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AN APPROACH TO CROP PLANNING THROUGH MOISTURE AVAILABILITY ANALYSIS IN DRYLAND AREAS

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SUMMARY

Variations in the moisture availability were examined for Jamnagar utilising weekly rainfall data and U.S. pan evaporation data for a number of years when sowing commenced early, normal or late during Kharif season. In the years of early showing, sufficient moisture is available from 6th to 20th week after sowing. When sowing commences at the normal time assured adequate soil moisture is available till 18 weeks after sowing where as for late sowing years it is available for 15 weeks after sowing, Considering the pattern of moisture availability, groundnut crop is suitable for early sowing years. During normal years any of the crops Jowar, Bajra or Groundnut can be safely grown whereas for late sowing years a short duration pulse is suitable.

Keywords : Crop strategy; Potential/actual evapotranspiration; moisture stress; run test; χ^2 test.

Introduction

Variation in the amount and the time of commencement of monsoon is an annual feature in the country but the extent of variability is large in the semi-arid areas. This variation affects the availability of soil moisture during the crop season which ultimately influences the crop yield. For efficient crop planning, it is, therefore, necessary to have detailed information on the pattern of availability of soil moisture under varying time of commencement of monsoon. In past, some research workers viz. Krishnan and Rao [1], Rao and Vyas [4], Saksena and Bhargava [5] examined the pattern of availability of weeks with sufficient and deficient moisture availability. Krishnan *et al.* [2] examined the alternative systems of sowing under different rainfall patterns. The principal limitation of

these investigations was that they have not used the information so derived for the crop strategy under varying set of conditions. Krishnan and Rao [3] have identified the optimum sowing period for groundnut crop in Bijapur. In the present paper, an attempt is made (i) to study the pattern of availability of weekly soil moisture during cropping seasons commencing from different weeks suited to sowing, (ii) to examine association between the amount of rainfall and the time of commencement of sowing, (iii) to estimate the duration of safe growing periods, (iv) to obtain the chances of occurrence of moisture stress during each week of the season and (v) to develop the proper crop strategy on the basis of information available from (i) to (iv). For this purpose, the data on rainfall, evaporation etc. is utilised for Jamnagar (Gujarat).

Material and Methods

Weekly rainfall data for 72 years from 1901 to 1975 (three years missing) and U.S. pan evaporation data for 11 years from 1961 to 1971 for Jamnagar were collected from India Meteorological Department. Modified values of evaporation (i.e. multiplied by 0.65) were taken as the estimates of weekly potential evapo-transpiration (PE). The period for which evaporation data was not available, average of 11 years were used. Estimates of weekly actual evapo-transpiration (AE) were obtained by using the water balance model. The very first week between June to September with AE $\geqslant$ PE/2 was considered as the sowing week.

For the present investigations, each year was classified under system I if sowing week falls between 23rd to 25th standard week (4-24 June), system II if sowing week falls between 26th to 28th standard week (25 June-15 July) and system III if sowing week falls on 29th week or later (16 July or later).

To test whether the order of occurrence of normal sowing years and abnormal years was random, run test was applied. The statistics used for testing the hypothesis that the order in which normal and abnormal years occur is random is given below :

$$Z = \frac{r - u_r}{\sigma_r} \sim N(0, 1)$$

where 'r' is the total number of runs of both kinds. n_1 and n_2 is number of elements of both the kinds.

$$u_r = \frac{2n_1 n_2}{n_1 + n_2} + 1 \quad \text{and} \quad \sigma_r = \sqrt{\frac{2n_1 n_2 (2n_1 n_2) - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)}}$$

If the value of Z is more than 1.96, hypothesis is rejected.

A year was further classified as deficient if the total rainfall was less than 50% of the normal, surplus if it was more than 150% of normal and normal if the rainfall was between ± 50% of the normal. For each of these systems, the association between the commencement of sowing and quantum of rainfall in the season was examined by chi-square test. For each of these systems starting from sowing week, the average cumulative AE (CAE) and cumulative PE/2 (CPE/2) values were calculated for 23 weeks. The period when CAE curve is above the CPE/2 curve is the stress free period during the cropping season. Weeks with CAE $\geqslant$ CPE/2 were considered as moisture stress free, weeks with CPE/4 $\leqslant$ CAE $<$ CPE/2 were considered as moderate stress weeks and with CAE $<$ CPE/4 as severe stress weeks. Existence of these three types of periods was examined for each week of the three systems. The chance of occurrence of these types of periods during the cropping season were also worked out for each system.

Results and Discussion

The distribution of years under three systems was 24, 35 and 13 respectively. Total number of years under system I and III form abnormal years and years under system II are normal years. To test whether the order in which normal or abnormal years of sowing occurred were random or not, the run test was used. It was found that the order of occurrence of normal or abnormal rainfall years was random. The chances of commencement of sowing in a year at normal time were 0.49 against the chances of abnormal commencement being 0.51.

Table 1 gives the frequency of occurrence of different rainfall amounts (deficient, normal and surplus) under the three systems. The value of

TABLE 1—FREQUENCY DISTRIBUTION OF DEFICIENT, NORMAL AND SURPLUS RAINFALL YEARS UNDER THREE SYSTEMS JAMNAGAR

Rainfall	*Period of sowing*				
	System I	*System II*	*System III*	*Total*	%
Deficient 50% of normal	3	10	8	21	29.1
Normal ± 50% of normal	15	19	5	39	54.5
Surplus 150% of normal	6	6	0	12	16.4
Total	24	35	13	72	
%	33.3	48.6	18.1		$x^2 = 11.04$

chi-square is 11.04 which is highly significant. This indicates the association between the two characters namely, time of commencement of sowing and the amount of rainfall. This in fact shows the association between the time of commencement of rainfall and amount of rainfall available during the season. Earlier the conditions are favourable for commencement of sowing, more is the amount of rainfall in the entire season and vice-versa.

Weekly average cumulative AE and PE/2 values were worked out for each year separately. These cumulative values for the three systems were plotted on the graph and are shown in Fig. 1. Weeks for which CAE

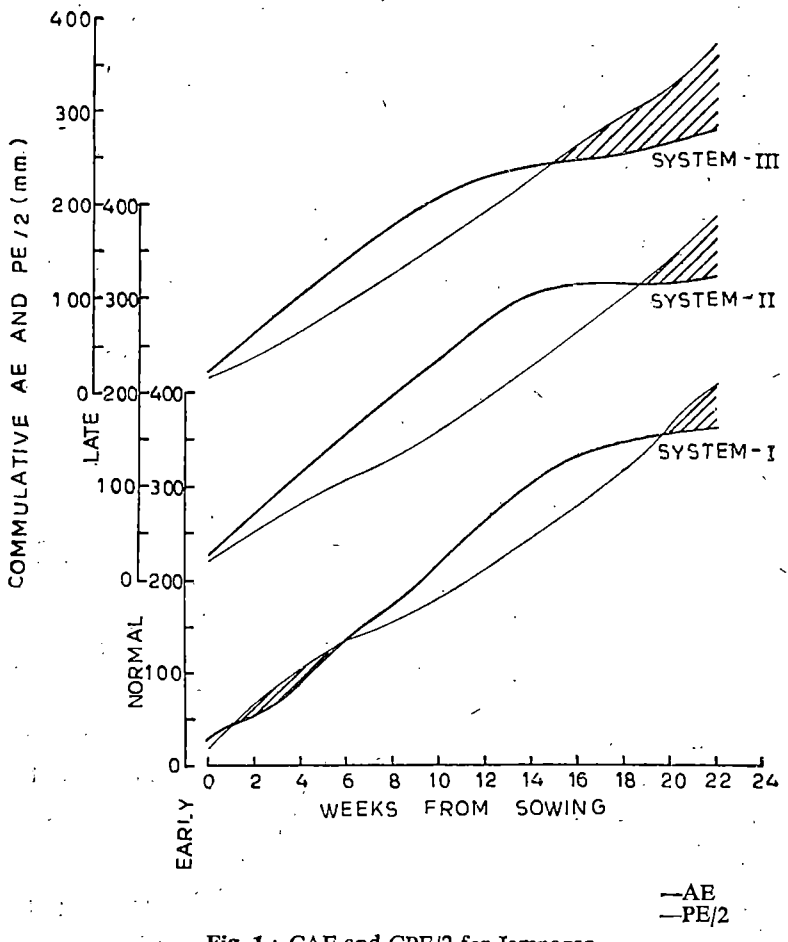

Fig. 1 : CAE and CPE/2 for Jamnagar.

curve is above the CPE/2 curve are the stress free weeks. The figure shows that for the system I the CPE/2 curve is above CAE for the first 6 weeks, the moisture deficiency is maximum towards the second or third week

and thereafter this deficiency starts decreasing rapidly. From the 7th week onwards till 20th week the adequacy of moisture is maintained. After the 20th week there is a moderate moisture stress for subsequent two weeks followed by severe moisture stress. A continuous stress free period of 14 weeks exists under this system from 6th to 20th week after sowing. Under the system II CAE curve is above CPE/2 curve for a period of 18 weeks right from the sowing week. Therefore, duration of continuous stress free period under this system is 18 weeks followed by 2 moderate stress weeks and the rest of the weeks are severe stress weeks. Under system III, CAE curve remains above the CPE/2 curve for 15 weeks. After the 15th week one week of moderate stress and the rest of the weeks of severe moisture stress occur.

Probability of CAE being greater than or equal to CPE/2 for each week was worked out. These probabilities are plotted in Fig. 2. It shows that

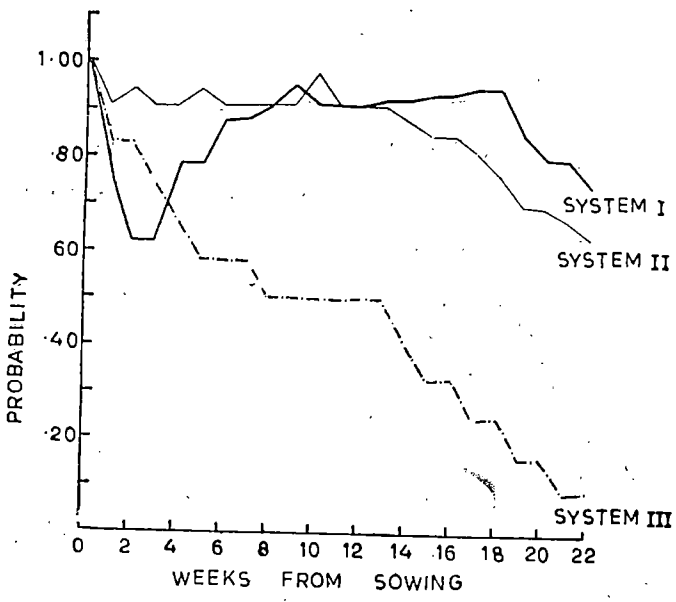

Fig. 2. Probability of CAE $\geq$ CPE/2 during each week.

the chances of each week being stress free are highest for the normal period of sowing and for late sowing the chances are very low after 5th week of sowing where as for the early sowing chances are very low for the first 5 weeks after sowing. This shows that years of normal sowing are safest for the crops and also have the longest safe period.

This is further confirmed by Table 2 which gives the distribution of years under different systems having specified number of stress free weeks during the entire period of 22 weeks after sowing. Under system I, two-thirds of years had 12 or more stress free weeks, under system II this proportion is only 0.44 and under system III it reduces to 0.30. Under system III the probability of a year having 6 or less stress free weeks is .46 which is highest.

TABLE 2—FREQUENCY DISTRIBUTION OF STRESS FREE WEEKS UNDER THREE SYSTEMS—JAMNAGAR

Systems	*6 or less weeks*	*7-11 weeks*	*12 or more weeks*	*Total*
I	3	5	16	24
II	3	16	16	35
III	6	3	4	13
Total	12	24	36	72

System I is ideally suited for groundnut crop. Under this system the chances of having stress free weeks from 6 to 20 weeks of season are very high. Though the soil moisture depletion starts from 16th week but the moisture availability is sufficient till 20th week which helps in easy harvesting of the crop. The soil moisture build up continues for first 13 weeks under system II and thereafter depletion starts. The chances of each week being stress free are very high for first 15 weeks. Therefore, during this system groundnut, jowar and bajra can be safely grown. Under system III only for the first 6 weeks the soil moisture continues to built up and thereafter the depletion starts. The chances of stress free weeks are high for first 6 weeks and thereafter these chances reduce rapidly. Under such conditions a pulse crop of short duration can safely be grown.

Conclusions

Sowing week between 4-24 June, was classified under system I, between 25th June to 15th July under system II and later than 16th July under system III. There was an association between the amount of rainfall and the time of its commencement. Earlier the rain starts more the amount is. During the years of early sowing longer cropping season exists. The cumulative AE and cumulative PE/2 model showed that during the first five weeks after sowing adequate moisture is not available; but from 6th to 20th week sufficient moisture is available for the crops. Probability of

12 or more weeks being stress free is 0.66 during these years. During the years when sowing commences at the normal time assured adequate soil moisture is available till 18 weeks after sowing. The probability of 12 or more moisture stress free weeks during these years is 0.44. During the late sowing years though adequate soil moisture is available for 15 weeks after sowing on the average but the probability of 12 or more weeks being stress free is only 0.30. On the basis of the pattern of moisture availability groundnut crop is suitable for early sowing years. During normal years any of the crops jowar, bajra, or groundnut can be safely grown whereas for late sowing years a short duration pulse is suitable.

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