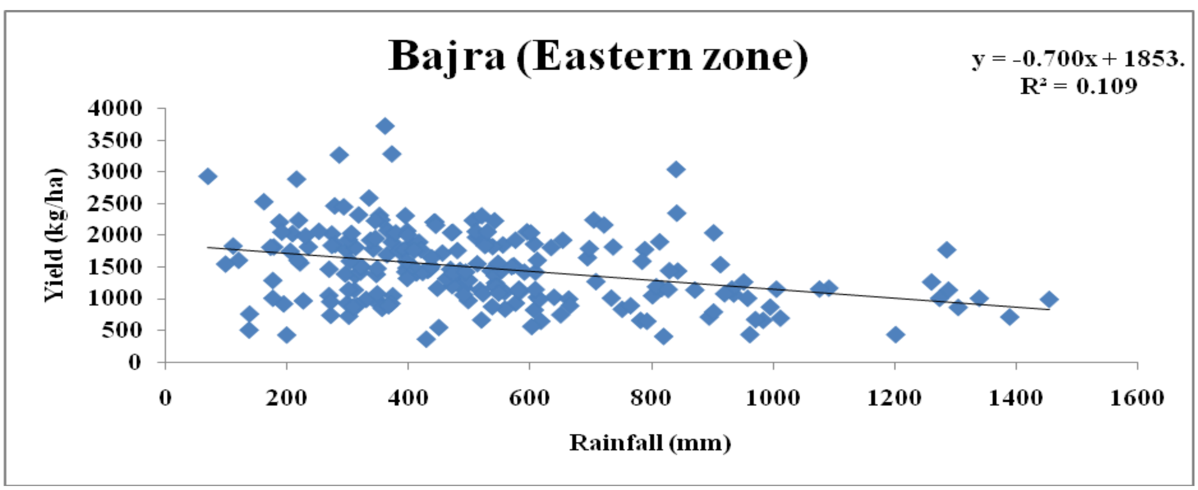

Figure.3 Relationship of rainfall (mm) and crop productivity (kg/ha) of bajra crop in eastern zone of Haryana during *Kharif* season

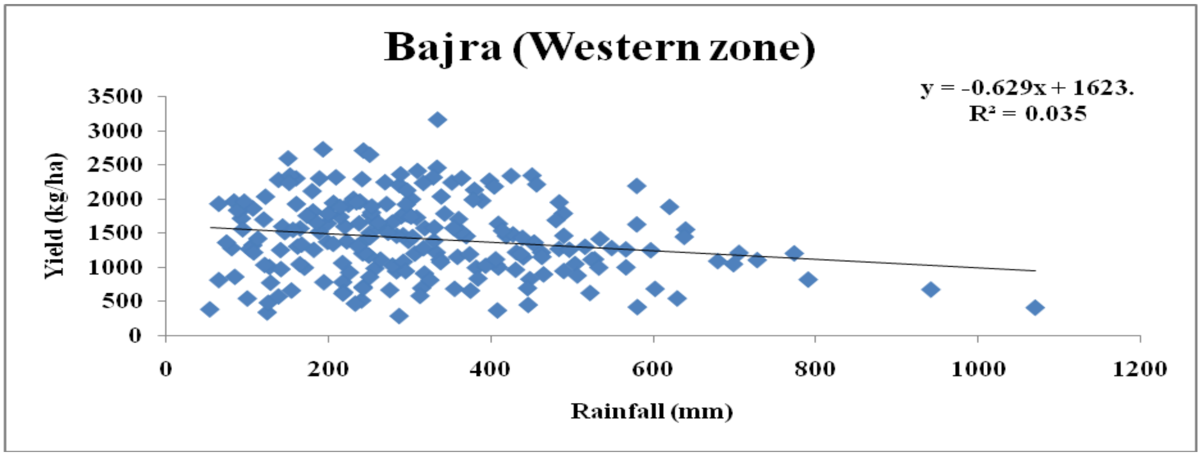

Figure.4 Relationship of rainfall (mm) and crop productivity (kg/ha) of bajra crop in western zone of Haryana during *Kharif* season

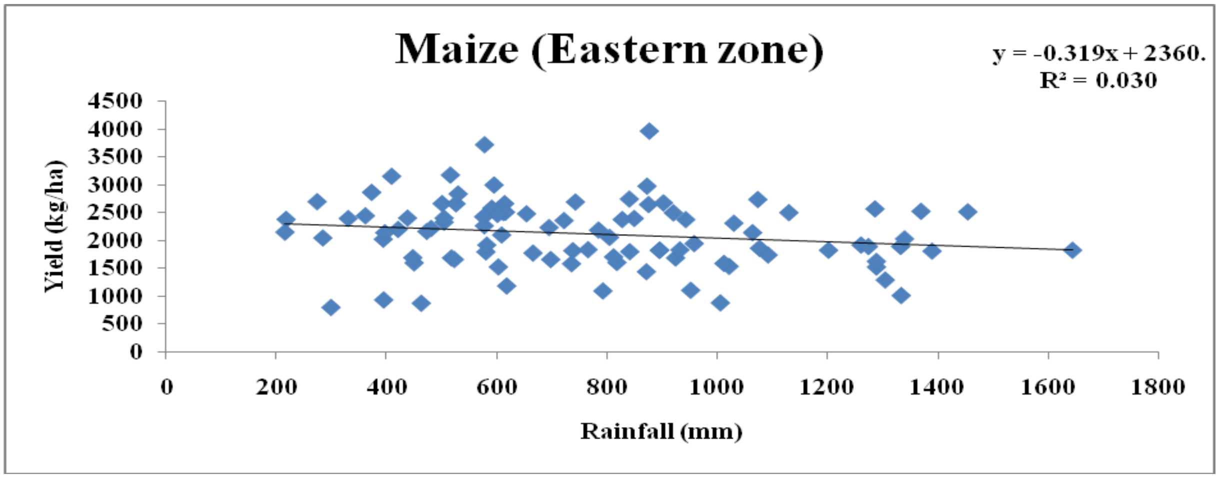

Figure.5 Relationship of rainfall (mm) and crop productivity (kg/ha) of maize crop in eastern zone of Haryana during *Kharif* season

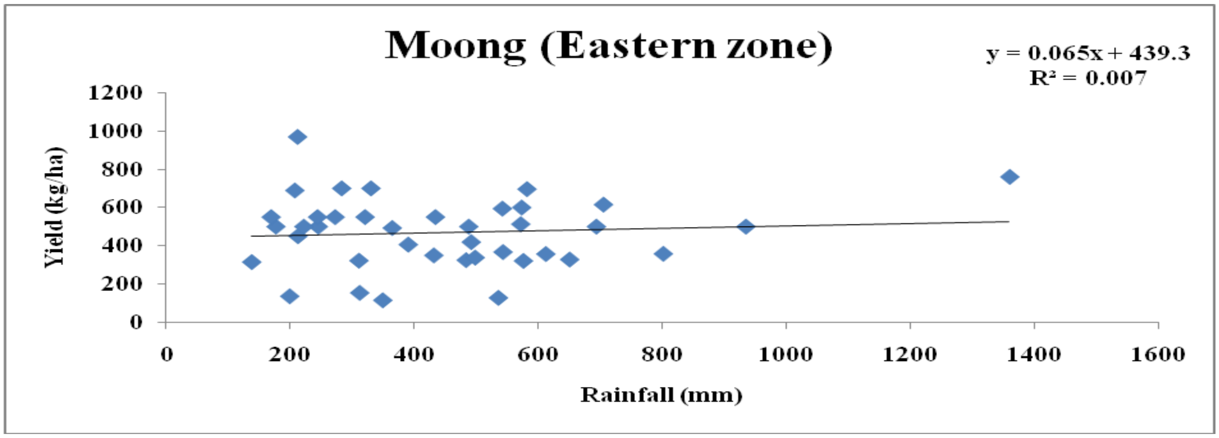

Figure.6 Relationship of rainfall (mm) and crop productivity (kg/ha) of moong crop in eastern zone of Haryana during *Kharif* season

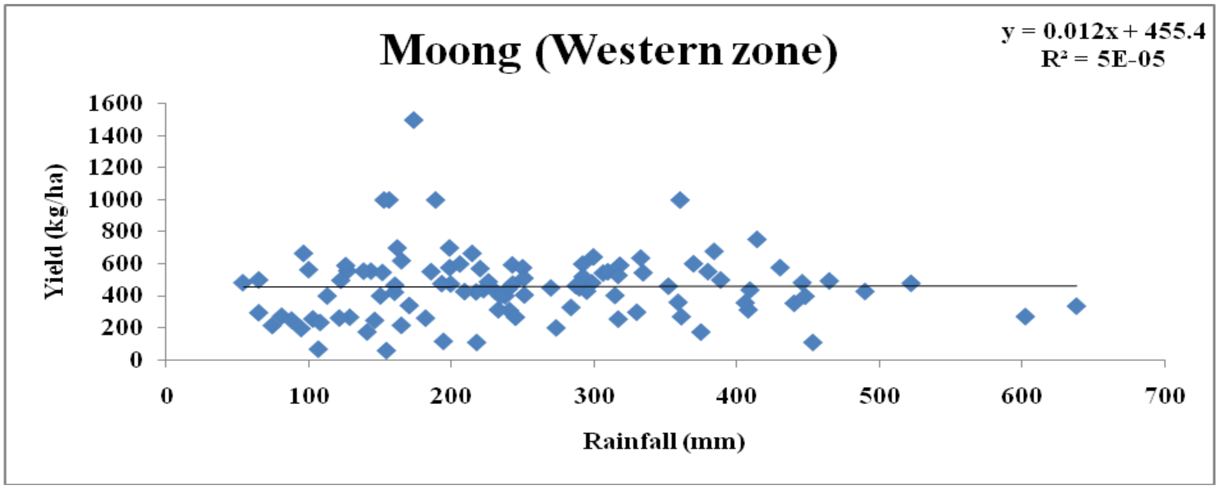

Figure.7 Relationship of rainfall (mm) and crop productivity (kg/ha) of moong crop in western zone of Haryana during *Kharif* season

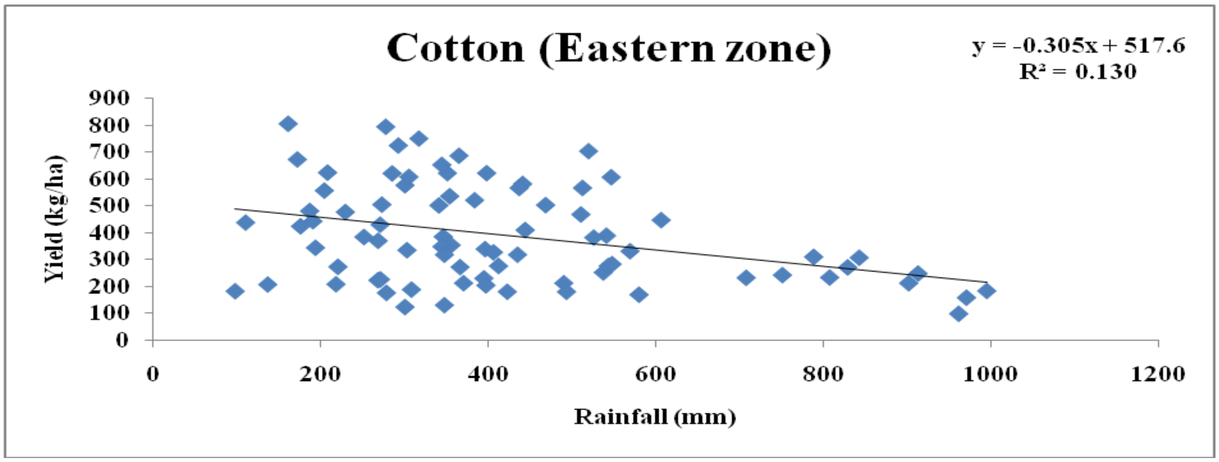

Figure.8 Relationship of rainfall (mm) and crop productivity (kg/ha) of cotton crop in eastern zone of Haryana during *Kharif* season

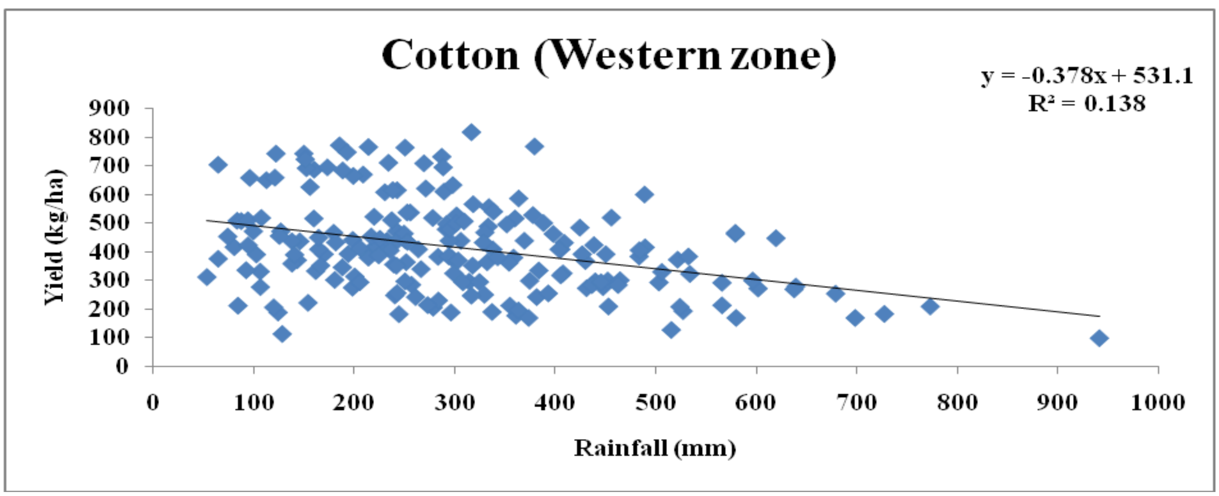

Figure.9 Relationship of rainfall (mm) and crop productivity (kg/ha) of cotton crop in western zone of Haryana during *Kharif* season

The cotton crop was grown in districts of Jind, Sonipat and Kaithal (Eastern zone); Bhiwani, Hisar, Mahendergarh, Rohtak, Sirsa, Rewari, Jhajjar and Fatehabad of western zone of Haryana (Figures 8 and 9, respectively). The crop productivity trends were found decreasing with increasing rainfall in both the zones and rate of decrease is comparatively higher in western zone. Williford (1992) observed that rainfall above of 50 mm reduces cotton yield and grade. The high rainfall results in high humidity which favours the pest and disease incidence. Arif *et al.,* (2006) observed a relationship with humidity which results in heavy infestation in cotton crop. The findings of Parvin *et al.,* (2005) are also support our results as he reported that yield declines 2.35 kg of lint per day and 4.09 kg of lint per centimeter of accumulated rainfall. Traore *et al.,* (2013) has the similar opinion that higher rainfall amount reduces cotton yields as a result of increased air humidity that support evelopment of harmful insects.

In conclusion, the adverse effects of drought on crop productivity was nullified by the assured irrigation facilities and increased rainfall, decreased the productivity by favouring the high incidence of pest and diseases except moong crop which is grown in summer season and relish the rainfall.

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