Effect of fallowing on crop growth
TOP : Bajra after crop BOTTOM : Bajra after fallow.

SOME RECOMMENDATION FOR BARANI CULTIVATIONS IN THE PUNJAB STATE

by

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INTRODUCTION

About sixty percent of the land in Punjab (India) depends directly or indirectly on rains for crop production. Although there are two rainfall seasons in the year, yet most of the rain is received from July to September, which constitutes the monsoon season. The second rainfall season falls in winter from November to March, but the amount of rainfall received is very small being only 15 to 20 per cent of the total annual precipitation. It is, therefore, a problem to raise the *barani* crops in the Punjab, particularly in areas of scanty rainfall. This has been virtually true of the south-eastern parts of the Punjab comprising of the Districts of Rohtak, Hissar and Gurgaon. In order to study crop farming in this region, a Dry Farming Research Station was started at Rohtak to find out the methods for successful crop production on limited rainfall, the distribution of which is very erratic from year to year. This scheme remained in operation from 1935 to 1943.

The average rainfall during this period was 16·35 inches made up of 12·65 inches and 3.70 inches in summer and winter respectively. Rainfall in the years 1936, 1937 and 1942 was above the normal, that in 1942 being far in excess. Rainfall in the years 1935, 1940 and 1941 was about normal, while that in the years 1938 and 1939 was very low, being about half of the normal. Thus the period of investigation covered three good, three normal and two bad years.

There were two types of soils at the Research Station—(i) light loam, and (ii) medium loam, the former being 85 per cent of the total area.

The results of these investigations will be of great value in raising of crops in rainfed areas in general and those receiving 15 to 20 inches of rainfall, in particular. Different investigations covering the different phases of dry-farming were taken up for study and these, with the results obtained, are discussed below:-

1. **Levelling and Bunding of fields:-** Levelling of the field is a very important operationfor effecting uniform absorption of rain water on the entire area. It is essential that the slope of the field should be measured and the field properly terraced, so that any contiguous level area is enclosed in between two terraces. Even a slight slope in a field which may not be perceptible to the eye may greatly influence the yield of the crops. This is borne out by the yield data of the different blocks of a field which had a slope of one foot in 660 feet. The blocks were equal in area but were situated at different levels, and the

separating *bunds* being not sufficiently high to check surface run-off, the water accumulated in blocks V and VI which were at the lowest level.

Yield of grain in maunds per block.

	I	II	III	IV	V	VI
Bajra 937	0.55	0.44	0.45	0.38	1.26	1.48
Gram (1936-37)	0.34	0.16	0.19	0.26	0.68	0.67

This difference in the yield of different blocks is attributable to the fact that the whole of the moisture and plant nutrients accumulated near one end of the field and, therefore, the yields of blocks V and VI were higher than those from the rest of the field. In order to effect uniform distribution of rain water and check run-off, *bunds* were made at short distances. The yields of wheat, given below show that by dividing the field into small *kiaras* uniform yield from each block could be obtained.

Yield of wheat grain in maunds per block

I	II	III	IV	V	VI
0.52	0.49	0.60	0.55	0.50	0.57

In order to prevent run-off and to conserve soil and rain water and to effect a uniform distribution of the latter, it is necessary that the fields should be enclosed by suitable *bunds*. Dimensions of such *bunds* depend on the amount and intensity of rainfall, the gradient and the nature of the soil. Under Rohtak conditions one foot high *bunds* have been found to be satisfactory. Fields approximately one acre in area should be enclosed by such *bunds*. To effect uniform distribution of rain water over the entire area of the field, it is suggested that the acre field should be further divided into five strips or *kiaras* by building "cross-*bunds*" nine inches high. The *bunds* should be built on contour, and each *kiara* should be properly levelled.

The utility of constructing *bunds* around the fields is clearly borne out by the results tabulated below:-

Average yield of grain in maunds per acre.

Treatments	Gram			Barley	
	1935-36	1936-37	1937-38	1936-37	1937-38
Bunds	11.29	4.57	2.34	16.54	13.22
No bunds	11.54	3.22	1.91	12.71	11.0

II **Cultivation :**—Cultivation is the most important operation under dry-farming and is carried out with the following three objects :—

1. Absorption of rain water.
2. Conservation of rain water.
3. Formation of seed bed.

Fig.1. Cultivated Field at the Station

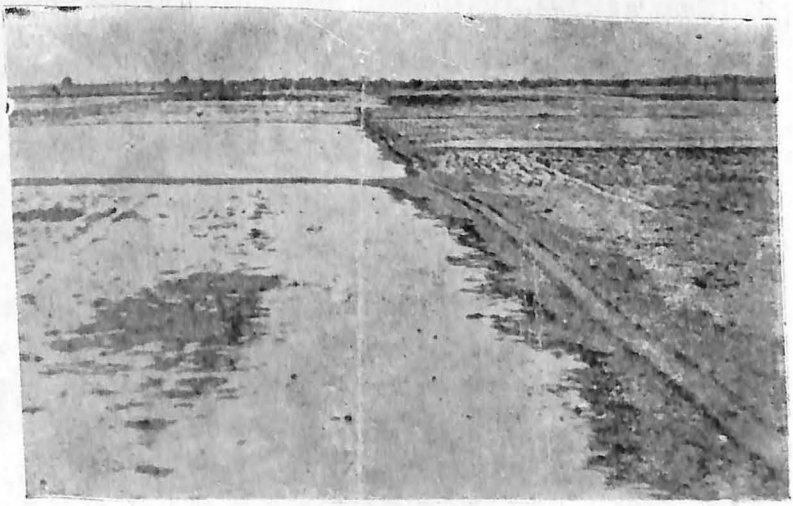


Fig. 2. Uncultivated Zamindar's Field

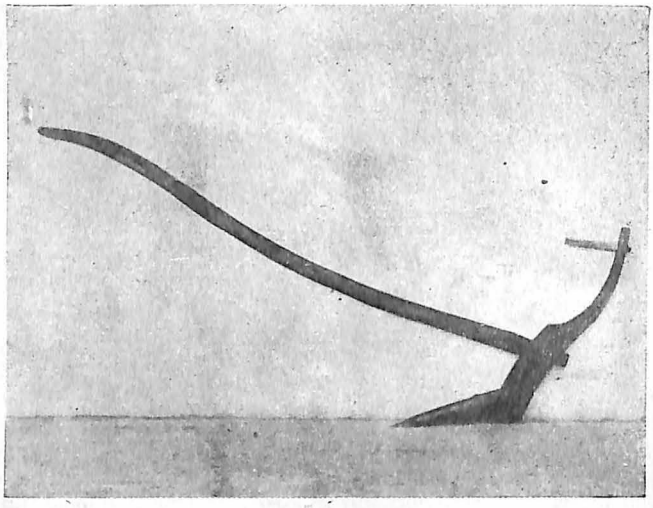


Fig. 3. Country Plough

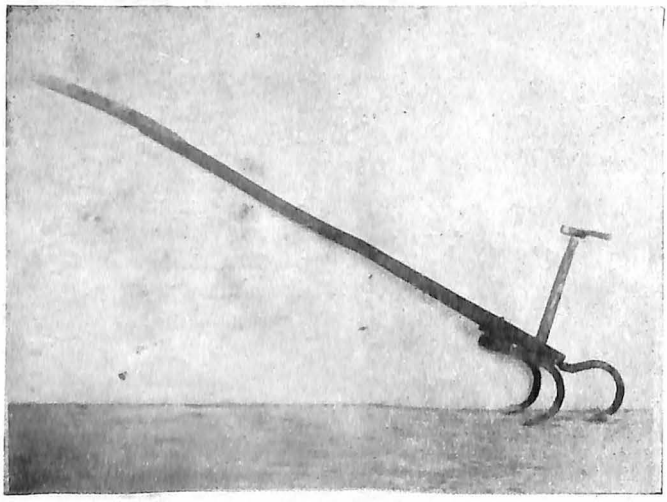


Fig. 4. Lyallpur Hoe

1. **Absorption of rain water :**—The increase in the amount of moisture at various depths of soil was studied in fields, where surface run-off was minimum and the field surface was kept loose by frequent ploughing and harrowing. After the monsoon season, there was an increase in moisture content in the entire six feet soil column, irrespective of the amount of summer rainfall, the water gained by the 6th foot being 4 to 10 per cent of the total rain water absorbed. However, more than 80 per cent of this water was stored in the first 4 feet column of a field. Absorption from summer rains amounted to 28·8 per cent while that due to winter rains amounted to 60·2 per cent of the total rains received during the season. The amount of rain water that can enter the soil also depends on the intensity of showers. Showers of less than half an inch do not enter the soil but are lost at the surface by evaporation, while 40 to 50 per cent of the showers of half inch to one inch and 80 to 90 per cent of the showers of more than one inch find their way into the soil.

To effect maximum absorption it is necessary to cultivate the land, which should be opened with the first shower of rain. Water is readily absorbed in a cultivated soil, and thus it is protected from being lost by evaporation.

Well cultivated fields at the farm quickly absorbed the rain water, which remained standing in the adjoining cultivators' fields (Photos 1 & 2).

It has been further observed that the depth of the ploughing has no effect on the conservation of moisture. Moisture stored in the plots cultivated by Meston or country plough was more than that in the plots ploughed by Raja or the Hindustan ploughs. Therefore, any plough which is available with the cultivator can be used for opening the land. Subsequent cultivation should be given with the object of keeping the land free from weeds, and for this purpose Lyallpur hoe or any other hoe can be used.

Cultivation should always be done across the slope of the land in such a manner as to obstruct the flow of rain water. For this purpose country plough and Lyallpur hoe which form furrows and ridges are best suited (Photos 3 and 4).

2. **Conservation of rain water :**—To keep the water avilable for the crop, it is necessary that the losses of water from the soil should be prevented as far as possible. Loss of moisture can take place by direct evaporation from the soil surface or removed by weeds.

Conservation of moisture can be effected in the following ways :-

(i) Eradication of weeds
(ii) Soil mulch formation
(iii) Interculture of crops.

The relative influence of these factors in moisture conservation was studied under field conditions.

(i) **Eradication of weeds :**—Weeds desiccate the soil of its moisture as their roots extend to great depths. The depths to which these roots penetrate are given below :

Botanical name	*Local name*	*Depth of the root system in inches*
1. Convolvulus campestric	Lehli	120
2. Voluterella divaricata	Brahmadandi	90
3. Launea nudicaulis	Gobhi	72
4. Euphorbia prostrata	Lajvanti	54
5. Tribulus terrestris	Bakhadi Bhakhra	48
6. Chenopodium album	Bathu	48
7. Trianthema monogyna	Santhi	47
8. Polygonum plebium	Chachavanti	47
9. Convolvulus sp. arvensis	Hirankhuri	42
10. Euphorbia dracunculoides	Dodak	42
11. Heliotropium eichawaldii	Kamedi	38
12. Eclipta alba	Gabdad	37
13. Portulaca cleracea	Nuni	30
14. Amaranthus paniculatus	Ghaulai	20

The fields infested with weeds do not contain enough moisture for the growth of other crops. Some perennial weeds like *Mallah Ber bushes and Dhab* grass are very common in these areas (Photo 5).

To store water in the soil for successful growing of crops it is essential that the fields should be kept free from these and other weeds. If *Mallah Ber* bushes are to be maintained as scarcity fodder, these should be kept in a separate field instead of allowing them to grow wild on the entire holding. These should be removed by digging them out. *Ber* bushes have thick roots which have been found to go as deep as 6 feet. Therefore, their removal is an expensive and difficult operation, but this should not be grudged if it it decided to grow successful *barani* crops. For removing non perennial weeds the land should be cultivated whenever it is infested with them. For this purpose Lyallpur hoe can be used with advantage. This will also help in the absorption of rain water. Weeds send their roots very deep. (Photo 6)

Therefore these remove the entire amount of available moisture present in the six feet column of soil. This amounts to about six inches of rain-fall, a quantity of water which is sufficient to produce 1,000 pounds of *bajra* grain. Distribution of moisture at the time of sowing wheat in two fields, one with weeds and the other free of weeds is given in the table below:-

Moisture per cent on oven-dry soil

	0-6″	6″-12″	2nd′	3rd′	4th′	5th′	6th′
Weeds removed	3.55	7.86	12.44	13.11	12.58	10.77	8.22
Standing	1.54	4.71	6.49	7.71	7.64	5.15	3.50

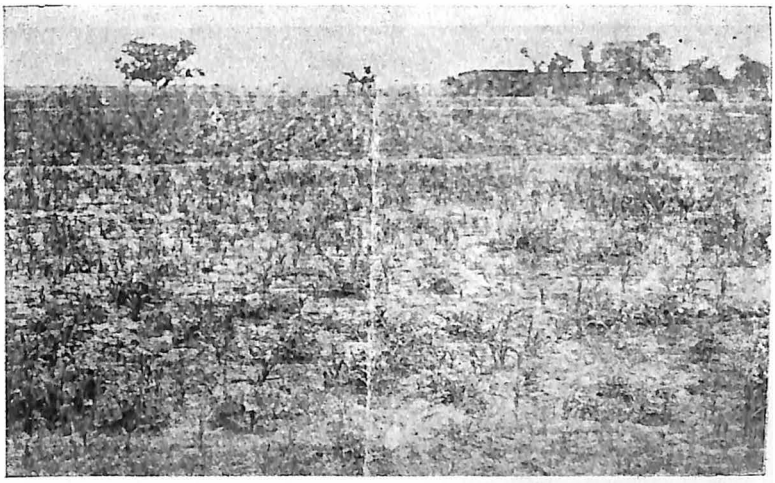


Fig. 5. A field full of Weeds and Mullah Bushes

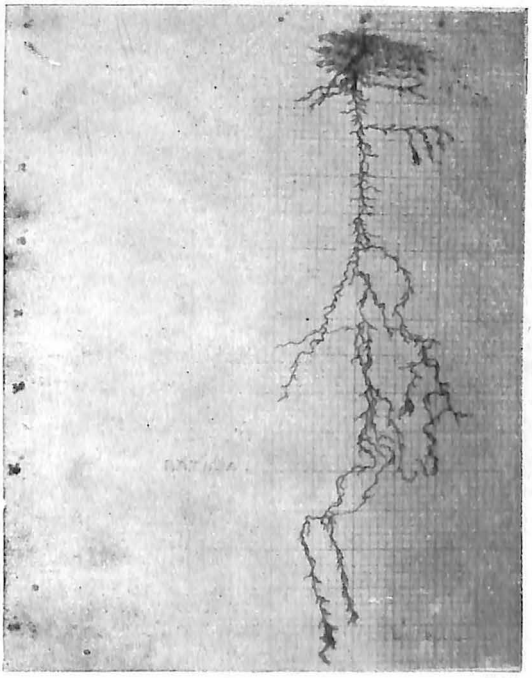
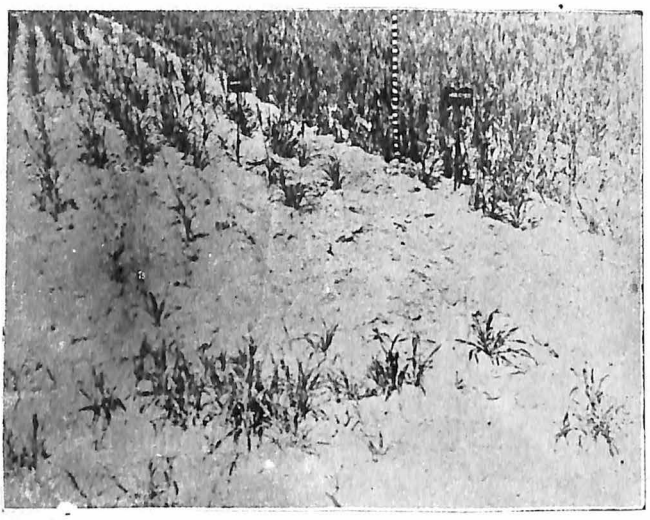


Fig. 6. Root System of Chenopodium album (Bathu weed)



Unmulched Mulched

Fig. 7. Barley Crop

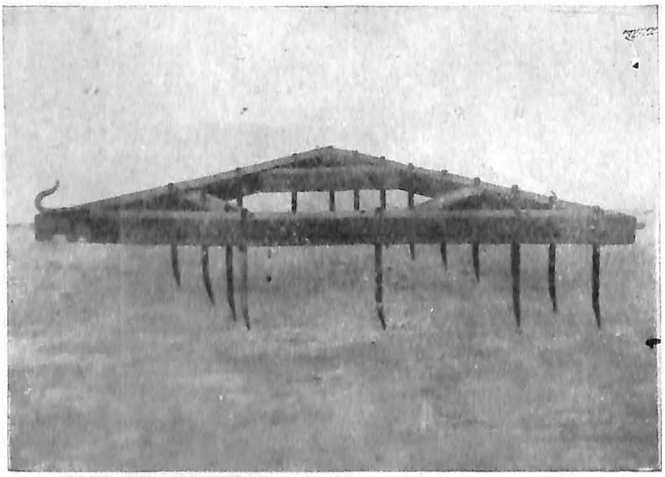


Fig. 8. Bar Harrow

Due to the competition with weeds, roots of crops cannot develop well and thus they are deprived of the moistnre stored in the deeper depths.

Yields of the crops from the areas infested with weeds are very poor as will be evident from the results given below:-

Yields in maunds per acre

	Gram 1936-37		Barley 1937-38		Barley 1939-40	
	Grain	Straw	Grain	Straw	Grain	Straw
1. Cultivated	9.45	11.48	4.0	3.6	4.6	4.26
2. Uncultivated but weeds removed	4.35	5.45	3.05	3.03	5.29	5·04
3. Uncultivaed	1.87	2.55	0.4	0.67	1.63	1.73

(ii) *Formation of soil mulch*:- Soil mulch is nothing but a well-pulverised layer of soil on the surface of the field. Such a layer retards evaporation and in a mulched field there is always more moisture in the soil layer below the soil mulch as compared to the corresponding layer of the unmulched plot. This higher content of moisture in the top six inches secures better germination. Soil mulch is necessary particularly for conserving moisture for the sowing of *rabi* crops. After the close of monsoon rains, the land should be cultivated with Lyallpur hoe followed by light *sohaga* to maintain soil mulch. In mulched plots the crops always has a better stand which subsequently results in higher yields (Photo 7).

The yields results are given below:-

Yield of grain in maunds per acre from mulched and unmulched plots

Gram				Barley					
1936 - 37		1937 - 38		1940 - 41		1941 - 42		1942 - 43	
Mulched	Unmulched	Mulched	Unmulched	Mulched	Unmulched	Mulched	Unmulched	Mulched	Unmul
10.73	4.84	4.01	3.05	10.88	8.70	5.16	3.11	15.57	12.27

The effect of mulch on the moisture content of soil lasts only for about a month or so. Afterwards, there is no difference between the moisture cantent of mulched and unmulched plots. Therefore use of mulch is limited to sowing of *rabi* crops as it helps in carrying more moisture after the close of rains in the month of September to middle or end of October when *rubi* crops are to be sown. Due to higher moisture there is better germination and this results in much higher yields ultimately.

(iii) *Interculture of crops* :- It is a practice which is followed for removing weeds and forming mulch in a standing crop with a view to prevent losses of moisture by evaporation and for aeration to increase

the amount of nitrates - a source of available nitrogen for crops. This operation is mostly important for *kharif* crops, but it can be used for the *rabi* crops also if infested with weeds.

Kharif crops:- *Bajra* is the main crop of the *barani* tract and it is given interculture by using *Kasola*, Lyallpur hoe or horse hoe. When *Kasola* is to be used, the distance between the rows should be one foot, but when interculture is to be done with a hoe drawn by bullocks, two rows of the crop should be sown 8 inches apart while distance between two such double rows should be 18 inches. Interculture is done in the eighteeen inches space between rows by using hoe, drawn by bullocks. The benefit which can accrue from such a practice can be seen from the yield data given below:-

Yield in maunds per acre (Bajra)

Treatments	*Kharif 1935*	*Kharif 1936*	*Kharif 1937*
	Grain	Grain	Grain
Hand hoe interculture	5·86	17·68	10·70
Horse hoe interculture	5·27	17·62	11·22
No interculture	4·84	13·48	9·26

Rabi crops : For the interculture of the *rabi* crops at the germination stage, a Bar Harrow or Lever Harrow can be used. The Bar Harrow is a cheap implement which is within the reach of every farmer (Photo 8).

The number of harrowings to be given will depend mainly on the intensity of weeds, but it is essential that weeds should not be allowed to grow.

3. **Formation of seed bed :**

Kharif crops :--For sowing *kharif* crops, a rough seed bed would suffice. The land can be cultivated with Lyallpur hoe or country plough for sowing the crop. *Sohaga* should not be used for the preparation of seed bed for *kharif* crops and the furrows should be left open.

Rabi crops : A fine and deep seed bed is necessary for the sowing and proper germination of *rabi* crops. The summer rains are generally over in September, when the season is yet too hot for growing of *rabi* crops like wheat, barley and gram. Only 4 to 6 weeks later the season gets sufficiently cool to permit the sowing of these crops. During this interim period, the moisture should be conserved in such a way that there is sufficient supply of it in the surface five inches or so for the germination of the seeds. Therefore, the same operations as are needed for the formation of soil mulch after the close of rains in September are quite adequate for the preparation of a seed bed. During the years receiving sufficient summer rains, a good seed bed can be obtained by cultivating the land with Lyallpur hoe followed by a light *sohaga*.

In case Lyallpur hoe is not available, only *dese* plough may be used. However, it is advisable that a *barani* farmer should possess a Lyallpur hoe. It is a cheap implement and does three times more work than the *desi* plough. In the *barani* areas, the entire holding comes into *Vattar* more or less at the same time and for conserving moisture, it is necessary to cultivate the land as quickly as possible after the rains. This can be done more speedily with a Lyallpur hoe as compared to a *desi* plough.

If at the time of sowing, it is found that the moisture in the top soil is not enough for the germination of the seed, the seed bed should be compacted with a heavy stone roller. Such an operation will help in raising up moisture from the sub-soil and thus make more moisture available for germination. The seed should be placed on the surface of the firm soil beneath the soil mulch by seeding through a *pore* or *nali*.

III. **Artificial mulches** : By keeping the land covered with plant trash 2 to 3 inches in thickness, it is possible to conserve moisture better and save the soil from eroding away. Such a practice is of great advantage when it is intended to raise truck crops, sugarcane, cotton, etc., especially on sloping lands. Amount of moisture conserved and the yield of cotton obtained under artificial mulch is given in the table below :

Moisture as percentage on oven-dry soil

	0-3″	3″-6″	6″-12″	2nd feet	3rd feet	Total yield of cotton in maunds per acre.
Artificial mulch	11.33	11.60	12.62	14.09	14:10	17.35
Soil mulch	5.39	8.31	10.65	12.35	12.35	6.60

This practice has also been tried for sowing of sugarcane and the yields obtained are given below:-

Treatments	*Yields in mannds per acre* 1949-50	1950-51	Average for two years.
Without trash	821.2	169.2	495.2
With trash	1042.7	365.2	703.9

This practice is expensive and cumbersome but the advantage that accrues fully compensates the trouble taken and the expenses incurred.

IV **Crops**:- All the crops which are commonly found in this locality were tried to find out their suitability under *barani* conditions.

(a) **Kharif crops**:- The crops tried were *bajra*, *jowar*, cotton sesamum, maize, *guara*, sugarcane, soybean and groundnut. Out of these, *bajra*, *jawar*, *guara* and cotton were found to do well and can be

recommended for growing in the dry areas of the south-east Punjab. The rest of the crops do well only in years of good rainfall, while in the dry years their yields are negligible.

Bajra:- Bajra has been found to be the most successful in the *kharif* season on account of its quick growth and its power to resist drought. It ripens in the end of September, within two and a half to three months from the date of its sowing. There is no other crop in this region which can compare with its rapid growth and early maturity.

Guara:- This is a very hardy *kharif* legume and has done very well even in the years when *bajra* crop failed. Compared to *bajra*, which for grain formation depends upon August rains, this crop does produce some grain even when August rains fail or the rains are low. The crop ripens in November and has given the best out-turn as compared to the other *kharif* pulses.

Jowar:- This crop can be grown only for fodder purposes. Under these conditions very little grain is produced. *Jowar* is not so suited to the dry-farming areas as are the aforesaid two crops.

Cotton:—Cotton is suited specially well to the *barani* conditions as it has the advantage of being able to use moisture from deeper layers, which is not available to other crops. It, however requires special attention and should be sown in the end of February or beginning of March, and this depends on the incidence of winter rainfall. Cotton should only be grown in the fields which have been lying fallow during the preceding season.

Ratoon cotton was grown for several years. In years of good rainfall its yields are equal to those of the sown crop, because ratoon crop with its well established root system can make use of moisture present in the deeper layers.

(b) **Rabi crops:-** Out of the *rabi* crops tried, barley, wheat, gram and brassica oilseeds, such as, *sarson* and *taramira* have been found successful.

Barley:- It has been found to be the most drought-resistant crop and is highly suitable for dry areas. The key to its success is that it can be sown earlier than the other *rabi* crops and matures earlier i.e., by the middle of March. Moreover, it can give a satisfactory yield on light soils also.

Wheat:- Wheat is not so hardy as barley and is, therefore, sown to a limited extent under *barani* conditions. It can only be sown when there is an adequate supply of moisture in the soil at the time of sowing. The crop takes about 5½ months to mature and, therefore has to face a very dry period which starts under these conditions after the middle of March. This badly affects the proper development and maturity of the crop. The success of this crop depends on the winter rains.

Gram: It is one of the most important *rabi* crops of the dry-farming areas of the Punjab. Its success mainly depends on the initial soil moisture present in the soil. However, the winter rains during January and February are very beneficial and improve its yield to a considerable extent. When hard pans are met with in the sub-soil, a peculiar type of wilting is observed. This can be remedied by deep ploughing.

Brassica oilseeds: These oilseeds are generally deep rooted crops. *Sarson* and *Taramira* have done very well under dry-farming.

Varieties of crops recommended

Kharif	Jowar	J. S. 20, 21
	Desi cotton	M-60 A2 in south-east Punjab
	Sugarcane	Co. 223, 285
Rabi	Wheat	South-east Punjab 9D with December rains C228
	Gram	I.P. 58
	Barley	Type 4
	Bajra	No suitable variety available so far.

V. **Root system of different crops:** A detailed study of the root system of different crop-plants has been made and the results which are given below will not be without interest to *barani* farmers. The depths reached by roots of different crop-plants and the maximum spread at their maturity stage in the soil are given below:

Depths and spread of root system of different crops

Season and crops	Maturity stage Maximum depth inches	Maximum spread inches
Kharif millets		
Juar (*Andropogon sorghum*)	42	20
Bajra (*Pennisetum typhoideum*)	26	26
Pulses		
Mung (*Phaseolus mungo*)	40	22
Mash (*Phaseolus radiatus*)	41	23
Arhar (*Cajanus indicus*)	74	18
Oilseeds		
Soyabean (*Soya maius*) (*Clycine hispida*)	68	25
Groundnut (*Arachis hypogea*)	23	31
Til (*Sesamum indicum*)	32	12
Others		
Guara [*Cyamopsis psoralioides*]	60	14
Cotton (*July sown*)	63	22
Cereals		
Wheat (*Triticum vulgare*)	40	19
Barley (*Hordeum vulgare*)	35	10
Gram (*Cicer arietinum*)	45	22
Oilseeds		
Sarson (*Brassica campestris*)	48	16

Linseed (*Linum usitatissimum*)	63	21
Taramira (*Eruca sativa*)	108	22

The growth and spread of the roots of wheat, gram, *bajra*, *guara* and barley can be seen in Photographs 9-13.

Fig. 9 Root System of Wheat (Triticum vulgare)

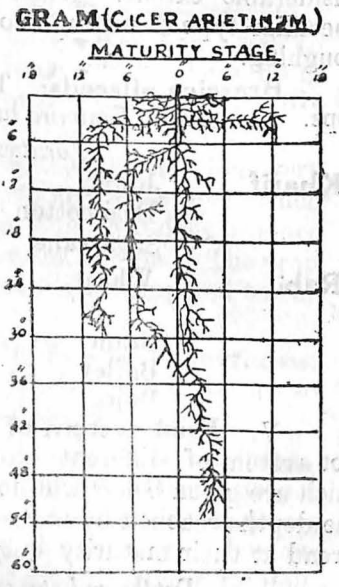


Fig. 10 Root System of Gram (Cicer arietinum)

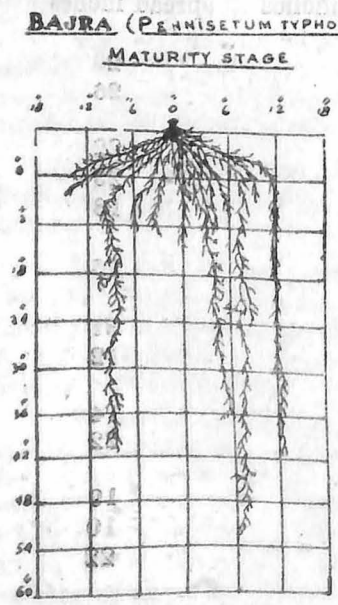


Fig. 11 Root System of Bajra (Pennisetum typhoideum)

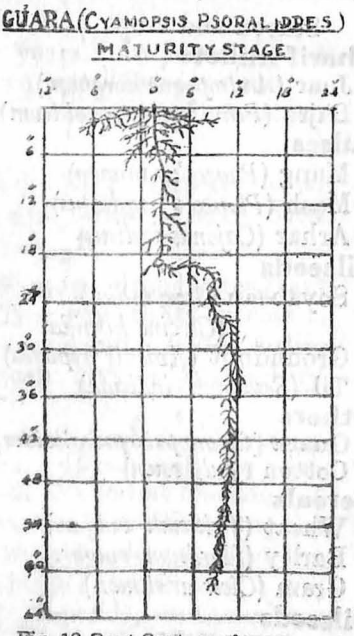


Fig. 12 Root System of guara (Cyamopsis psoreloides)

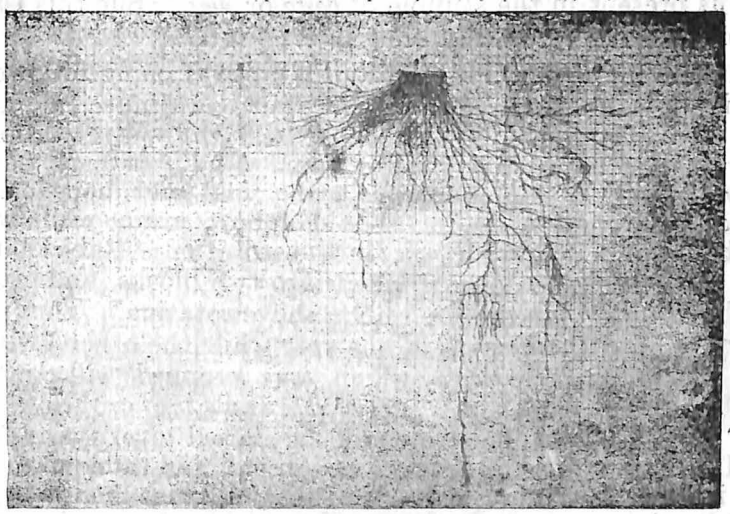


Fig. 13. Root System of Barley

VI. Time of sowing

Rabi crops : Under dry-farming conditions the time of sowing is a very important factor for successful growing of crops. Sowings cannot be made immediately after cessation of rains due to the high temperatures prevailing at this time. On the other hand these cannot be delayed much for fear of loss of preserved moisture. Optimum temperature for securing good germination of wheat is 90°F to 60°F but the temperatures for other *rabi* crops, are higher. Therefore, the best sowing time for barley and gram has been observed to be from early October while that for wheat is from the fourth week of October to the first week of November. Oilseeds can be sown earlier than these crops, say in the first week of October.

Maximum period for which adequate moisture for germination can be preserved is a month and a half. The duration of the period depends on the amount of rainfall received during the monsoon season; it is longer when the rains are normal or above normal. Therefore, in the years when the rains stop early, i.e., the first week of September, early sowings (barley and gram in the first week of October and wheat in the end or third week of October) will give the best results.

Kharif crops : *Bajra, juar and guara* should be sown immediately after the break of monsoons. Cotton, however, should be sown in the end of February or beginning of March.

VIII. Rotation of crops : In the south-east Punjab no definite rotation is followed. As soon as the monsoon rains set in, the cultivators in the tract generally put their entire holding under *kharif* crops year after year. If there is any *rabi* crop, it is gram which can be sown immediately after *bajra* in September, provided sufficient

moisture is present in the stubble of *bajra* or *juar*. But this is possible only in exceptional years, say once in six years.

At present no specific rotation of crops is being followed. This system is defective, as the soil is exhausted of nutrients and weeds persist. It is recommended that both *kharif* and *rabi* crops should be grown in alternate years in the same land. It has been found that a system of rotation of crops is economical and beneficial. It is suggested that *bajra* and *juar* should follow gram while wheat and barley should alternate with *guara* in the rotation "Rabi-kharif-fallow-fallow." The land should be divided into two blocks and each block should be cropped according to the above rotation. Thus one block will carry *rabi* and *kharif* crops in one year while the other will remain fallow. Next year the area which was cropped will remain fallow while the fallow block will carry *rabi* and *kharif* crops one after the other. In this way one crop will be raised every year from each field. In the years when rains are in excess and adequate moisture is left in the field after harvesting of *bajra*, gram crop may be sown. In the following year a second crop of gram may be got from the same field. In this way two crops can be raised during years of good rainfal without upsetting the rotation.

Such a system of rotation is best suited for keeping the land free from weeds as well as for conserving moisture. It has been found that fields sown with *bajra* absorb more moisture and water moves to greater depths than those sown with *guara*. Increase due to the effect of *bajra* crop in six feet column of soil was to the extent of 1·18 inches. Therefore, higher yields of gram are obtained when gram follows *bajra* instead of *guara*.

In the years when rains are very scanty it is not possible to raise any crop from the field from which a crop is raised every year. In order to obtain some crop even in the drought years it is essential that in a part of one's holding (1/4th to 1/6th) only two crops should be raised in three years and the *kharif* crops should be sown in a field which has been lying fallow for full one year. It has been found that in such an area there is 100 to 150 tons more water per acre in six feet column of soil as compared with the field wherefrom a crop is taken every year. Percentage moisture present in a six feet column of the fallow and cropped plots is given below :

Moisture in six feet column soil

Percentage on oven-dry soil	1937	1938	1939	1941	1942
Crop every year (100% intensity)	9·08	9·06	9·08	9·41	10·20
Two crops in 3 years (66% intensity)	13·85	11·41	10.33	14·97	11·03

The yield of *bajra* and *guara* obtained from such a fallow field

was about double of that obtained from the field cropped every year. One great advantage in following such a rotation is that one can get some *kharif* crops even in the years when rains are scanty, whereas nothing can be raised from the fields which are cropped every year. Rotation to be followed in this system will be :—

Rabi-Fallow-Fallow-Kharif-Fallow Fallow-Rabi

The quality of *bajra* grain obtained from the fallow fields is better as it contains about one percent more of protein than *bajra* which follows *guara* or gram.

There is no doubt that by following this rotation there is loss of one to two maunds of grain every year as compared to the 100% intensity rotation but this is recommended as a measure to obtain some crop even during the drought years. This rotation is an insurance against famine; it builds up soil fertility and crops produced are of better quality and, therefore, it is strongly recommended to *barani* farmers. The yields of *bajra* grain from such a rotation are given below :

Yield of bajra grain in maunds per acre

	Kharif 1936	Kharif 1937	Kharif 1939	Kharif 1941	Kharif 1942
A. *Bajra* after *guara*	13·90	4·36	1·79	2·77	9·18
B. *Bajra* after gram	12·40	6·24	1.42	6·24	11·81
C. *Bajra* after fallow	...	11·25	1·77	12 66	13·41

Fallow fields should be kept free from weeds otherwise no benefit will accrue from fallowing. The difference in stand of the *bajra* crop sown after fallow and after a crop in a year of scanty rainfall can be observed from the photograph on the front page

VIII. Soil and soil fertility

1. Texture and structure of soil and crop yields :— The success or failure of the crop mainly depends on the moisture conserved in the sub-soil, and its availability to the crop. Fields having medium to heavy loam sub-soil are more suitable both for *kharif* and *rabi* crops, but when sub-soil is heavy clay or silty clay, the fields though suitable for the kharif crops are not good for *rabi* crops, especially the legumes. Yields along with other particulars are given below :

Description of field	Yield of crops in maunds per acre		Description of the field	Yield of crop in maunds per acre
	Bajra	*Gram*		*Moth*
Field No. 57 sub-soil heavy loam	17·07	8·24	Field No. 45 sub-soil heavy loam	9·32
Field No. 73 sub-soil silty clay	19·71	3·32	Field No. 90 sub-soil stiff clay	3·10

2. Soil fertility :- Soil fertility is of great importance, particularly in the case of *barani* lands, as in a fertile soil much more crop can be produced as compared to a poor soil with the same quantity of water. Therefore, a judicious application of manures and fertilizers to the *barani* lands is as essential, if not more, as to the irrigated areas.

Application of farm yard manure : It is recommended that farm yard manure at the rate of $2\frac{1}{2}$ tons per acre should be applied every alternate year before sowing *bajra*. Well rotten manure should be mixed with the upper six inches of soil about the 15th of June or earlier if a shower of rain is received.

Application of fertilizers (Nitrogenous fertilizers) :- One to two maunds of ammonium sulphate when applied to the standing *bajra* crop in the second week of August, has been found to increase the yield greatly. When rains received are just below normal, one maund, and if these are normal and above normal, two maunds of fertilizer should be applied. In the year when monsoon rains are much below the normal, fertilizer should not be applied.

Hard pan :- Physical structure is as important, if not more, as the nutrient status of a soil. It has been seen that gram crop wilts on the soil underlain with hard pan. Gram crop on such areas can only be grown if such a hard pan is broken. Increasing the nutrient status of the soil by the application of farm yard manure helps the gram to send its roots through the hard pan. (Photos 14 & 15).

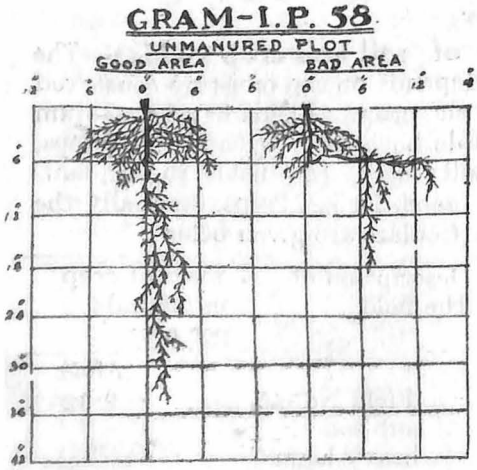


Fig. 14. Root System of Gram in good and bad areas without manuring

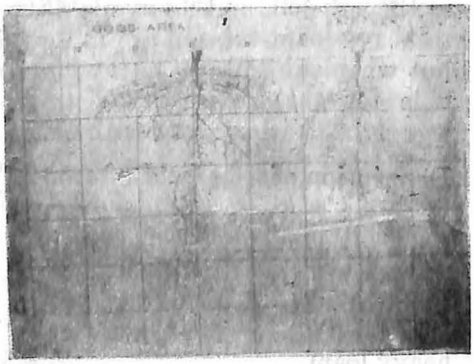


Fig. 15 Root System of Gram in good and bad areas with manuring

SUMMARY

A successful system of dry-farming depends in a large measure on an efficient use of rain-water as it is received, stored and utilized during crop growth. Most of the operations of a farmer in *barani* tracts are directed towards this end.

For successful dry-farming and obtaining maximum yields of crops, the following hints are given for general guidance.

1. Fields should be enclosed with proper *bunds*, divided into *kiaras* and levelled. *Bunds* should be built on contours as far as possible. One foot high *bunds* around the field and 9 inches high around *kiaras* have been found to be quite satisfactory.

2. Land should be opened with the plough with the first shower of rain. Subsequently it should be harrowed after every shower to remove weeds.

3. Artificial mulches conserve more moisture and can be used with advantage on sloping lands and for cash crops.

4. The land after the cessation of rains should be cultivated with *desi* plough or Lyallpur hoe or both for the formation of soil mulch and preparation of seed bed. Cultivation with a plough should be followed by *sohaga* to reduce moisture losses.

5. Gram and barley should be sown about the middle of October while wheat should be sown in the end of October. Kharif crops should be sown with the first shower of rain. The seed should be placed in the moist soil below soil mulch.

6. Crops should be sown in rotation. The following two rotations should be followed :—

(i) Rabi-Kharif-Fallow-Fallow (100% intensity)

(ii) Rabi-Fallow-Fallow-Kharif-fallow-fallow (66% intensity)

One-fourth to one-sixth of one's holding should be under the second rotation while on the remaining area rotation No. (i) should be followed.

7. Fertility of the land should be maintained by the judicious application of farm yard manure and fertilizers.

8. Interculture of *bajra* is very necessary. It can be done with a hoe or *Kasola*.

9. Cotton, *guara*, *bajra*, barley, gram, wheat, *sarson* and *taramira* have been found to grow well under these conditions. Only those varieties of these crops should be sown which are recommended by the Department of Agriculture.

10. Land should be used according to its capability. Get your land surveyed and draw a proper plan for its use.