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Short communication

Pearl millet production over western Haryana in relation to monsoon rainfall*

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Rainfall over the western parts of Haryana is the major limiting factor for crop production over the area. This area receives more than 80% of its annual rainfall during the monsoon season. Average seasonal rainfall (June-September) varies from about 250 mm to 400 mm. Even this rainfall is not evenly distributed over entire season. The coefficient of variation of the seasonal rainfall ranges from 80 to 100% (Anonymous, 1991).

Pearl millet is a major crop of the area during the *kharif* season. The crop is generally sown as a rainfed crop with the outbreak of monsoon rains during the first fortnight of July. Bishnoi *et al.* (1991), while considering a single station (Hisar) in the region, have reported that a well distributed rainfall of about 400 mm is sufficient for optimum yield of the crop. But the total seasonal rainfall explained only about 76% variability in the crop yeild. This is because the rainfall is not evenly distributed over the crop season and there are spells of heavy / deficient rains which cause fluctuations in the grain yields depending upon their coincidence with the critical stages of the crop. The rainfall pattern for different categories of pearl millet yield have been characterised in the present study so that it could be used as a tool for crop yield estimation.

The area under study comprised of 4 districts - Sirsa, Fatehabad, Hisar and Bhiwani. Average grain yield of pearl millet for these four district for 32 years (1960-1991) have been obtained from the India Meterological Department, Pune. Average weekly rainfall of these six stations have been taken as the average weekly rainfall for the area. As the weekly rainfall data for year 1966 and 1967 were not available, the effective data set comprised of 30 years. Pearlmillet is a short duration crop sown during the first fortnight of July with the out break of monsoon rains. Hence weekly rainfall for 11 weeks - from meteorological week (MW) 27 (2-8 July) to MW 37 (10-16 Sept.) have been considered.

The grain yields exhibited a significant increasing trend over the study period, primarily due to varietal/ technological advancements. A linear tread line was fitted to the grain yields. The departures of actual yield from the trend yield were found out for each year. These departures have been clubbed into four categories -
excellent (departures >= 20%),
normal (+/- 19%),
poor (-20 to -50%) and
very poor (<-50%).

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Fig. 1: Study area and location of selected raingauge stations

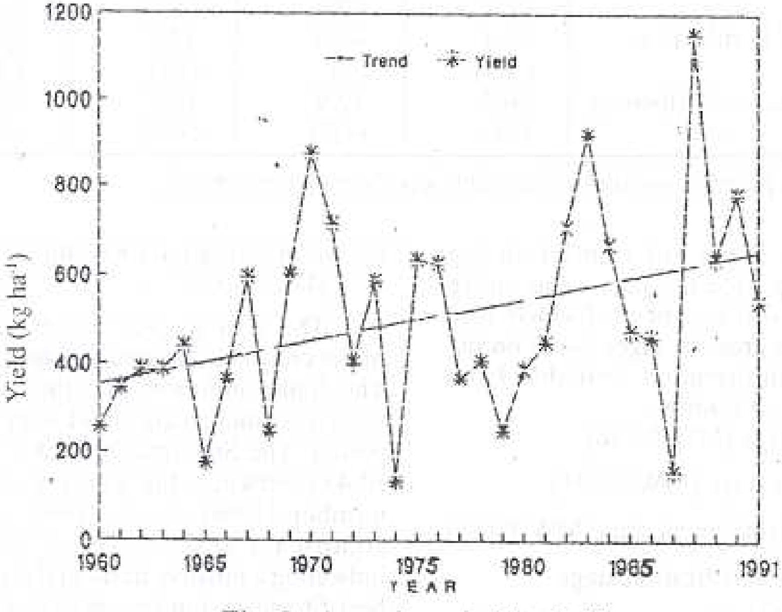

Fig. 2 : Annual pearlmillet yields

Table 1 : Coefficient of correlation between the detrended yield and monthly / seasonal rainfall

Parameters	July	Aug.	Sept.	July-Aug.	July-Sept.
Rainfall	0.08	0.31	0.54*	0.26	0.43*
Natural Log of Rainfall	0.19	0.44*	0.38*	0.41 *	0.51*

*Significant at 5% level of probability

Table 2 : Rainfall at different growth stages of Pearl millet crop during different types of yield years.

Crop Stage	Departure from trend yield			
	≥ 20%	±19%	-20% to -50 %	≤ -50%
Sowing	44.4 (2)*	46.6 (7)	65.2 (49)	24.6 (-44)
Vegetative	93.9 (11)	79.9 (-5)	120.7 (43)	33.9 (-60)
Panicle Development	63.4 (42)	53.6 (20)	34.5 (-23)	9.7 (-78)
Flowering / Fertilization	31.1 (-29)	42.5 (0)	52.7 (24)	16.2 (-62)
Grain Formation / Ripening	36.3 (14)	19.9 (-37)	16.7 (-47)	10.4 (-67)

*Figures in parenthesis are the per cent departures from normal.

To study the impect of rainfall during different crop growth stages, the entire cropping season has been divided into following five growth stages based on the background information available from various research studies.

(i) Sowing stage (MW 27-28)

(ii Vegetative stage (MW 29-31)

(iii)Panicle development stage(MW 32-33)

(iv)Flowering/Fertilization stage (MW 34-35)

(v) Grain formation / Ripening stage (MW 36-37)

The year to year yield of the pearl millet crop over the area are shown in Fig.2. The figure indicates that the yields have shown an increasing trend over the study period. The Spearman's Rank Correlation (0.43) between the yield and the year number (1960- 1,....., 1991 - 32) was significant at 5% level of probability indicating a positive trend in the yields. The best fit regression line between yield and year number was found to be linear as shown below.

Yield (kg ha^{-1}) =344.2 + 9.75 year Number ($r = 0.391$)

The dapartures of actual yield from the trend yield as obtained from the above education (detrended yield) were found to be poorly correlated with the July-September cumulative rainfall ($r = 0.43$). The correlation, though significant at 5% level of probability, has very little utility for predicting the yields. The coefficients of correlation between the detrended yields and monthly rainfall and their logarithmic transformations have been presented in Table 1. It is evident from the table that the yield has higher correlation with the loogarithmic values of rainfall than with the actual values, indicating that the yield does not increase linearly with the increase in rainfall.

The multiple regression equation between the detrended yields and monthly/ periodical rainfall has been developed using the step-wise regression method. The best model for predicting the yield over the area was found to be as below.

$$Y = -634.4 + 2.3\ X1 + 118.2\ X2 \quad (R^2 = 0.39)$$

Where, Y is the departure of actual yield from the trend yield (kg ha^{-1})

X1 is the September rainfall (mm)

X2 is the Nutural log of August rainfall (mm)

Even after introducing the non-significant variables in the regression equation, the R^2 value obtained was 0.57. It showed that the monthly rainfall could explain only 57% variability in the pearl millet yield and hence can not be very useful for predicting the yields.

As it was not feasible satisfactorily predict the grain yield using monthly / seasonal rainfall, it was decided to characterise the rainfall climatology for different categories of grain yield. For this purpose, the grain yields were clubbed into four categories as described in the previous section. As the pearl millet crop, like any other crop, is sensitive to the rainfall received during different crop growth stages, the rainfall distribution over the critical growth stage was found out and the same as presented in Table 2.

The excellent yield years received nearly normal rainfall during sowing; slightly above normal rainfall during vegetative and grain formation stages, above normal rainfall during panicle development stage and deficient rainfall during flowering (anthesis) stage. On the other hand, the poor yield years received above normal rainfall during sowing, vegetative and flowering stages. Very poor yield years received scanty rainfall throughout the growing season.

Table 2 also shows that there is not much difference between the total rainfall received during excellent and poor yield years. It is the distribution of rainfall over the cropping season which results in the difference in the yields.

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