

WATER BALANCE AND CROP PLANNING - A CASE STUDY OF WESTERN RAJASTHAN

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ABSTRACT

Based on the weekly water balance computations for eighty years (1901-1980) variability in the average length of the growing season in the Western Rajasthan was analysed. The date of commencement of *kharif* season rains was found to influence considerably, the periods of water availability for crop growth. Therefore, to assess the impact of commencement to the growing season on crop performance, length of the growing season and its variability under early, normal and late commencement of the monsoon rains were also studied. Probabilities of occurrence of the growing seasons of varying lengths were investigated. Possible adjustments in the cropping patterns are discussed. Water harvesting potentials of different regions in the Western Rajasthan are projected alongwith possible changes in the cropping systems.

INTRODUCTION

In Western Rajasthan, which covers 62 per cent of the Indian arid zone, water is a major limiting factor in successful crop production. Rainfed agriculture is beset with many critical problems specially low and erratic distribution of the rainfall. Apart from variations in the total seasonal rainfall, the region experiences large variability in the time of commencement of the sowing rains as well as in the distribution of the rainfall within the crop growing season. The existing traditional and subsistence oriented cropping patterns lead to indiscriminate use of the agricultural land and also to low economic returns (Mann and Singh, 1977). In order to improve and stabilize the economy of this arid region, there is a great need for a rational crop

planning with the aid of suitable agronomical methods.

The crop growing season depends not only on the rainfall distribution but also on the water holding capacity and moisture release characteristics of the soil as crops extract stored moisture during the rainless period. The water balance method of Thornthwaite and Mathur (1955) takes into account all these factors for estimating actual evapotranspiration. Application of this method on a short term (weekly) basis within the growing seasons would bring out a clear picture of the moisture deficiency and the surplus during different phenological stages, thus leading to a better assessment of the consumptive use and the crop yield. Applicability of this approach for crop planning in Western Rajasthan has been discussed here.

MATERIAL AND METHODS

The daily rainfall data recorded for eighty year (1901 to 1980) at nine stations i.e., Sikar, Nagaur, Barmer, Jaisalmer, Jodhpur, Churu, Jhunjhunu, Pali and Jalore have been considered. The agricultural land covers about 70 per cent of the area in Western Rajasthan. About 60 per cent of agricultural land have sandy to loamy sand soils and about 10 per cent have medium to moderately fine textured soils. The soil is 70 to 100 cm deep and underlain by a thick layer of calcium carbonate pan known as *kankar*. The average water holding capacities of the sandy to loamy sand, loamy and clay loam soils are about 100 mm, 150 mm and 200 mm, respectively.

Normal values of the potential evapotranspiration were estimated using Panman's (1948) method and weekly water balance was computed as per Thorntwaite and Mather (1955). The ratio of the actual evapotranspiration to the potential evapotranspiration, termed as Index of Moisture Adequacy (I_{ma}) (Subrahmanyam *et. al.* 1963), was estimated weekwise from the water balance data.

Average date of the onset of the monsoon in eastern part of the Western Rajasthan falls in the last week of June (26th met. week) and in the first week of July (27th met. week) in the western part. The commencement of the growing season in the region was, therefore classified as early i.e. upto 25th standard week, normal i.e., during 26th to 28th week and late i.e. 29th week onwards. The average

weekly values of I_{ma} were calculated as per above classification of the growing season. Probabilities of the occurrence of the growing season ranging from 8 to 18 weeks were also estimated accordingly for all the selected stations. Amount of the surplus water, its probable period of occurrence and probabilities of harvesting surplus water amounts of at least 50 mm and 100 mm were also estimated.

RESULTS AND DISCUSSION

Relationship between actual evapotranspiration during the growing season, length of the growing season and its probability of occurrence under average conditions are depicted in Figs. 1 to 3 for three stations i. e. Jhunjhunu (mean annual rainfall 404 mm) located in the northern part, Pali (mean annual rainfall 420 mm) located in the southern part and Barmer (mean annual rainfall 282 mm) located in the western sector. Major rainfed crops of these regions are pearl millet and *kharif* pulses of 14 weeks and 10 weeks duration, respectively. Hence, the probabilities of the occurrence of the crop growing season and the mean water availability (AE) during the crop growth period were worked out for 14 and 10 weeks along with other possible lengths of the growing season.

At Jhunjhunu probability of the occurrence of crop growing season of 14 weeks duration is 52 per cent with a mean water availability for crop growth (AE) of 268 mm (Fig. 1). Corresponding values for the 10 weeks crop growing season are 74 per cent and 207 mm. Probability of

the success of crops of longer duration (more than 14 weeks) are less than 40 per cent. Thus, in Jhunjhunu region, there are chances of success for crops of 14 weeks duration once in two years and crops of 10 to 12 weeks duration can be successfully grown in two out of three years.

Mean length of the crop growing season under early commencement exceeds 16 to 18 weeks with probability of 55 to 47 per cent and upto 12 to 14 weeks with probability of 70 to 60 per cent (Table 1). It means that under early commencement of the crop growing season there are better chances of obtaining a growing period of more than 16 weeks once in two years and crops e.g. pearl millet which complete major part of the life cycle in 12 to 14 weeks are sure to succeed in two out of three years. In contrast, probabilities of the crop growing season exceeding 14 weeks under the normal commencement and even 12 weeks under the late commencement conditions are not suitable for crops like pearl millet to be grown in Jhunjhunu region.

At Pali mean probabilities of the occurrence of the crop growing season of 14 and 10 weeks duration work out to be 37 and 66 per cent with mean water availabilities of 328 mm and 229 mm, respectively (Fig. 2). It means that crops of 14 weeks duration can succeed only once in three years while crops of 10 weeks duration e.g. *kharif* pulses, have chances to succeed in two out of three years. Cultivation of long duration crops in this region is, therefore, a risky proposition.

Chances of success of short duration crops at Pali are greater during normal commencement (Table 1) Under early or late commencement (Table 1). Under early commencement, which occurs, on an average, once in five years (20 per cent probability), chances of success of long duration crops are 40 per cent and above. Success of long duration crops are less under normal commencement and remote under late commencement conditions. This restricts the choice of crops especially under late commencement and remote under late commencement conditions to only short duration (10 weeks) ones.

In the Barmer region successful crop growing season under average conditions does not exceed 8 weeks. Probability of the occurrence of the crop growing season of 10 weeks duration is only 41 per cent with a mean water availability (AE) of 212 mm (Fig. 3). However, under early commencement conditions chances of the success of short duration (10 weeks) crops e.g. *kharif* pulses and oilseed crops are brighter. The chances of crop success are even under normal commencement conditions, not good to remote under late commencement (Table 1). Thus, this region is suitable for short duration crops only and that too if grown under early and normal commencement of the monsoon. Under late commencement conditions it is advisable to grow only fodder crops to get some economic returns.

WATER HARVESTING POTENTIALS

Surplus water can occur once in two years at Pali (53 percent) and once in

Table 1. Probabilities of occurrence of growing season of different lengths under early, normal and late onset of monsoon.

	Length of growing season (weeks)	Probability of occurrence (%)		
		Early onset	Normal onset	Late onset
JHUNJHUNU	8	73	88	72
	10	70	84	58
	12	70	78	53
	14	60	68	28
	16	55	44	23
	18	47	33	10
PALI	8	65	85	71
	10	55	77	53
	12	48	60	25
	14	47	41	10
	16	40	31	3
BARMER	8	77	66	37
	10	70	59	30
	12	54	47	9
	14	10	36	6

Table 2. Water harvesting potentials in different regions of western Rajasthan.

Locations	Mean surplus (mm)	Highest surplus (mm)	Probable period of water surplus	No. of surplus year (%)
PALI	144	545	30th-36th week (23rd July-9th September)	53
JALORE	107	376	30th-36th week (23rd July-9th September)	40
JODHPUR	112	363	31st-36th week (30th July-9th September)	34
SIKAR	86	239	34th-35th week (20th August-2nd August)	29
JHUNJHUNU	73	226	32nd-34th week (6th August-26th August)	26
BARMER	96	323	30th-34th week (23rd July-26th August)	25
JAISALMER	42	110	33rd-35th week (13th August-2nd September)	10
CHURU	62	159	34th-35th week (20th August-2nd September)	9
NAGAUR	235	596	33rd-35th week (13th August-2nd September)	8

in three years at Jalore and Jodhpur (Table 2). At Sikar, Jhunjhunu and Barmer there are chances of collecting surplus water once in 4 years. In these regions highest probabilities for surplus water occur during the middle of August (33rd and 34th standard weeks) with chances of surplus water occurrence extending from 23rd July to 9th September. Singh (1980) adopting a bare catchment area of 2500 m² and water collection pond of 174 m³ at the Central Arid Zone Research Institute, Jodhpur showed that run off exceeding 50 to 100 mm can be harvested successfully and can be recycled not only to save the crop during periods of severe moisture stress but also to raise a second crop; thereby increasing the cropping intensity and net returns from the agricultural lands (mann *et. al.*, 1974; Rama Krishna and Sastri, 1980). The present study, thus brings out that water balance approach is useful in crop planning in western Rajasthan.

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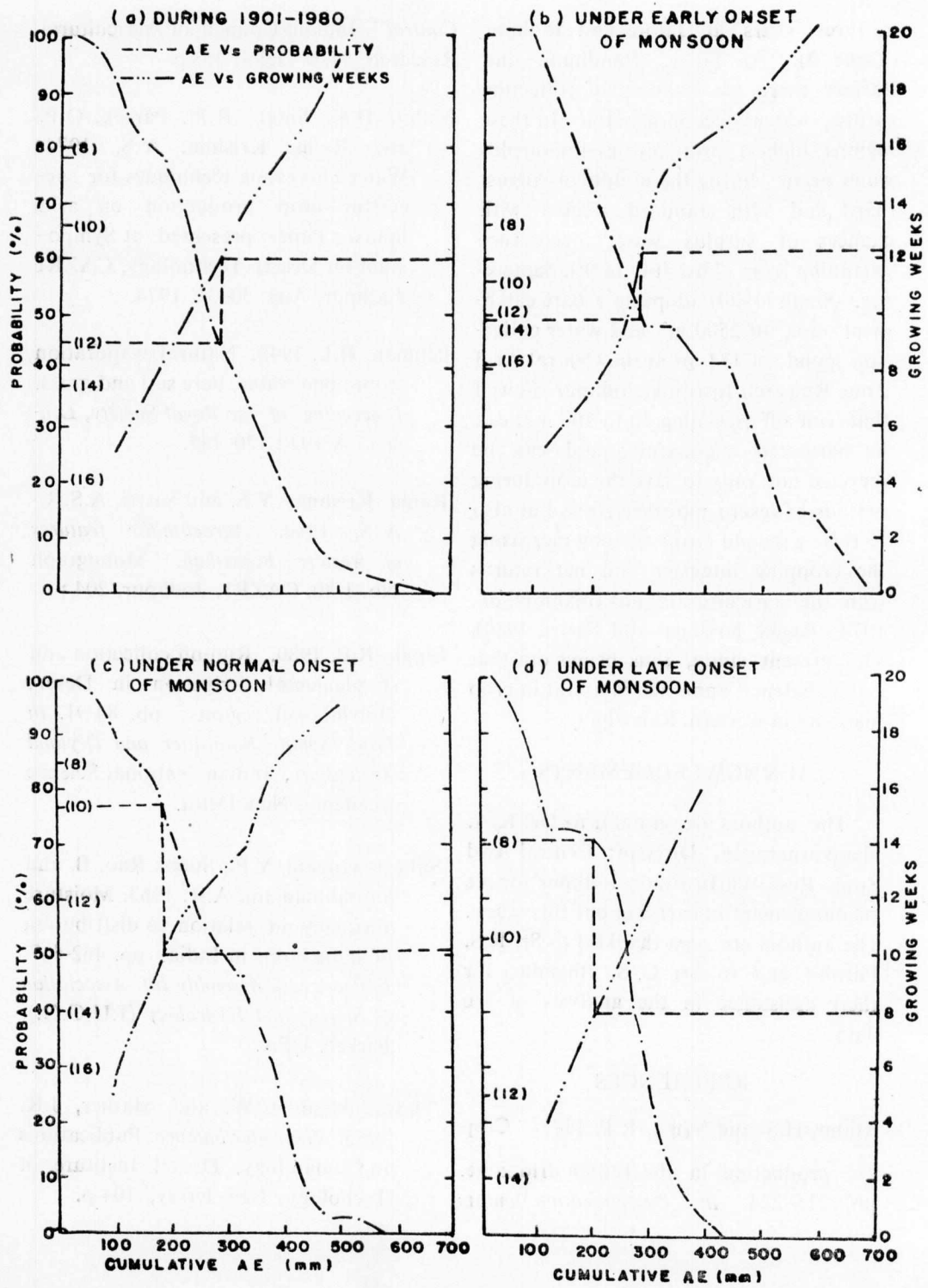


Fig. 1

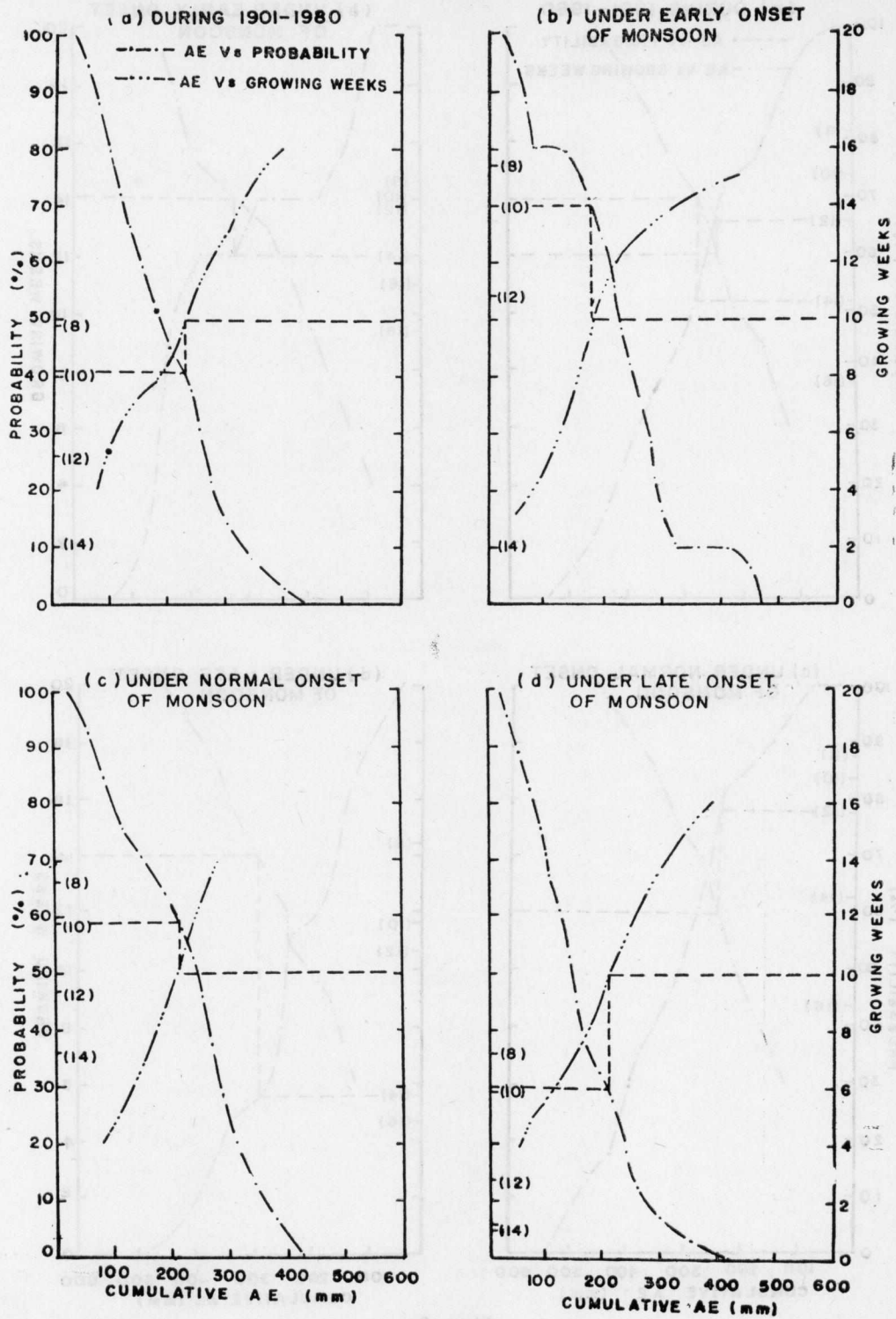


Fig. 2

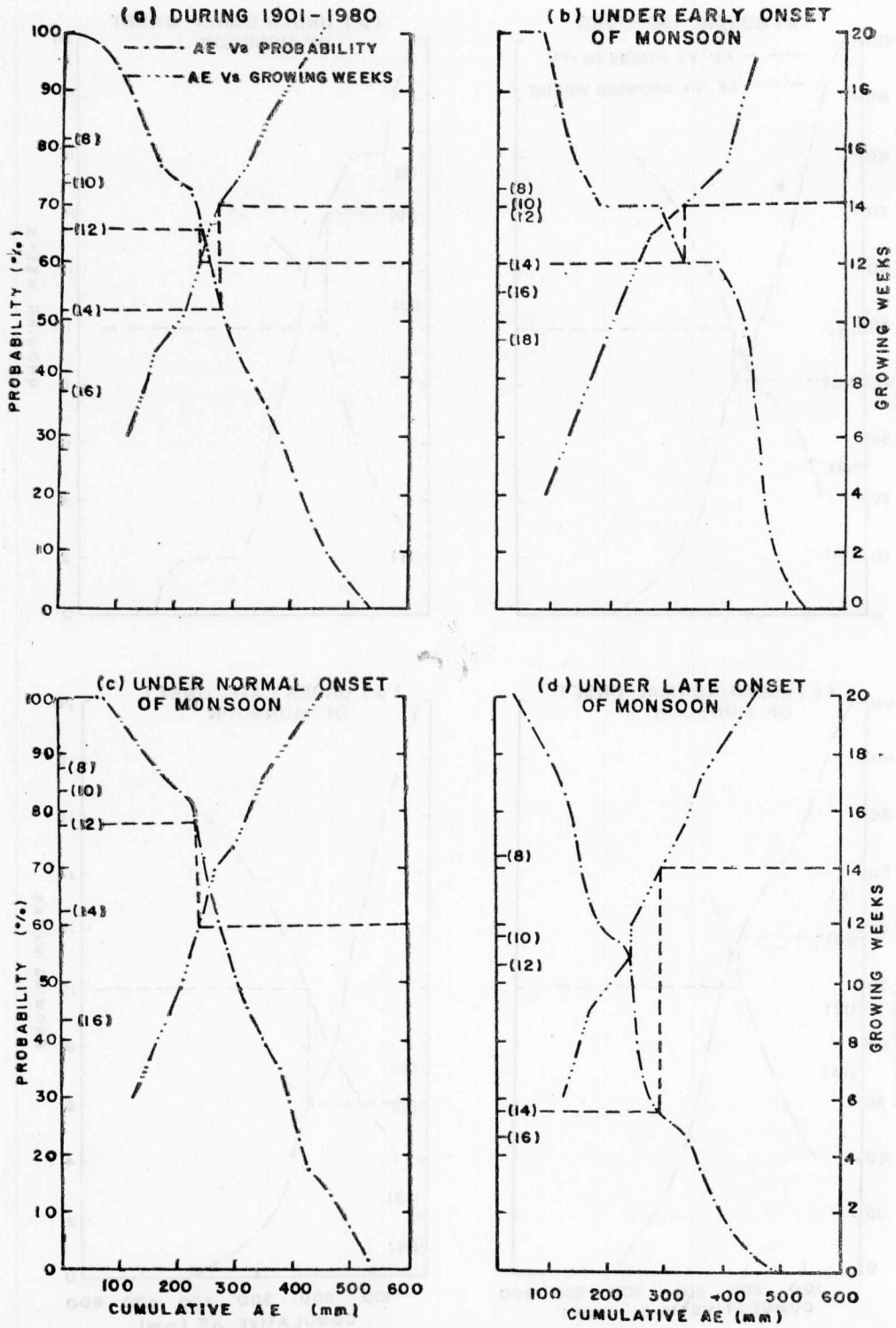


Fig. 3

Fig. 1 PROBABILITIES OF OCCURRENCE OF CROP GROWING SEASONS OF DIFFERENT LENGTHS AT PALI :

Fig. 2 PROBABILITIES OF OCCURRENCE OF CROP GROWING SEASONS OF DIFFERENT LENGTHS AT BARMER ;

Fig. 3 PROBABILITIES OF OCCURRENCE OF CROP GROWING SEASONS OF DIFFERENT LENGTHS AT JHUNJHUNU :

Constraints to achieve these yield potentials may be technological, economic, sociological or their combination. A preliminary study indicated that the average yield of dryland rain in the farmers' field is about 10.5 dt/ha and the potential yield estimated through demonstrations on the farmers' field is about 13.8 dt/ha (Hobbar, 1980). This study has therefore been taken up to measure the on-farm gap between the potential and the actual yields and to evaluate the role of technological, physical and economic factors associated with the yield gap.

MATERIAL AND METHODS

The study was taken up at Zainapoor (Bikaner) under the Operational Research Project for Bikaner district, during the

INTRODUCTION

Though considerable progress in research has taken place to evolve new technologies in improving the crop yield in dryland agriculture, the yield levels in farmers' fields remain far less than what could have been achieved (Datta et al., 1973). Studies have shown that gaps between the potential yield and the actual yield in farmers' fields are substantial and need systematic investigation to understand their magnitude and cause (Rao, Shekara and Hobbar, 1981). While adoption studies throw light on the reasons for non-adoption of new technologies, they do not answer the questions pertaining to reasons for unavailability of the potential yield by farmers even after the adoption of new technologies.