SPREAD OF AREA UNDER HIGH YIELDING VARIETIES IN PUNJAB AND HARYANA

A STUDY IN SPATIAL VARIATIONS
AND THE FACTORS BEHIND IT

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OF THE DEGREE OF
MASTER OF PHILOSOPHY

By

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I certify that the dissertation entitled "Spread of Area under High Yielding Varieties in Punjab and Haryana - A Study in Spatial Variations and the Factors Behind it" submitted by Utpal Baruah in fulfilment of twelve credits out of the total requirements of twenty-four credits for the Degree of Master of Philosophy (M.Phil) of the University, is a bonafide work to the best of my knowledge and may be placed before the examiners for their consideration.

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Utpal Baruah

Utpal Baruah

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CHAPTER I

INTRODUCTION

I

SOME FEATURES OF AGRICULTURAL DEVELOPMENT IN INDIA

The food position of India alongwith most of the developing countries became severely impaired by the middle of 1960s. As one critic observed: "The problem can be simply stated: the less developed world is losing the capacity to feed itself."[1] The observation is supported by the fact that "before the war, the less developed regions were exporting 11 million tons of grain per year to developed countries. After the war their roles were reversed. During the early post-war years 4 million tons of grain per year moved from developed to less developed world. This flow increased averaging 13 million tons per year in the late 50s. In the 60s, the flow has increased further reaching 21 millions in 1961."[2]

The developed countries claim that they have to choose between the more deserving and the less deserving

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1 L.R. Brown, "Increasing World Food Outputs : Problems and Prospects" Foreign Agricultural Report (Washington, D.C.), no. 25, 1965.

2 Ibid., p. vi.

countries. For example, Paddock Brothers, the authors of Famine 1975[3] assessing India's performance argued that India is one of the countries which has to be sacrificed for the sake of more deserving countries. They further argue that even 25% of the wheat production of the United States of America, which is consumed in India, cannot keep famine out of India.

With the exception of the "Pearson Report"[4] which concedes that "Agriculture (in India) was not neglected in the first three plan periods" many commentators hold that the main reason for this sad state was the neglect of the agricultural sector in the developing countries and mainly so in India.

As a background to the study of performance of agriculture in post-independent India, a brief note on the performances during the pre-independent India is necessary. Taking a long 57 years period from 1891 to 1947 Blyn[5] has found aggregate foodgrain output increased at an average rate of only 0.11% per year. In fact, during the latter half of the period the percentage increase of foodgrain output was a mere 0.03 per year. During this period, the population

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3 W. & P. Paddock, Famine 1975! (London, Wiedenfeld and Nicolson, 1968).

4 L.B. Pearson, "Partners in Development" Report of the Commission on International Development (London, Praeger Publishers Inc. Pall Press, 1969).

5 G. Blyn, Agricultural Trends in India, 1891-1947 : Output, Availability and Productivity (1966).

in British India, even though increasing at the low rate of 0.67% per year, was far higher than that of foodgrain output. The population explosion in India really starts after 1920s and during the period 1911 and 1941 per capita output of foodgrain declined by 29%. This shows clearly the deteriorating food situation in India prior to the independence in 1947.

Food problem became a national issue in India with independence. During the British period food scarcity was no less severe but was not given sufficient attention except setting up of some 'enquiry committees' during the periods of severe famines.[6]

As a matter of fact, India was actually importing foodgrains long before independence. Thus, during the years 1944 and 1947, imports of foodgrains were as under:[7]

1944 - 1.6 million tonnes

1945 - 1.8 million tonnes

1946 - 2.6 million tonnes

1947 - 2.7 million tonnes

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6 We do not deny the investment made by British Government on irrigation specially in the State of Punjab but since it was very little in the need of India, we do not consider it as sufficient.

7 V.M. Dandekar, "Food and Freedom", <u>Economic Series</u> (Karnatak University), no. 6 (1967), p. 3.

In view of the persistence of food crisis in the country, the government took it up as a major national problem and attempted to solve it through development of agriculture.

Agricultural production showed distinct improvement over the plan period (1951-56). The output of foodgrains in 1955-56 at 66.63 million tonnes were nearly 11 million tonnes above the production level of 1949-50. (Table 1.1)

Table 1.1

Area, Production and Average Yield of Foodgrains in India and Imports

Year	Area in million HA	Increase or decrease in area	Production million tonnes	Increase or decrease in m. tonnes	Yield per HA (kg)	Increase or decrease in Av. Yield	Imports million tonnes	Per capita net availability of foodgrains gms/day
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1949-50	99.28	-	54.92	-	553	-	352	-
50-51	97.32	1.96	50.83	-4.09	522	-31	4.80	394.8
51-52	96.96	0.36	51.99	1.16	536	14	3.86	384.5
52-53	102.06	5.10	59.20	7.21	580	44	2.00	412.6
53-54	109.06	7.00	69.82	10.62	640	60	.81	457.8
54-55	107.86	-1.20	68.04	-1.78	631	-9	.70	444.0
55-56	110.55	2.69	66.53	-1.51	603	-20	1.44	430.7
56-57	111.14	.59	69.80	3.33	629	26	3.58	447.1
57-58	109.48	-1.66	64.31	-6.55	587	-42	3.17	408.8

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Table 1.1 contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1958-59	114.76	5.28	77.14	12.83	672	85	3.81	468.3
59-60	115.82	1.06	76.67	-.47	662	-10	5.06	442.6
60-61	115.58	-.24	82.01	5.34	710	48	3.49	468.7
61-62	117.23	1.65	82.70	.69	705	- 5	3.64	460.9
62-63	116.00	-1.23	78.45	- 4.25	676	-27	4.50	443.8
63-64	116.25	.25	80.24	1.79	690	14	6.27	452.0
64-65	117.53	1.28	89.00	8.76	757	67	7.46	408.1
65-66	116.40	-1.13	72.26	-16.74	621	-136	10.36	408.1
66-67	115.01	-1.30	76.00	3.74	660	39	8.67	401.4
67-68	121.48	6.30	95.10	19.10	783	123	5.69	460.2
68-69	120.04	-1.00	24.00	-1.10	781	2	3.87	455.1
69-70	123.57	3.53	99.50	5.50	805	24	3.63	455.0
70-71	123.31	-.26	108.44	8.94	872	67	2.05	469.0
71-72	112.62	-.69	105.16	-3.28	858	-14	.45	467.4
72-73	117.42	-5.20	95.20	-9.96	811	-47	3.61	424.5
73-74	126.12	8.70	103.61	8.41	821	10	4.87	448.5

Source: Indian Agriculture in Brief (New Delhi, Ministry of Agriculture, 1975).

The turning point came in 1953-54 with a peak production of 69.82 million tonnes of foodgrains. During the plan period the imports of foodgrains were considerably curtailed.

As a result of a spirit of complacency on the basis of the achievements of the First Plan in the field of food-grains output, a good deal of which was due to good weather and large coverage of reported area - a target of 76.2 million tonnes was laid down for 1960-61. The last year of the Second Five Year Plan showed an increase of 15% over the then expected output of 1955-56, that is 66.04 million tonnes. During this plan the target was exceeded and further went to 82 million tonnes in the year 1960-61. This target was on the basis of population growth. But it is found that the assumed population growth rate turned out to be an under-estimate. Moreover, the year to year fluctuations reduced per capita net availability from domestic sources and as a result the price increased (table 1.2). And as a result, the import has increased to 3.49 million tonnes in 1960-61.

With the experience of the two plans in view, the Planning Commission observed that in the scheme of development during the Third Plan (1961-66) the first priority necessarily belongs to agriculture. The best year from the point of view of performance which witnessed a record production of 89.60 million tonnes was 1964-65.

But the overall performance of the plan had gone down due to drought conditions in 1965-66 and the country had to import 10.36 million tonnes of foodgrains.

Table 1.2

Per Capita Net Availability of Cereals
(gms/day)

Year	From Domestic Sources	From Imports	Index of wholesale prices of cereals
(1)	(2)*	(3)	(4)
1950-51	304.9	30.6	101.8
1951-52	299.9	24.6	101.8
1952-53	336.3	12.6	100.0
1953-54	381.9	5.0	97.8
1954-55	368.1	3.7	79.6
1955-56	361.6	7.9	75.5
1956-57	353.8	20.6	96.3
1957-58	331.3	18.2	100.9
1958-59	371.8	20.8	106.8
1959-60	354.5	27.5	104.1
1960-61	379.7	18.3	104.1

* col. (2) = Domestic Net Production + Decline in Government stock

Source: Reproduced from N.K. Chandra, "Issues in Foreign Aid and Trade in Economic Division, State Planning Board, Kerala, ed., Alternate Policies for the Fourth Five Year Plan, 1969, p. 189.

Three consecutive annual plans (1966-1969) were implemented after the Third Year Plan. The irrigation, high yielding variety, fertilizer technology package were introduced in agriculture in the country. As a result of new technology further aided by good rains foodgrain production rose up to 95.05 million tonnes in 1967-68. The import of foodgrains came down to 3.87 million tonnes in 1968-69.

Special attention was devoted to multiplications and distribution of improved seeds during the Fourth Five Year Plan (1969-74). The year 1970-71 showed a record production. Only 0.45 million tonnes of foodgrains were imported during 1971-72, but in the subsequent year the import had gone up again.

Various programmes aiming at experiments at different levels were introduced during five year plans.

India's Grow More Food Campaign, initiated in 1947, was the nation's first developmental adventure.

Its main objective was to encourage and assist cultivators in increasing the food production. Great emphasis was placed on bringing the idle land under the plough.

In order to have an integrated advance in all spheres of village life, an organisation of Community Development was set up during the First Five Year Plan, which now covers the whole country. Its aim was to achieve rural development through people's participation, initiative and co-operation.

In 1957, the Ford Foundation team, suggested for intensive efforts for production in certain selected districts with a combination of all the technological improvements and concentration of more power and resources. This is known as Intensive Agriculture Development Programme (IADP).

The extension of IADP programme is Intensive Agriculture Area Programme (IAAP) which was expected to lead to growth in output and productivity of some important crops such as wheat, paddy, millets, sugarcane etc. The number of IAAP districts were five in 1957 which came to 117 in 1966-67. The package included use of fertilizers, seeds, implements etc.

High Yielding Variety Programme (HYVP):

The HYVP was launched in the kharif season of 1966-67 in selected areas. It envisaged popularization of the HYV of paddy, wheat, maize, jowar and bajra over fairly large areas. This programme was based on the experience gained in the IADP, where the farmers applied improved practices to attain higher level of yield. They succeeded in increasing the productivity rate by about 50% over normal yield.[8] However, after some time the yield response reached

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8 ICAR, Agricultural Year Book (New Delhi, 1970).

a plateau and in spite of best efforts and care the yield did not show any appreciable increase. This led the agricultural scientists to probe the matter in depth and, as a result, the point emerged that the existing strains of various varieties of crops did not have capacity to absorb and convert higher dozes of plant food into grains and this was considered as an important limiting factor. Efforts were already under way to break the barrier and fortunately, some promising varieties were identified and developed to absorb higher dozes of plant food and convert it into grains at a higher rate than the known strains of the varieties. The present study aims at observing the spatial distribution of HYV of cereals under different environmental, institutional and technological conditions.

Quest for HYV

The Indian Council of Agriculture Research (ICAR) had tried to evolve and introduce improved varieties of seed in India. The efforts during pre-independence period were confined to two main crops, viz. rice and wheat. Other foodgrains were grown chiefly from traditional varieties.

Out of more than 1,000 varieties of rice cultivated in India, about 500 improved varieties giving 10 to 20% higher yield were evolved and released in different parts of the country before 1950.[9] Wheat improvement work started with

9 ICAR, Handbook of Agriculture (New Delhi, 1966).

the pure line selections in the beginning of the century, later on until the thirties, emphasis was laid on evolving better quality and higher yielding cereals. The varieties evolved became susceptible to disease, particularly rusts and smuts. Therefore, emphasis shifted to evolve disease resistant varieties. About 100 varieties of improved wheat possessing desirable characteristics were recommended for use in different regions.[10]

These improved breeds belonged to the tall conventional varieties which are adaptable for low or average fertility conditions, uncertain weather and poor water availability and control. Many of these varieties are resistant to endemic diseases and insects and successfully compete with weeds. Against this, the weak and tall straw, high tillering plants, late maturity and long drooping leaves made them unsuitable for modern agricultural practices under intensive farming conditions. Application of high doses of fertilizer on the traditional varieties led mainly to vegetative growth and lodging rather than increased yield.

High Yielding Varieties (HYV)

Earlier under the joint programme conducted by the Food and Agricultural Organisation (FAO) of the U.N. and

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10 S.P. Khole, "Wheat Varieties in India", ICAR Technical Bulletin, no. 18, February 1968.

the ICAR, initiated in 1950, attempts were made to evolve HYV of rice by crossing *japonica* and Indian varieties. Because of the difficulties in getting a wide spectrum of recommendation, only one or two released. ADT rice evolved under this programme turned out to be an outstanding variety.[11] The variety, which recorded substantial improvement in yield, is now widely planted in the Tanjore district of Tamil Nadu state. However, efforts to evolve HYV continued.

The Maize Breeding Scheme, initiated in 1957, was the first centre-state co-ordinated research improvement project on cereals in India. The basic objective of the scheme were to develop high yielding, adopted hybrids or composite varieties along with associated technology. The headquarters of the project for maize, is located at the Indian Agricultural Research Institute (IARI) and research is conducted at 17 stations in the country in different ecological zones. Breeding materials have been obtained from all maize growing regions of the world and their performances under Indian conditions have been evaluated in 1961, four maize hybrids were released by this programme and utilised for commercial production. Three types of these additional hybrids were approved for release in 1963. By 1971, ten hybrids and six composite varieties of maize were released

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11 In addition, other varieties, produced under this breeding programme include Malinja and Mahsuri which are planted in Malaysia. The latter variety was further developed in Malaysia with Japanese assistance.

to farmers.

The work on bajra started in 1963, is co-ordinated under the All India Co-ordinated Millet Improvement Projects, with its headquarters at Jamnagar (Gujarat). The project produced two hybrids which released in 1965 and 1966. Since then other hybrids have been developed and released.

The Co-ordinated Wheat Improvement Programme being co-ordinated by the IARI, New Delhi, began in 1961. Previously an increase in wheat production was severely limited by the characteristics of the varieties in use. Dwarf material from Mexico provided the basis for a breakthrough with the introduction of several Mexican varieties of wheat. In 1963, the co-ordinated programme gathered new momentum. The varieties tested included Mayo 64, Sonora 63, Sonora 64, Lerma Rojo 64, and Line 8154. On the basis of the data collected in Central Variety Release Committee approved the release of Lerma Rojo 64 and Sonara 64 for general cultivation in India. In 1965, 250 tons of Senara 64 and Lerma Rojo 64, in the summer of 1966, 18,000 tons of Sonara 64 and Lerma 64 seed - both red grain varieties were imported from Mexico and planted widely. Meanwhile, by making use of the introduced germplasm in the breeding programme, six amber of white seed strains were released - Kalyan Sona, Sonalika, Chotti Lerma, Sharbati Sonara, Safed Lerma and PV 18 for adoption in different regions. These latter adopted dwarf varieties had by 1969 completely replaced the earlier Mexican varieties in India. The breeding programme were greatly expanded and a large number of Indo-Mexican crosses are in different stages of development. As a result, two new "triple-dwarf" wheat varieties were released in 1971. Work has also been intensified to develop varieties and associated management practices for wheat production on non-irrigated areas, which accounts for over half of the area under wheat in India.

The All India Co-ordinated Rice Improvement Project (AICRIP) with headquarters at Hyderabad was initiated in 1962. The project actually started functioning in 1964. The introduction of high yielding dwarf varieties and breeding material from Taiwan and the International Rice Research Institute, Philippines, greatly enhanced the opportunities for increased production. Taichung native I arrived in India in 1963. It was, however, released after conducting field trails for testing the adaptability in 1966-67. Subsequently IR-8 and IR-9 developed in IRRI were introduced and released in June 1966. These exotic varieties due to their susceptibility to disease and poor acceptance by the consumer were not widely adopted by farmers.

In the light of the above propositions and review of development, the following hypotheses are prepared to be tested in this study:

1. Agro-climatic factors play a predominant role on the area spread and yield per unit of land of different crops.
2. Yield is a major component of agricultural growth.

3. Share of area under high yielding variety leads to substantial increase in yield rate and output.
4. The spread of HYV depends on the operation of the following factors and their interactions.

   (i) Climatic factors; soil texture, porosity, permeability, degree of weathering, normal fertility, salinity, stoniness etc.

   (ii) Technological factors in irrigation, fertilizer and mechanization.

   (iii) Institutional factors like the proportion and pattern of land distribution, agricultural labour, socially deprived population.

   (iv) Literacy.

   (v) Level of agricultural income of a district.
5. The spread of HYV of different crops is also influenced by the pattern of the relative cost of production.

II

PATTERN AND PACE OF AGRICULTURAL DEVELOPMENT IN PUNJAB AND HARYANA

A study of the performance and post-independence Indian agriculture shows that there was no significant change in the production of foodgrain output during the period 1952-55 and 1969-72. Table 1.3 gives a statewise break up of growth rate of foodgrain output during the period 1952-55 and 1959-62 and 1959-62 to 1969-72.

Table 1.3

Annual Compound Growth Rate of Output of Foodgrain

S.No.	State	1952-55 to 1959-62	1959-62 to 1969-72
1	Tamil Nadu	4.7	2.5
2	Punjab[12]	3.7	8.0
3	Gujarat	-.02	7.4
4	Mysore	3.1	2.9
5	Rajasthan	2.8	3.4
6	Madhya Pradesh	3.2	1.6
7	Maharashtra	2.5	-1.2
8	Bihar	2.7	1.1
9	Kerala	4.4	1.8
10	Andhra Pradesh	3.1	1.1
11	Uttar Pradesh	1.3	2.8
12	Orissa	1.6	1.0
13	Assam	0.6	1.3
14	West Bengal	0.3	3.8
All India		2.7	2.7

Source: S.K. Rao and P. Patnaik, Unpublished Paper.

12 Punjab, under reference here, means present Punjab, Haryana and part of Himachal Pradesh.

An inter-state comparison suggests that except in Punjab and Gujarat, there was no significant change in the growth rate of foodgrain output during this period. For Gujarat it is obviously due to its low base. We are here interested in studying the performance of Punjab which had acquired the top position in the second period from third position in the first period. The performance of Punjab shows that not only it topped the list, but it had registered an increase of more than double of its annual output growth rate of the previous period. Punjab's annual foodgrains output growth rate stood at 8.0% in the second period while that of all India was only 2.7%. The tremendous success of Punjab's agriculture draws our attention and induces us to make a specific study of the state. Many economists by the end of 60s agreed that whatever little achievement of Indian economy had in its modernisation programme of agriculture was mainly in the States of Punjab and Haryana.

Another reason for taking this region for specific study is its history of agricultural development. Punjab is the only state which shows a significant positive performance.

The main reason lies in the fact that Punjab has better irrigation facilities than the other states. During the British period a major part of public investment was spent on the irrigation of Punjab.[13] Although

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13 R.C. Dutt, Economic History of India (New Delhi, 1970), vol. II.

a larger part of irrigated land and irrigation facilities went to Pakistan at the time of independence still Indian part of Punjab had better irrigation facilities than the other states.[14] On the other hand, the agricultural importance of Punjab influenced the Government of India to build up new irrigation facilities.

Several institutional and socio-economic factors were also responsible for the development of agriculture in Punjab. The Mahalwari system of land settlement had conferred land rights to the village communities and in spite of the existence of some big absentee landlords in certain pockets, by and large, the land was self-cultivated.[15] The partition and consequent refugee resettlement led to the breaking up of some big estates of former landlords who migrated to Pakistan. The various land reform legislations after independence resulted in terminating the superior rights and in many cases enabled the occupancy tenants to become full owners. However, there is evidence to suggest that these legislations also encouraged many absentee landlords to evict the tenants and resume land for so-called self-cultivation. Nevertheless, self-cultivation is the

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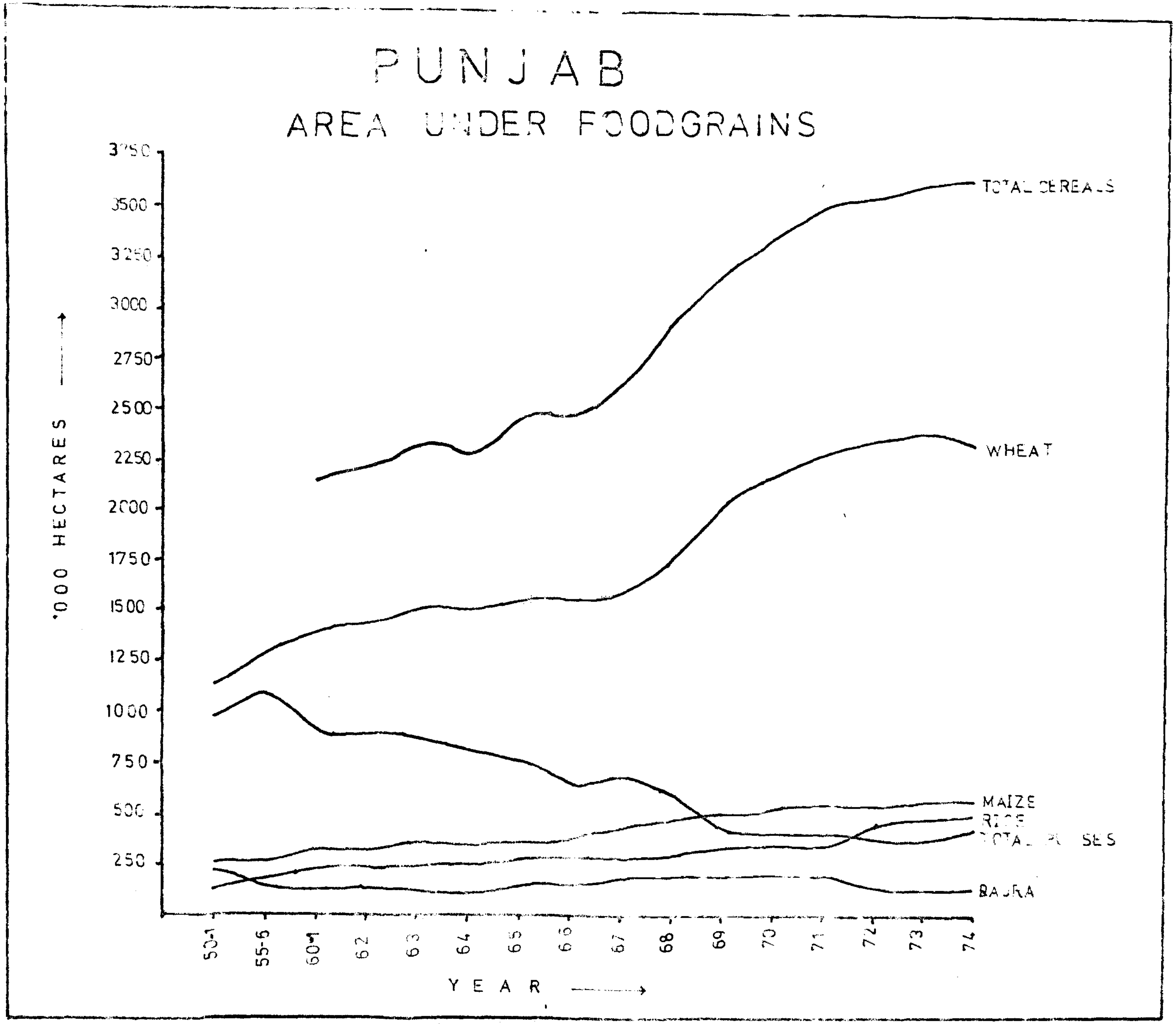
14 V.K.R.V. Rao, "Agricultural Production and Productivity during the Plan Periods", Indian Journal of Agricultural Economics, January-March 1962.

15 G.S. Bhalla, "Punjab Economy - Growth and Prospects", Occasional Paper No. 2, Centre for the Study of Regional Development, JNU, New Delhi, 1976. (unpublished paper)


PUNJAB
AREA UNDER FOODGRAINS
'000 HECTARES
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
TOTAL CEREALS
WHEAT
MAIZE
RICE
BAJRA
50-1
55-6
60-1
62
63
64
65
66
67
68
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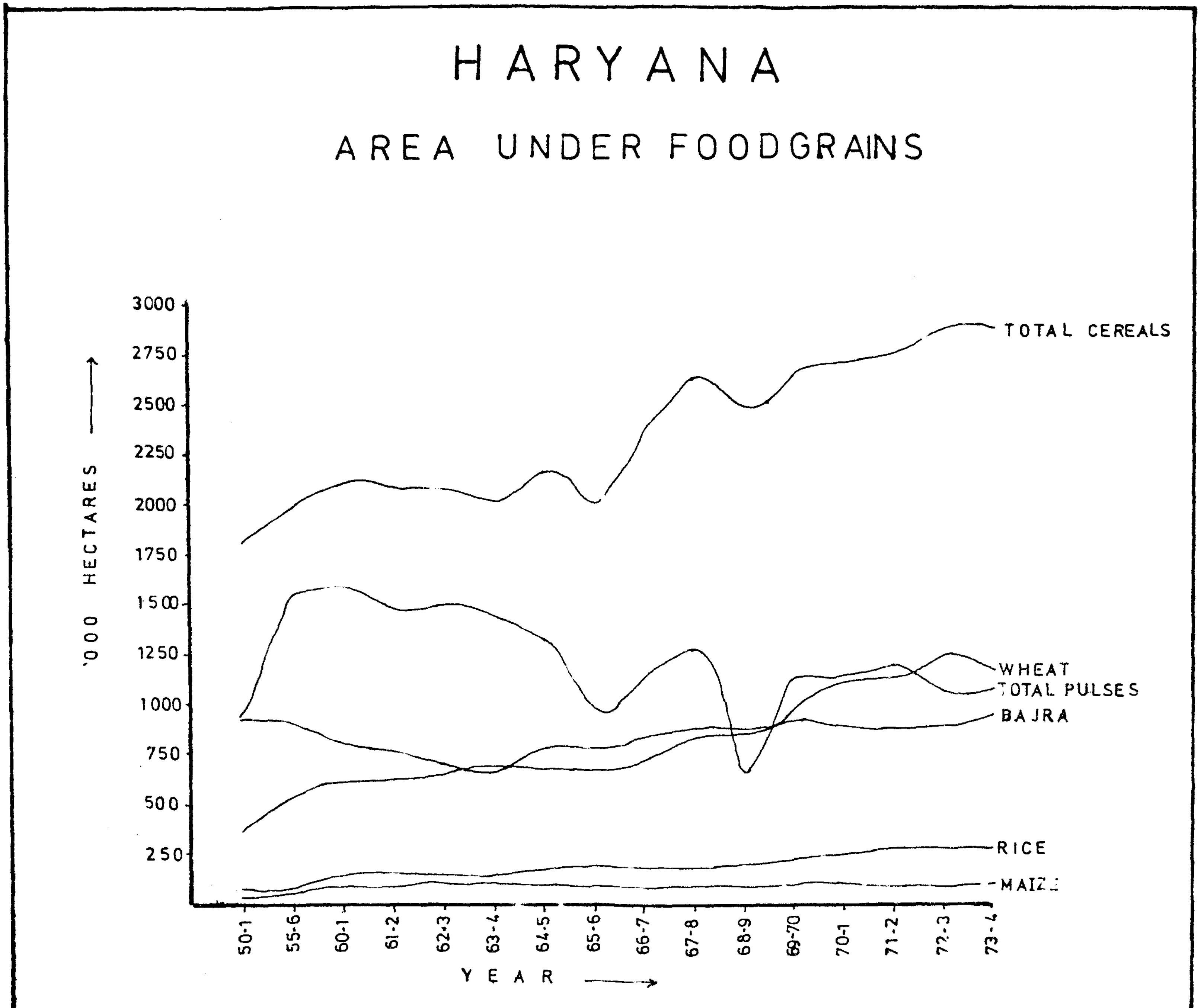
70
71
72
73
74
YEAR

FIG 1a



HARYANA
AREA UNDER FOODGRAINS
'000 HECTARES
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
TOTAL CEREALS
WHEAT
TOTAL PULSES
BAJRA
RICE
50-1
55-6
60-1
61-2
62-3
63-4
64-5
65-6
66-7
67-8
68-9
69-70
70-1
71-2
73-4
YEAR

FIG. 1b

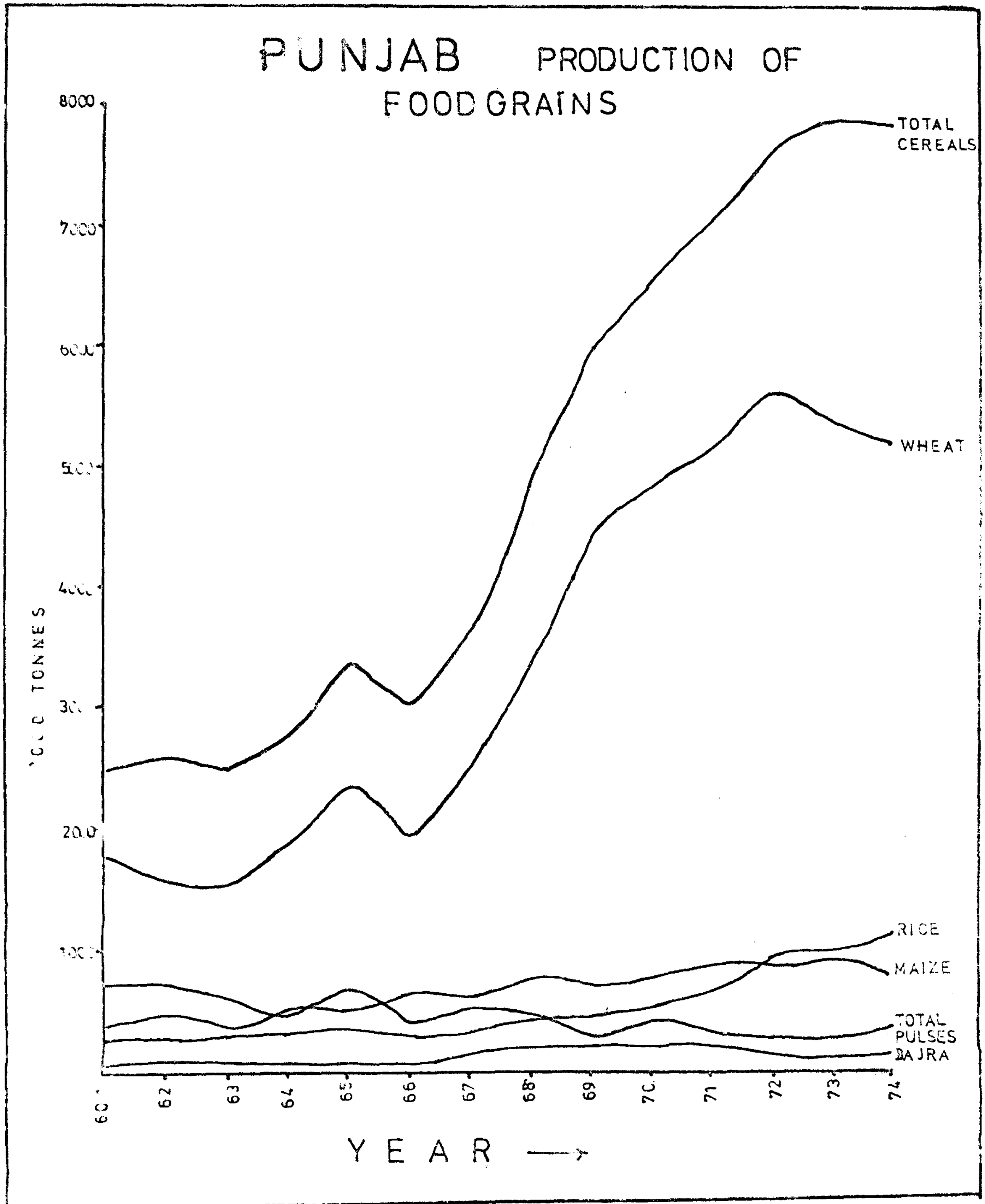

PUNJAB PRODUCTION OF
FOOD GRAINS
8000
7000
6000
5000
4000
3000
2000
1000
'000 TONNES
60
62
63
64
65
66
67
68
69
70
71
72
73
74
YEAR
TOTAL CEREALS
WHEAT
RICE
MAIZE
TOTAL PULSES
BAJRA

FIG. 2a

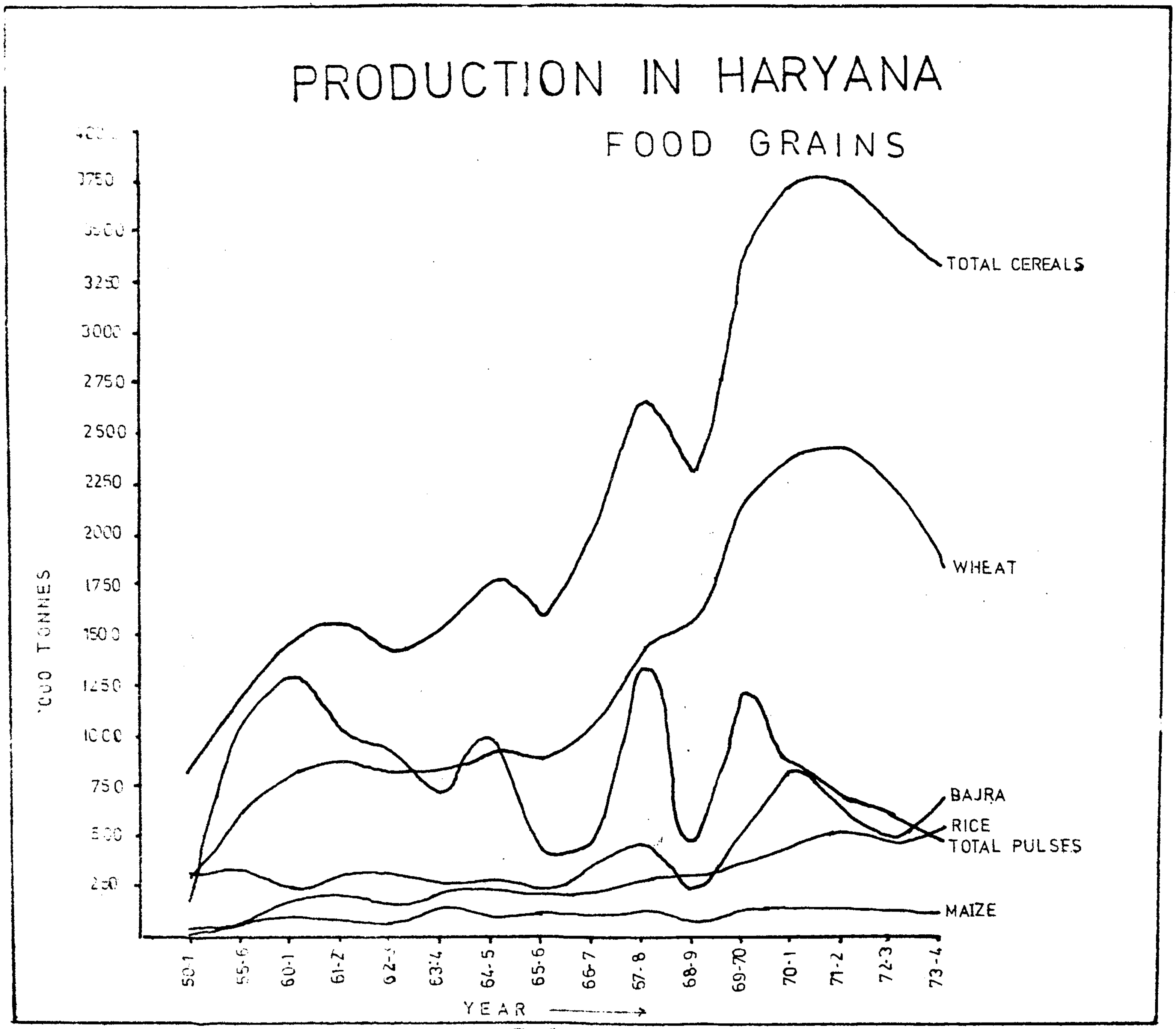

PRODUCTION IN HARYANA
FOOD GRAINS
'000 TONNES
3750
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
250
TOTAL CEREALS
WHEAT
BAJRA
RICE
TOTAL PULSES
MAIZE
50-1
60-1
61-2
63-4
64-5
65-6
66-7
68-9
69-70
70-1
71-2
72-3
73-4
YEAR

FIG. 2b

predominant mode in Punjab and 84.15% of the land is wholely owned or self-operated and only 9.67% is partly owned and partly rented in Punjab and that in Haryana is 84.40% and 10.20% respectively.[16]

As a result of the developments mentioned above, the production and area of cereals are increasing.

In Haryana among the cereals, area under rice, maize and wheat is increasing while that of bajra is more or less same since 1950-51. Area under gram has declined from 1,543 thousand hectares in 1960-61 to 993 thousand hectares in 1973-74, which results in total decline in area under total pulses (Graph 1(a) and (b)]. But as a whole, area under foodgrains is found to be always in an upward trend (see appendix I).

Area under rice, maize and wheat in Punjab shows an upward trend while that of jowar and bajra downward trend. Area under total pulses has declined very sharply. As a whole, we find area under foodgrains has gone to 4,099 thousand hectares in 1972-73 from 2,838 thousand hectares of 1950-51 (see appendix II).

Production of foodgrains has been found to be highest in 1970-71 in case of Haryana and in 1971-72 in case of Punjab (Graph no. 2 (a) and (b)).

The period of the present study is 1964-65 to 1973-74. The starting point has its importance of being

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16 All India Report on Agricultural Census, 1970-71 (Government of India, Ministry of Agriculture, New Delhi, 1975).

the initial year of the inception of green revolution in India. Both the states show an upward trend in production of total foodgrains and it is same in case of all cereals except maize. After this year, there is no systematic trend in production though the year 1971-72 shows highest production in case of Punjab and 1970-71 shows highest in case of Haryana. In some stages of the study the year 1970-71 has been taken as the point of reference because the relevant data are available only for that year.

Data beyond 1973-74 is not available at the time of the study was in progress and so the latest year has been chosen as 1973-74 without definite criterion of choice.

In some of the exercises in the present study we have taken 1968-69 as the last point of the reference taking 1964-65 as the base and in certain other exercises 1968-69 has been taken as the starting point of reference. This has been done to overcome the constraints of the data availability.

III

THE PROBLEM AND SCOPE OF THE STUDY

The study basically aims at examining, first, the spatial variation of HYV of four crops in the States of Punjab and Haryana, and second, the effect of technological, environmental and institutional factors on the extension of high yielding variety of rice, wheat, maize and bajra.

The present work has been divided in five sections. First section deals with the effect of environmental factors, viz., soil, temperature, moisture etc. on spread and yield of rice, wheat, maize and bajra. This has been studied in time series and emphasis has been laid on the change of area and yield during these points of time. Thornthwaite's moisture index as modified by Subramanyam and Cartar[17] has been used here. The spread of the crop is discussed with the climatic zone of Punjab and Haryana. At the same time, the yield aspect is also taken into consideration.

In the second section, it has been tried to see the role of yield in agricultural growth. The decomposition method of Minhas and Vaidhyanathan[18] is used here to find out the effect of yield on agricultural growth. This method makes possible to quantify the effects of various components. Quantification is necessary for inter-district comparison.

The yield or productivity of a region depends upon many factors, not only on high yielding variety. The role of high yielding variety area on productivity is being

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17 D.B. Carter, "Climate of African and Indian according to Thornthwaite's 1948 Classification", in A. Krishan and Mukhtar Singh, "Soil Climatic Zones in Relation to Cropping Patterns", in ICAR, Proceedings of the Symposium on Cropping Patterns in India (1972), p. 173.

18 Minhas and Vaidhyanathan, "Growth of Crop Output in India, 1951-4 to 1958-61" in Pramit Chowdhury, ed., Readings in Indian Agricultural Development (1972), p. 50.

discussed in Section III with the help of principal component analysis method. The other independent factors along with HYV area are amount of nitrogenous fertilizer, irrigated area, mechanization and soil characteristics.

After finding the position of HYV on productivity, a multiple regression analysis has been worked out on HYV taken as a dependent variable with 8 independent variables. These independent variables can broadly be categorised into environmental, technological and institutional. They are:

Y = Percentage of HYV area to total cropped area.

X_1 = Soil rating index.

X_2 = Percentage of gross area irrigated to total cropped area.

X_3 = Tonnage of nitrogenous fertilizer per 100 hec. of gross area irrigated (GAI).

X_4 = Mechanization Index

X_5 = Yield per hectare in money terms

X_6 = Percentage of agricultural labour to total agricultural worker.

X_7 = Percentage of rural Scheduled Caste to total rural population

X_8 = Percentage of educated and literate population to total population.

The last section mainly deals with the distribution pattern of HYV of rice, wheat, maize and bajra crop in a time series taking district as a unit. The role of irrigation has also been discussed in relation to the distribution pattern of HYV seeds. Thereafter an index has been deduced at both the points to check the change of HYV of different crop area to total cropped areas.

The distribution of different factors are portrayed on the maps with the help of chloropleth technique. The distribution is grouped mostly to four categories on the basis of mean plus minus standard deviation of it.

A Brief Note on Some Important Studies in the Field

Having briefly discussed our problem, it would be interesting to know the empirical findings of some of the studies in this context. Unfortunately, the studies referred to do not have a specific theoretical framework. These studies have concentrated on particular individual components of modernisation viz. fertilizer use, pesticides, new seeds etc. These studies have examined different aspects of the problem and cover a number of disciplines. Attempt has been made here to limit this review to major problem areas, which are more relevant to this study.

Size of Farm

Most of the studies have revealed that the size of the farm was positively associated with the acceptance of improved agricultural practices.[19] Lionberger and Coughenour[20] have reported that large farms encouraged the use of improved farm practices. According to the authors a 'critical minimum' size of farm was necessary for the successful adoption of improved farm practices. On the other hand, Rao,[21] claimed some aspects of modernisation viz. adoption of high yielding variety is size neutral.

Farm Income

Farm income is another important factor which is related to the adoption of improved farm practices.[22] It has been observed that a reciprocal cause and effect relationship is likely to exist between income and acceptance of improved farm practices. However, Desai and Sharma[23] did not find any significant difference in gross income between users and non-users of fertilizers.

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19 P.V. Blanckenburg, "Progressive Farmers and their Share in Agricultural Modernization" Preliminary Report on a Study in Mysore and Punjab (Bangalore, 1972); K.M. Choudhury and M. Maharaja, "Acceptance of Improved Agricultural Practices and their Diffusion among Wheat Growers in Pali District of Rajasthan", IJAE, vol. 21 (1966).

20 H.F. Lionberger and C.M. Coughenour, "Social Structure and Diffusion of Farm Information", Res. Bull 631, Agricultural Experiment Station, College of Agriculture, University of Missouri, 1957.

21 C.H.H. Rao, Technological Change and Distribution of Gains in Indian Agriculture (New Delhi, 1975).

22 K.M. Choudhury and M. Maharaja, op. cit.

23 D.K. Desai and B.M. Sharma, "Technological Change and Rate of Diffusion", IJAE, vol. 21 (1966).

Irrigation Facilities

A number of studies[24] indicated that the cultivators having irrigation facilities tend to adopt improved farm practices more than the cultivators without irrigation facilities. Desai and Sharma,[25] found no significant difference in the irrigation facilities available to users and non-users of fertilizer.

Education

Most of the studies indicated that education and the adoption of improved farm practices were positively associated in a significant manner.[26] However, a few studies revealed that education had less influence on the adoption of improved farm practices.[27]

An assessment of the different statistical methods used here is given along with the text.

Data Base

The present study is entirely based on secondary data. Our sources are publications of different government agencies, viz. Statistical Abstract of Punjab and Haryana

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24 L. Hodgden and H. Singh, Adoption of Recommended Agricultural Practices (Ford Foundation, New Delhi) (Mimeograph).

25 D.K. Desai and B.M. Sharma, op. cit.

26 K.M. Choudhury and M. Maharaja, op. cit.; and NCAER, Factors Affecting Fertilizer Consumption (New Delhi, 1967).

27 D.K. Desai and B.M. Sharma, op. cit.

published by the Directorate of Economics and Statistics of respective State Goverments, 'Fertilizer Statistics' published by Fertilizer Association of India, and Census of India. The Statistical Abstract is the main source of the data used in the present study. Generally, the researchers feel sceptical about the reliability of this secondary data. We must examine its reliability and limitations in the context of our study before attempting for further analysis based on this data. As it is beyond the capacity of individual (at this level) to go for primary data and hence one proceeds for the study with the inherent limitations of this data - in approximated reliability from having any very definite conclusion.

The statistics of area under different crops and area irrigated are taken from Statistical Abstract of the State Governments. State Government collects this sort of data through primary reporting agency viz. 'Patwari', which is an integrated part of revenue administration. The basis of their collection is not uniform.[28] Scepticism regarding the reliability of patwaris record is common in India.

The data on irrigated area suffers from under-reporting.[29] Irrigated area carries more revenue and there is an obvious tendency of underreporting to avoid revenue payment.

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28 Srinivasan and Vaidhyanathan, "Agriculture and Statistics" in C.R.Rao, ed., Data Base of Indian Economy (Calcutta, July 1972), Vol. 1, p. 34.

29 Ibid., p. 37.

The proportion of area and production of different crops in different states covered by crop cutting estimates is not uniform.[30] This coverage has, however, been increasing over time and in the case of major cereal crops practically the entire output is currently estimated by crop cutting experiments.

Data on the area covered by high yielding varieties of the major cereal crops is furnished annually by the State Agricultural Department which in turn is reported to be on the basis of the assessment made by the field itself.[31]

The basis for the estimates provided by the administrative departments is not very clear. They are obviously not estimated from any systematic surveys. It is believed that, in general, the assessment is derived on the basis of norms that of the quantity of improved seeds released and the average seed rate per hectare. The hybrids and other improved seeds that are produced, marketed by organised agencies with their scientific names. Therefore, this might be a reliable source. But in case of wheat and rice, where the improved seeds can be produced by the farmers themselves, such estimates can be quite unreliable. The only satisfactory way to get reliable estimates of area under improved variety of seeds would be through the surveys

30 Ibid., p. 39.

31 Ibid., pp. 50-51.

like the one conducted by Programme Evaluation Organisation (PEO). But PEO surveys the HYV crop on the State level. Therefore, knowing the above mentioned constrains, we are bound to take the data published in Statistical Abstract.

The fertilizer data from "Fertilizer Statistics" published by Fertilizer Association of India is also from the Government reports. Like in other cases, a major limitation of the fertilizer statistics is that it does not give an accurate idea of actual consumption in a particular area. The statistics give only an idea of distribution at the whole-sale level at that area.[32] Apart from the fact that this may differ from the actual purchases by the farmer, there is also the possibility that what is recorded as having been distributed in a particular area may not at all be used in the same area. It would have been very helpful if fertilizer on different crops with various irrigation facilities in different districts would have been available. Moreover, more detailed data on the timing and quantum of fertilizer used for different crops district-wise is quite necessary for this kind of study.

Data for agricultural labour, agricultural cultivator and scheduled caste population are taken from Census of India 1971. Census of India also is not free from certain limitations.

In India two methods - 'canvasser' and 'householder'

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32 Ibid., pp. 49-50.

are followed at the time of taking census.enumeration.[33] Under the 'canvasser' method the enumerator approaches every household and records the answer on the schedules himself after ascertaining the particulars from the head of the household or other knowledgeable person in the household. Under the 'householder' method the enumerator distributes the census schedules to each household in his jurisdiction and the head of the household is expected to fill the answer for all members of his household and the enumerator later collects back the answered scheduled soon after the census is over. Without going to the merits or demerits of each of these methods, it has to be recognized that in countries where literacy is still low, the 'canvasser' method is the only practical method. Even the enumerator sometimes cannot go from house to house due to lack of conveyance facilities, due to negligence and also to some extent the village people refuse to tell about the details of the schedule.

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33 S.C. Srivastav, "India Census in Perspective", Census of India Monograph Series Census Centenary (New Delhi, 1971), Monograph 1.

CHAPTER II

AGRO-CLIMATIC FACTORS IN RELATION TO AREA AND YIELD

In a spatial study of agricultural growth the analysis of the climatological factors is essential. And as it is normally expected that the climate of a region is a decisive factor in determining the cropping pattern of the region, it will be worthwhile to study the climate of a region in connection with its agricultural growth. For a proper appreciation of the climate of an area from agricultural point of view, it is necessary to consider simultaneously (i) the precipitation and actual evapotranspiration from cropped land and reduce them to a single moisture value index, and (ii) a thermal index.

The determination of actual evapotranspiration is difficult in practice as it depends on factors such as soil moisture content, the extent of plant cover and the colour of leaves, in addition to climatological factors.[1] Thornthwaite (1948) suggested a method of rational classification of climate by introducing the concept of "potential evapotranspiration" (PE) defined as the amount of water lost from the surface, completely covered with vegetation, if there is sufficient water in the soil at all times for the use of vegetation. He has developed a formula based on mean monthly temperature and the length of day-time hours for

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1 R.C. Ward, Principles of Hydrology (1967).

computing potential evapotranspiration. Thornthwaite also suggested scales in terms of moisture index and thermal index for defining climatic types. Based on Thornthwaite's method, Subramanyam and Carter (1954)[2] classified the climate in India into six moisture regions, viz. arid, semi-arid, dry sub-humid, moist sub-humid, humid and perhumid, and five thermal efficiency types. Subramanyam (1966)[3] "subdivided major climatic types into sub-types on the basis of moisture deficiency or surplus in winter and summer seasons. He divided the country into 10 climatic divisions based on moisture regions. The actual PE values, based as they are on temperature, were also utilized as thermal index to indicate the climatic types as mesothermal and megathermal. He concluded that almost whole of India except the high mountains of the eastern and north-eastern sections has megathermal climate. The climatic

2 D.B. Carter (1954) "Climates of Africa and India according to Thornthwaite's 1948 classification", Final Report publ. in Climate, vol. VII, 4, in Indian Council of Agricultural Research Publication, Proceedings of the Symposium on Cropping Patterns in India; D.B. Carter (1954), "Climates of Africa and India according to Thornthwaites" 1948 classification, Final Report Publ. in Climate, vol. VII, 4, Drex Inst. Techn. Lab. of Climatology, Centeron, N.J., USA, in A. Krishnan and Mukhtar Singh, "Soil Climatic Zones in Relation to Cropping Patterns", Indian Council of Agricultural Research, Proceedings of the Symposium on Cropping Patterns in India (1972), p. 172.

3 V.P. Subramanyam (1966); Climate Types of India according to the rational classification of Thornthwaite, Indian of Meterological Geography, ibid., p. 173.

types defined by him are, however, rather broad and cannot be utilized for correlating them with cropping patterns.

In these two studies, it was assumed that root zone of soil contained 10 cms of stored water at field capacity and this water could be utilized at the potential rate until its depletion. Further work by Thornthwaite and Mather (1955)[4] suggested that up to 30 cms depth of water would be available for deeprooted mature plants and evapotranspiration rate will diminish in proportion to the moisture content in the soil. The modified criterion was adopted by Subramanyam et al (1965)[5] for mapping climatic types in terms of moisture and thermal regions of India.

The approach to classification of climate is indeed fascinating but is not without its limitations. Admittedly, evapotranspiration falls off with decrease in soil moisture content but the assumption regarding the depth of water storage in soil would, naturally, depend on the root zone of a crop. Therefore, a more precise evaluation of actual evapotranspiration, is only possible if data are available on soil depth, field capacity and permanent wilting percentage values

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4 C. Thornthwaite and J.R. Mather (1955): The Water Balance Publ. in Climat, vol. VIII, 1, Drex. Inst. Tech. Lab. of Climatology, Centerton, N.J., USA, ibid., p. 173.

5 V.P. Subramanyam, B. Subbarao and A.R. Subramanyam (1967): Koppen and Thornthwaite, Climate's Classification as Applied to India, Annals of Arid Zone, 49, 46 to 55. Ibid., 173.

of soil. Such information is, however, not available for all the different soils in India. Moreover, estimation of potential evapotranspiration (PE) on the basis of temperature alone is inadequate as PE is influenced by other climatic factors too. More precise estimates of PE can be obtained with the formula developed by Penmann (1948)[6] which takes into account radiation, humidity, wind velocity and temperature. However, the number of stations where all these weather elements are recorded is rather small.

In the absence of information on soil moisture storage of different soils, an attempt has been made by Krishnan and Singh (1972)[7] to demarcate the zones by superimposing the moisture index (P-PE) x 100/PE and mean temperature, (Maximum + Minimum)/2, where PE is the mean annual potential evapotranspiration computed with the help of Thornthwaite's method and P is the mean annual precipitation, both expressed in the same unit, taking into account the available data from all stations in India and neighbourhood for which long period normals are available.

The under-mentioned scale was adopted in defining climatic zones in terms of moisture indices:

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6 H.L. Penmann (1948), "Natural Evaporation from Open Water are Soil and Grass", Proceedings of Royal Soc. 1032, 193, ibid. 173.

7 A. Krishnan and Mukhtar Singh, "Soil Climate Zones in Relation to Cropping Patterns", in ICAR, Proceedings of the Symposium of Cropping Patterns in India (1972), p. 174.

Zone No.	$\frac{P - PE}{PE} \times 100$ less than	Moisture Index	Moisture Belt
1		-80	Extremely dry
2		-60 to -80	Semi dry
3		-40 to -60	Dry
4		-20 to -40	Slightly dry
5		0 to 20	Slightly moist
6		20 to 50	Moist
7		50 to 100	Wet
8		> 100	Extremely wet

The classes in terms of temperature were as follows;

	Mean annual temperature (Max + Min)/2	Temperature Belt
A	28°c or more	Very hot
B	25°c - 28°c	Hot
C	20°c - 25°c	Mild
D	10°c - 20°c	Cold
E	10°c or less	Very cold

A study has been made by Krishnan and Singh (1972) with the help of moisture zone, thermal index, soil type, on districts and distribution of crops.

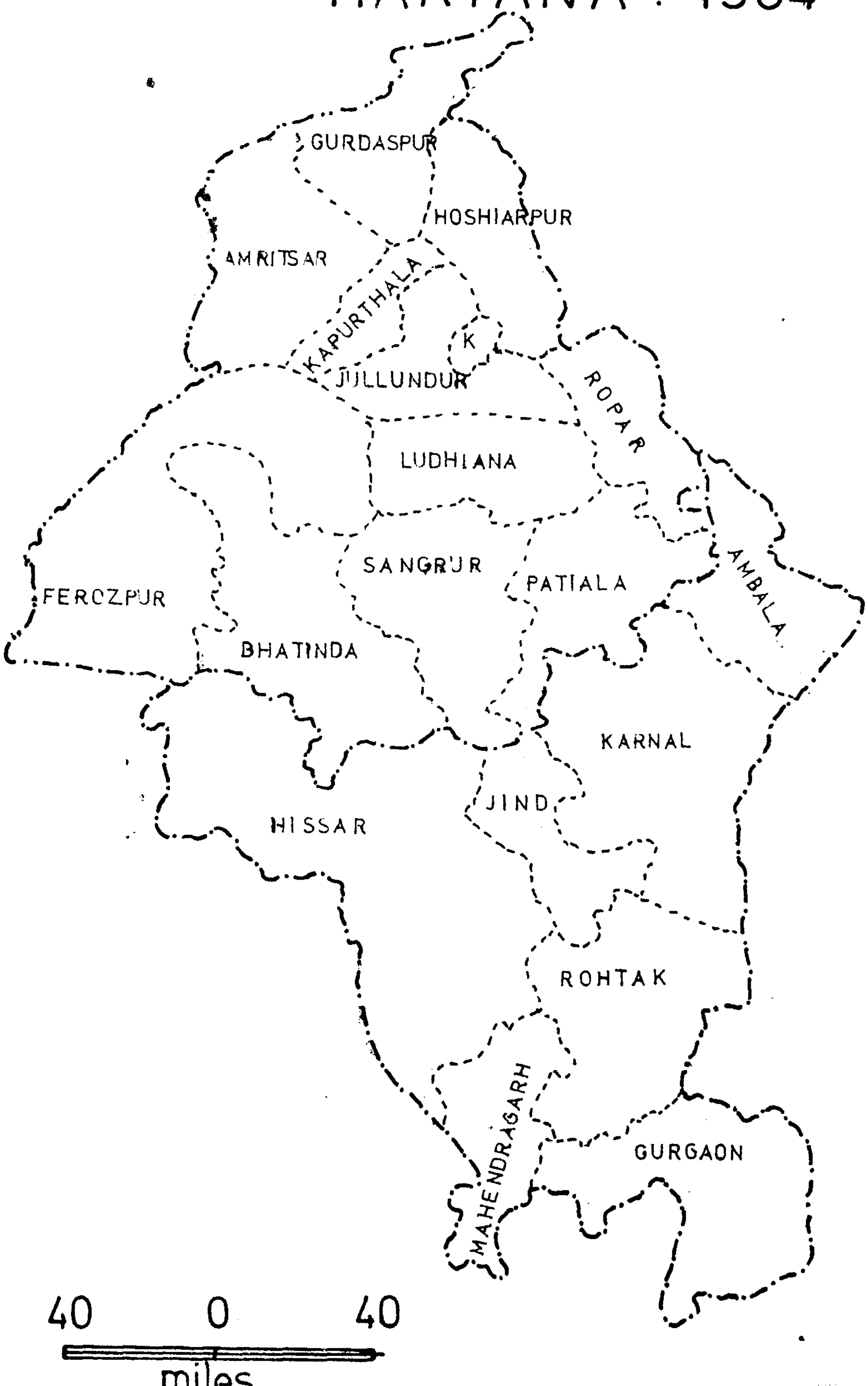
Distribution of important crops in various districts of soil climatic zones in Punjab and Haryana are shown below;

Table 2.1

Distribution of Important Crops in Various sub-climatic zones of Punjab and Haryana

Sr. No.	Moisture zone	Thermal index	Soil Type	Districts included in the soil-climatic zones	Distribution of crops in the zone (according to preference)
1	2	C	Alluvial soil	Bhatinda, Hissar Mahendragarh, Ferozepur	Gram, bajra Wheat, Cotton, Mustard
2	3	B	Alluvial soil	Gurgaon	Gram, Mustard, wheat, bajra, jowar, barley, maize, rice
3	3	C	Alluvial soil	Gurdaspur, Amritsar	wheat, gram, maize
				Kapurthala, Jullundur	bajra, sugarcane
				Luthiana, Sangrur	cotton, rice, jowar
				Patiala, Karnal and Rohtak	barley and mustard
4	4	C	Alluvial soil	Ambala	Wheat, gram, rice, bajra, maize, barley and Tur
5	5	C	Alluvial soil	Hoshiarpur and Ropar	Rice, wheat, gram, maize, sugarcane, barley, and mustard

DISTRICTS OF PUNJAB AND HARYANA : 1964



SOILS OF PUNJAB & HARYANA

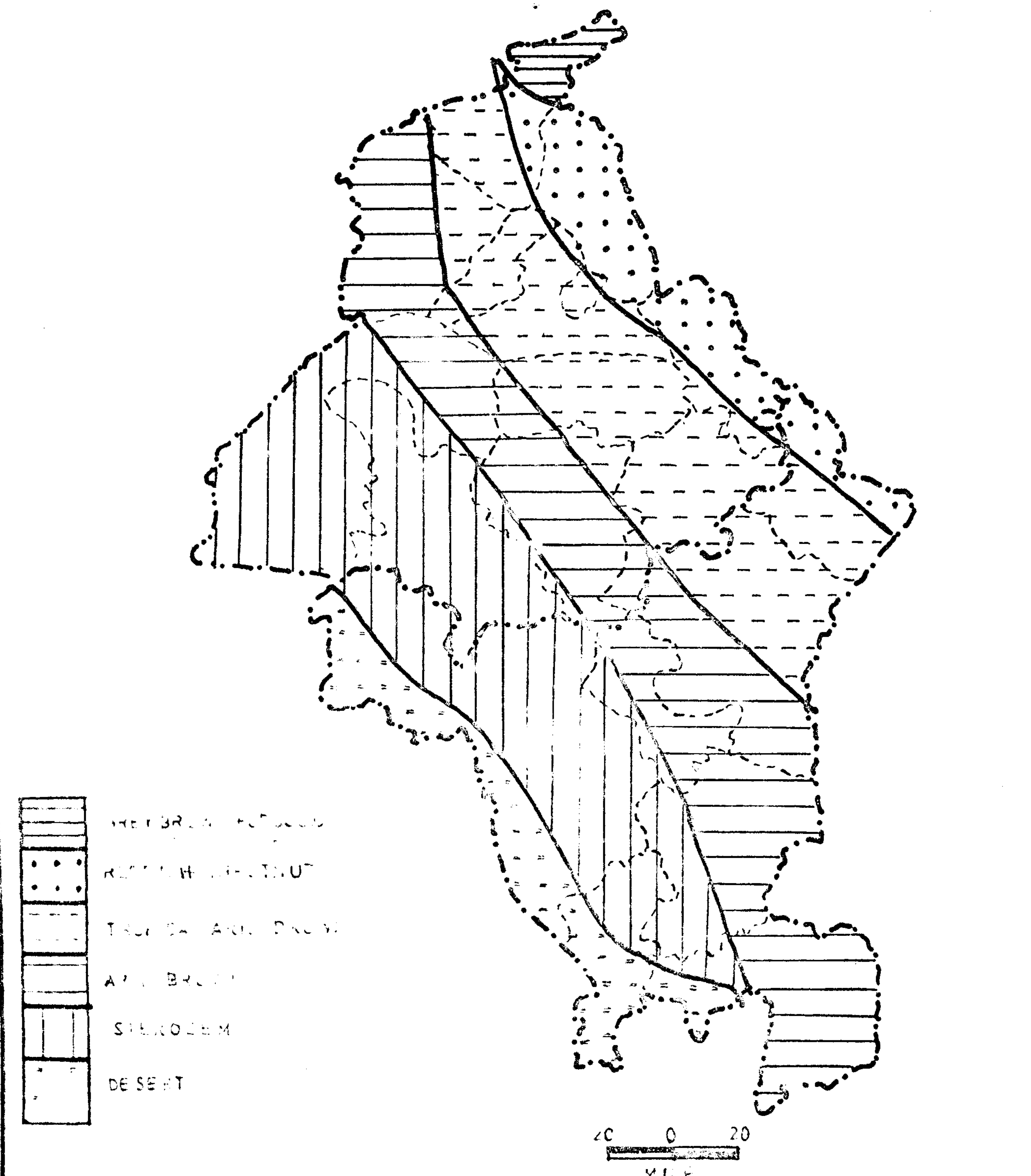


FIG. 3

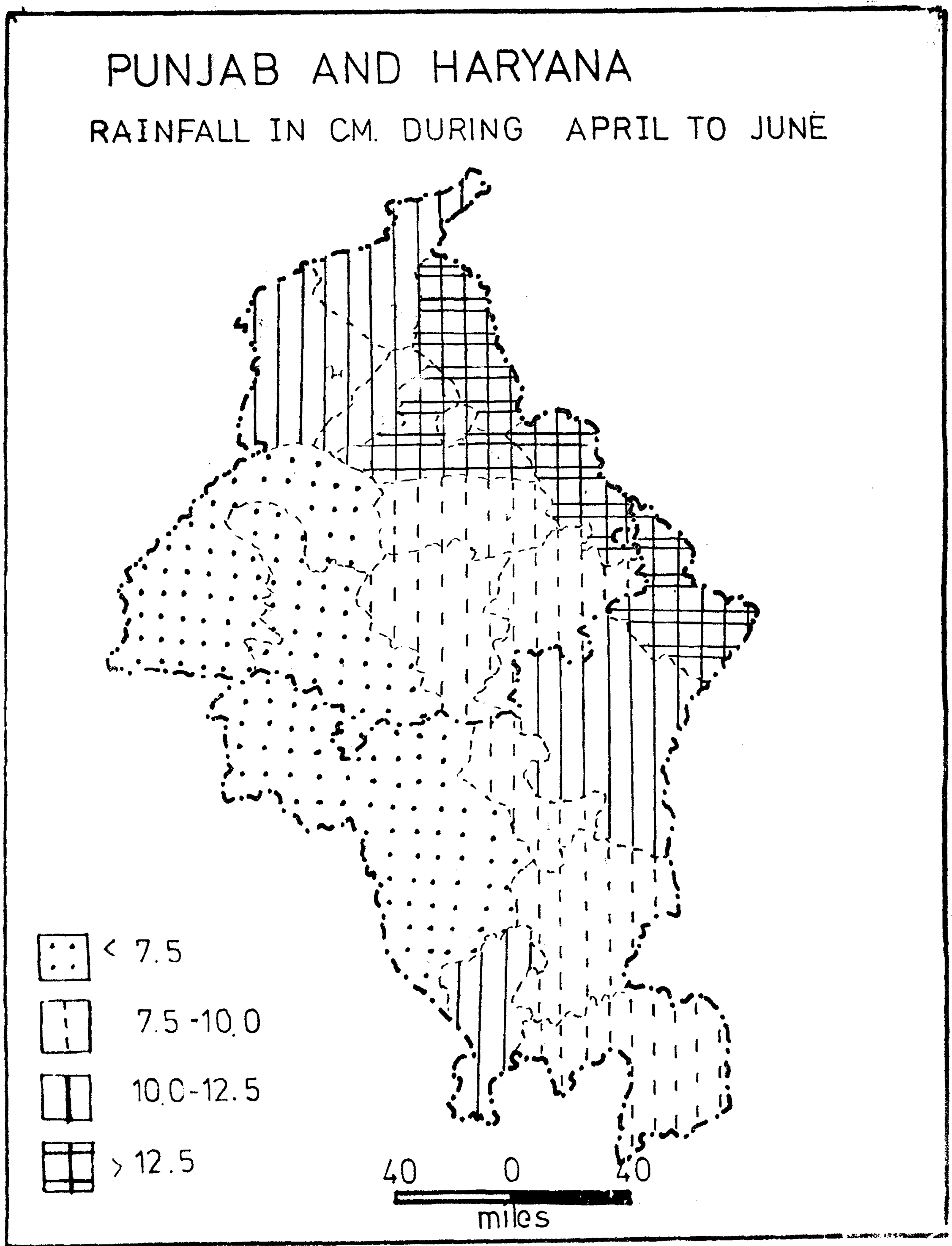

PUNJAB AND HARYANA
RAINFALL IN CM. DURING APRIL TO JUNE
< 7.5
7.5 -10.0
10.0-12.5
> 12.5
40 0 40
miles

FIG. 4a

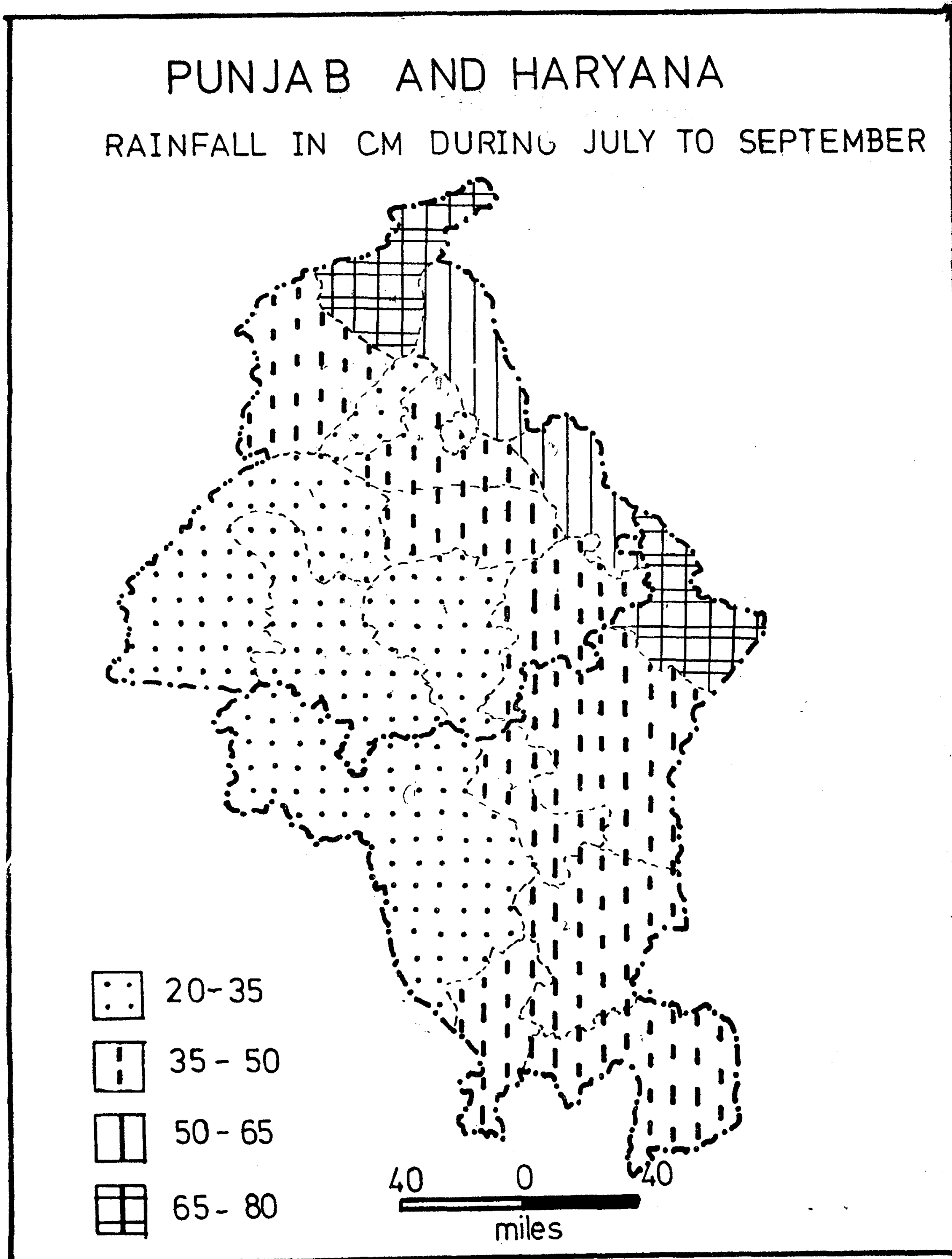

PUNJAB AND HARYANA
RAINFALL IN CM DURING JULY TO SEPTEMBER
20-35
35 - 50
50 - 65
65 - 80
40 0 40
miles

FIG. 4b

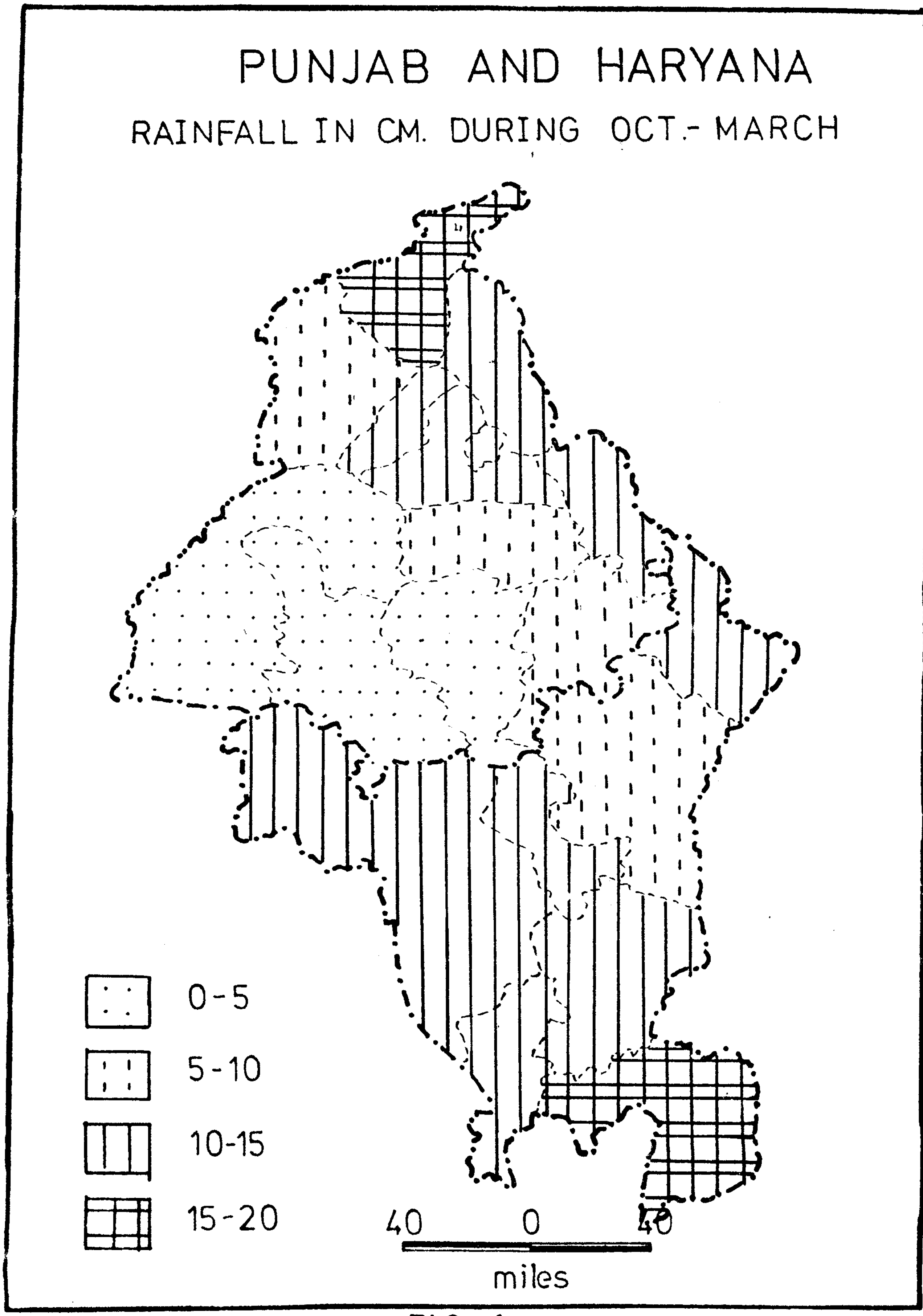

PUNJAB AND HARYANA
RAINFALL IN CM. DURING OCT.- MARCH
0-5
5-10
10-15
15-20
40
0
40
miles

FIG. 4c

Next, the region has been divided into zones according to soil characteristics. The following main zones may be identified in the region.[8] (map no. 3)

(1) Grey Brown Podzolic Soil:

This type of soil is found in north-eastern part of Gurdaspur.

(2) Reddish Chestnut Soil:

These soils are found in the eastern part of Gurdaspur, Hoshiarpur, Ropar and Narasingarh tehsil of Ambala District, with an annual rainfall of 1000-1500 mm (see appendix III). Soil erosion due to water is a very serious problem here. The soils are acidic to neutral in reaction. Wheat, rice, maize and seasamum are the main crops of this zone.

(3) Tropical arid soils:

These soils are found in remaining Gurdaspur, east of Amritsar, Kapurthala, Jullundur, Ludhiana, Patiala, rest of Ambala, part of Kurukshetra and part of Karnal district. The annual rainfall is 750-1000 cm. Water-logging, drainage salinity and alkalinity are quite serious problems here. Soils are deficient in nitrogen, phosphate and potash. Maize wheat, rice, gram and other pulses and sugarcane are the main

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8 G.S. Sidhu, A.C. Sharma and D.R. Dhingra, "Soils of Haryana", and G.S. Sekhon, M.S. Randhawa and S.L. Duggal, "Soils of Punjab", pub. in the Fertilizer Association of India, <u>Soils of India</u> (1972).

crops grown in this region.

(4) Arid Brown Soils (solonized):

These soils are found in Amritsar, east of Faridkot and Ferozepur, Sangrur, Jind, Kurukshetra, Karnal, Sonepat, parts of Rohtak and Gurgaon. The normal annual rainfall varies from 500 to 750 mm. Salinity and alkalinity are serious problems particularly in the irrigated areas. Wind and water erosion problems also exist. The soils are calcareous in nature and in most cases, kanker layers occur at a depth of 1.0 to 1.5 m. These soils are deficient in nitrogen and also in phosphate and potash. Groundnut, maize, wheat, rice, gram, cotton, sugarcane and jowar are the main crops in this zone.

(5) Sierozem Soils:

These soils are found in Ferozepur, Faridkot, Bhatinda, Hissar, Bhiwani, Rohtak and Mohendragarh. Annual rainfall varies from 300 to 500 mm. Salinity and alkalinity are serious problems particularly in irrigated areas. Wind erosion is also a common feature, in these districts. Soils are calcareous and usually have a massive kanker layer at depths of 0.75 to 1.25 metres. These soils are deficient in nitrogen, potash and phosphate. Cotton, gram, bajra, wheat are the main crops in this zone.

Table 2.2

Soil, Types, rainfall p^H and crops grown in the Districts of Punjab and Haryana

Sr. No.	Soil Type	Districts	Rainfall in mm	p^H	Crop Grown
1	Grey Brown Podzolic soil	Northeast Gurdaspur	>1,500 mm	<6.5	rice, maize, wheat
2	Reddish chestnut	Eastern Gurdaspur, Hoshiarpur, Ropar, Eastern Ambala	1,000 - 1,300 mm	6.5-7.5	wheat, rice, maize and seasamum
3	Tropical Arid Brown	Gurdaspur, Eastern Amritsar, Kapurthala, Jullundur, Ludhiana, Patiala, rest of Ambala, part of Kurukshetra and part of Karnal	750 - 1,000 mm	7.0-8.5	maize, wheat, rice and gram
4	Arid Brown	Amritsar, Eastern Faridkot and Ferozepur, Sangrur, Jind, Kurukshetra, Karnal, Sonepat, part of Rohtak and Gurgaon	500-750	7.5-8.5	Groundnut, maize, wheat, rice, gram, cotton, sugarcane, jowar
5	Sierozem soil	Ferozepur, Faridkot, Bhatinda, Hissar, Bhiwani, Rohtak and Mahendragarh	300-500 mm	8.0-8.5	cotton, gram, bajra and wheat
6	Desert Soil	Mahendragarh, Gurgaon, Hissar and Bhiwani	<300 mm	8.5-9.0	bajra, cotton, wheat and gram

Source: The Fertilizer Association of India, *Soils of India*.

(6) Desert Soil:

These soils are found in the southern parts of Mohendragarh, Gurgaon, Hissar and Bhiwani where the annual rainfall is less than 300 mm. Wind erosion is a serious problem here. These soils are also deficient in nitrogen, phosphate and potash. Bajra, cotton, wheat, gram are the principal crops grown in these soils.

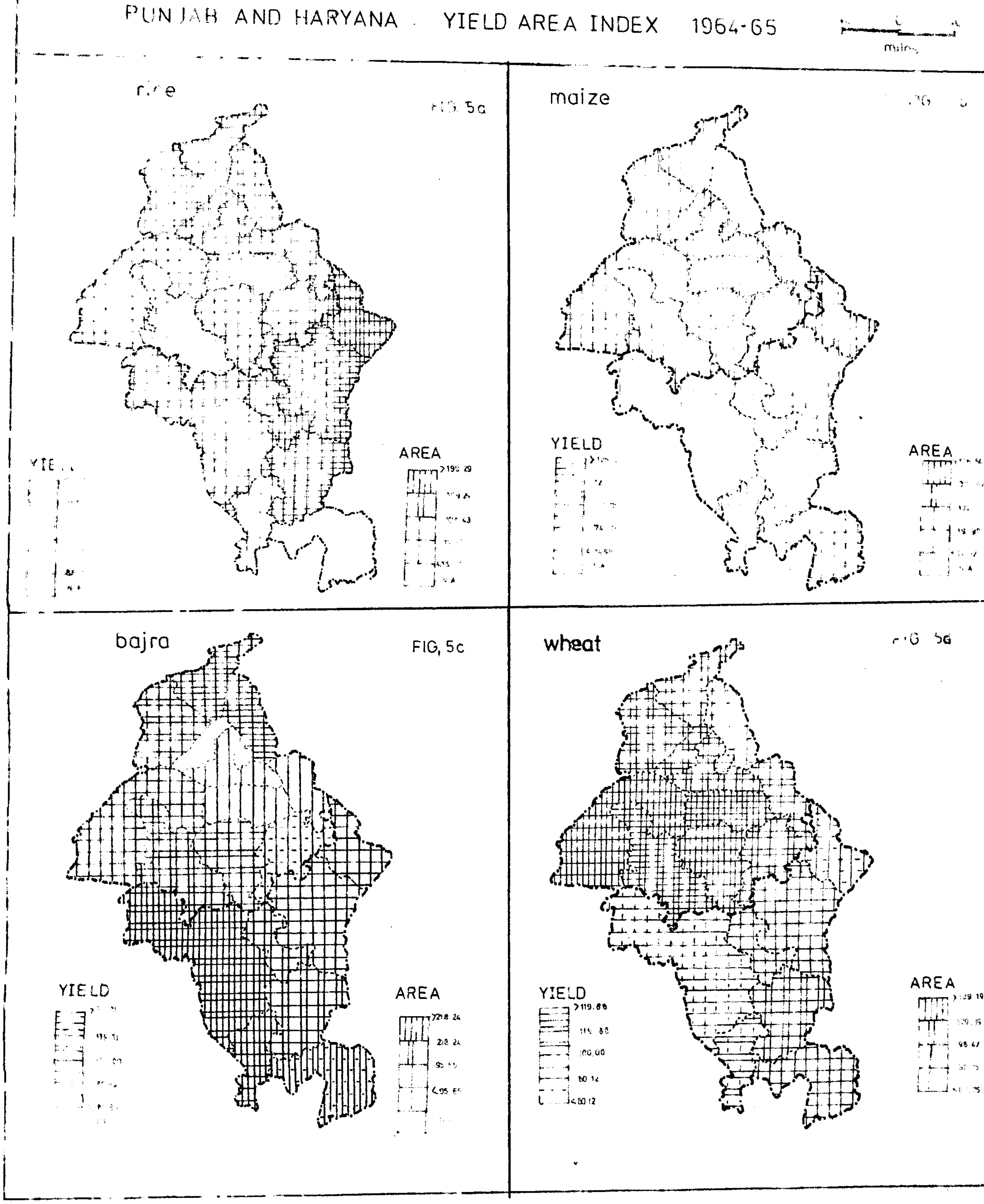
Keeping the above picture in view, in our study, we concentrate on yield and area of four crops viz. rice, maize, bajra and wheat.

The first question that arises is whether these crops which are grown in this region are grown on the best suitability of agro-climatic characteristics. An analysis of the productive efficiency of the four crops in different districts of Punjab and Haryana is done in terms of the relative average yield index and relative spread index of the crops. This study is made for three different points of time. The relative yield index (R.Y.I.) and relative spread index (R.S.I.) are calculated in the following way: (see appendices IV, V and VI)

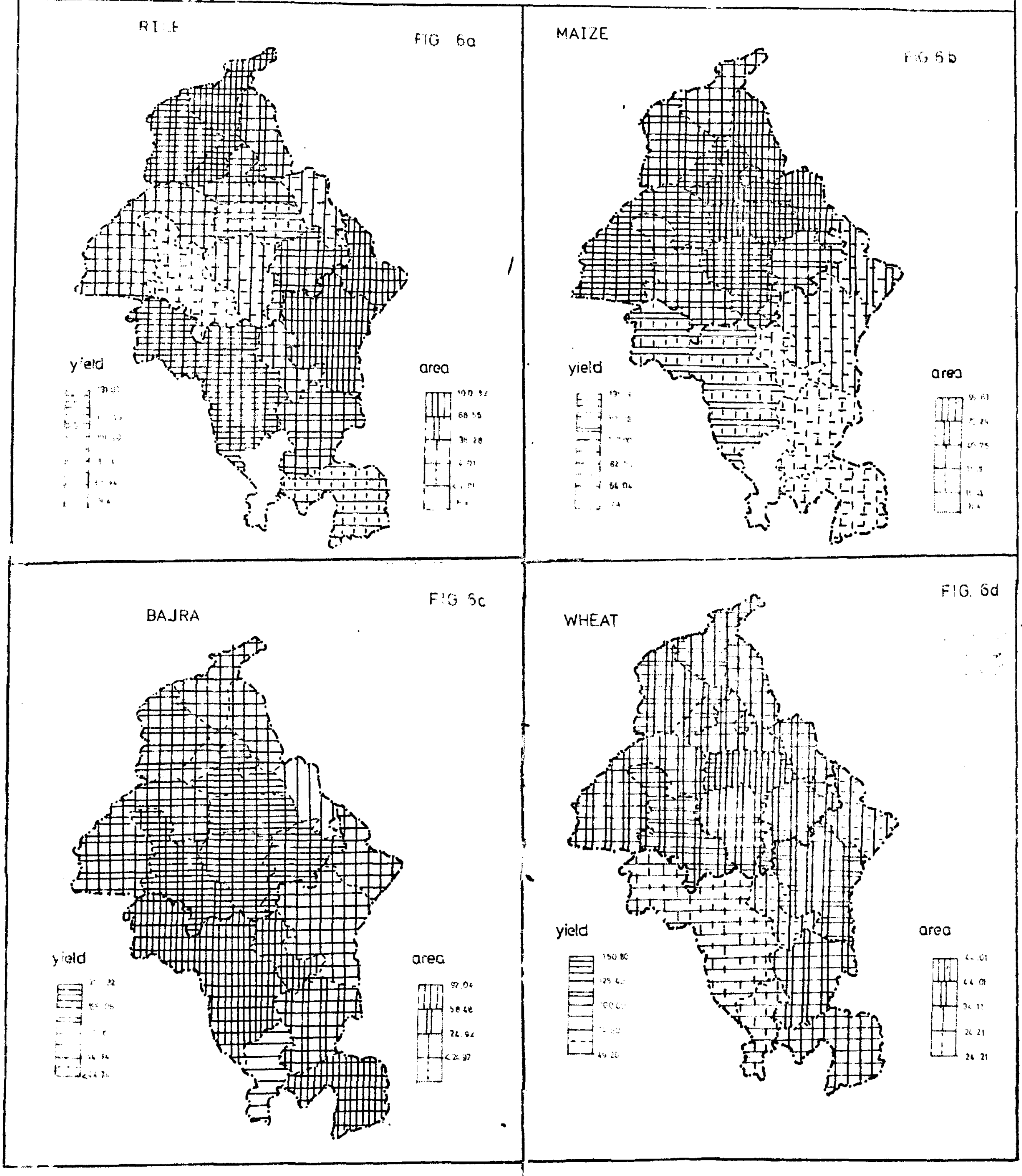
$$\text{R.Y.I.} = \frac{\text{Mean Yield for the crop in the district}}{\text{Mean all Punjab and Haryana yield}}$$

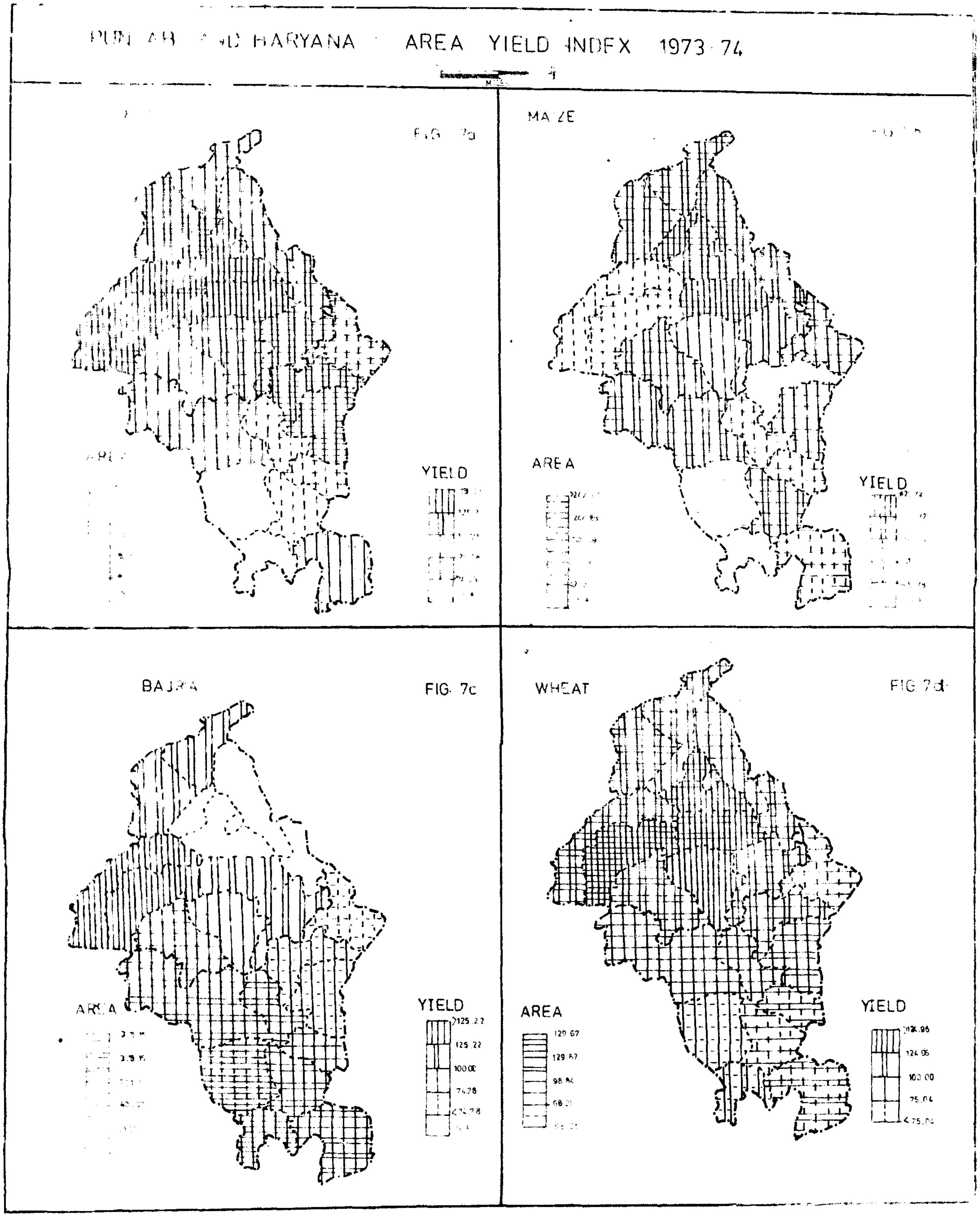
$$\text{R.S.I.} = \frac{\text{Area of the crop expressed as \% of the total cultivated area in the district}}{\text{Area of the crop expressed as \% of the total cultivated area in Punjab and Haryana}}$$

PUNJAB AND HARYANA YIELD AREA INDEX 1964-65



PUNJAB AND HARYANA : YIELD AREA INDEX 1968-69




HARYANA AREA YIELD INDEX 1973-74
FIG. 7a
YIELD
MAIZE
AREA
YIELD
BAJRA
FIG. 7c
AREA
YIELD
>125.22
125.22
100.00
74.28
<74.28
WHEAT
FIG. 7d
AREA
129.67
129.67
98.84
68.01
YIELD
>124.95
124.95
100.00
75.04
<75.04

These indices are grouped in four categories on the basis of mean plus minus standard deviation ($\bar{X} \pm \sigma$) and termed as very high, high, low and very low. These four categories are used in both area and yield index. Both are shown by vertical and horizontal chloropleth technique on the maps of four crops at three points of time [Figs. 5, 6, 7 (a b c d)].

Rice

Rice is a crop of very wide physiological adaptability, being grown in both tropical and temperate conditions, from sea level to about 7000' above sea level. They differ in their season of growth, maturation period, suitability to different conditions of soil, rainfall, temperature, altitude and adaptability to such special environments as flooded land, alkalinity and salinity, depth of standing water etc.

Suitable soil for cultivation of rice is clayey loam to clay soil. The optimum depth of top soil may vary from 18 to 22 cm and soil structure of laminar type provides a suitable environment for the rice crop.

The rice crop needs a hot and humid climate. The average temperature required throughout the life period of the crop ranges from 21^{0}c to 35^{0} centrigrade. It seldom succeeds where the temperature during the growing season is less than 25^{0} centrigrade. In Punjab, where the winter temperatures are low, only one crop of paddy is possible during the months of May to November. Short duration crops may be grown here before the onset of winter.

The spread of rice measured as a percentage share of area under rice to total cropped area[9] varies in the region from 29.55% in the district of Karnal to 0.04% in the district of Gurgaon in 1964-65. While Karnal again enjoyed the highest yield of rice of 1566 kg/ha, the district Bhatinda recorded the lowest yield of 1000 kg/ha during the same period.

District Jullundur has maintained the same position in case of both yield and area since 1964-65. The increase in area under rice is negligible in Jullundur during this period. Ludhiana during our years of study ranges between high and very high in terms of yield, while in respect to area, we find it low or very low.

District Ludhiana, while places itself either in high or very high group in terms of yield index gets a place only either in very low or low category in terms of area index.

Rice cultivation is quite popula... in districts of Amritsar and Kapurthala which in terms of yield and area indices place themselves in very high and high categories during this period.

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9 Here total cropped area is taken as area under rice + bajra + maize + wheat.

District Sangrur made a surprising improvement during this period, when it occupied a position in high category in 1973-74 in terms of yield index. It had a position only in the very low category in 1964-65. In terms of area index, it had no importance as it still remains in low category in 1973-74.

The performance of Gurgaon is very poor both in area and yield.

An important feature of Karnal distkict was that it had a better performance in area index. In fact, in 1964-65, it had the highest percentage share of rice area (29.55%) in this region. Its performance in yield was very unsatisfactory during this period when its position came down from very high category in 1964-65 and low category in 1973-74.

Maize

Maize is a warm-weather crop and its cultivation is spread over a wide range of climatic conditions as many different types of maize are available. The bulk of the crop is grown in warmer regions of temperate climate.

In India, maize is generally sown with the onset of the moonsoon in June or July and harvested in late September or October. Maize plant needs plenty of moisture in the early stage of growth. In areas with a rainfall of 75 cm or over, it can be grown without irrigation.

The most suitable soil for this crop is a deep dark silt loam. The optimum p^H range of the soil for raising a good crop of maize lies between 6.5 and 7.5.

Jullundur, Hoshiarpur, Ropar and Ludhiana are the four districts which show the highest spread index in 1973-74 and also reflect both high and very high category in yield. These four districts topped in 1968-69 also in case of area and so in case of yield except Ropar and Hoshiarpur. Even in 1964-65, the picture is almost same in case of yield and that of area with very high and high category.

District Gurdaspur, Kapurthala and Ambala fall in high category in 1973-74 in terms of area index and while in terms of yield Kapurthala was in very high, Gurdaspur in high and Ambala in low category. Except Ambala, rest maintained their position during the period.

Districts Amritsar, Faridkot, Bhatinda, Hissar, Gurgaon, Jind, Karnal, Kurukshetra, Rohtak and Sonepat lie in the third category in terms of area index in 1973-74. All these districts are, by and large, maintaining the same position throughout the period.

Bajra

Bajra is suited to warm areas of low rainfall (15" to 20") gives best performance under conditions of light showers followed by bright sunshine during the growth period. Heavy rain is disastrous for the crop.

Bajra is generally grown on poorer types of soils, such as sandy soils of the Punjab, Rajasthan and north Gujarat.

Area under bajra is decreasing in Punjab in a substantial way. During 1973-74, only Bhatinda had more than 50 hectares land under bajra. Bhiwani, Mahendragarh fall in the very high category in terms of area index in 1973-74. But in terms of yield index Bhiwani, Mahendragarh, placed themselves in low and very low category respectively during the same period. They maintain almost similar positions during the entire period. Gurgaon had a surprising performance of high area index on the one hand, and very low yield on the other, and Hissar, Jind and Rohtak, all are lying in high category in terms of yield and area during 1973-74. Districts Sonepat, Ambala, Kurukshetra are showing a poor performance throughout, in both yield and area index. Jullundur, Ludhiana and Patiala showed a high yield index in 1973-74, but there is hardly any spread of the said crop during this year.

Wheat

In temperate climates, two main types of wheat are grown, viz. spring wheat sown in March-May[10] and harvested in August-September and winter wheat sown in October-November and harvested between April and July. Each type has different

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10 Fertilizer Association of India, Agronomy of Wheat (1974).

growth characteristics. The spring wheat varieties have a short growing period and do not encounter very low temperatures in the early stages of their growth. Winter varieties on the other hand, have the ability to tolerate low temperatures in the early stages of growth, withstand in severe winter covered by snow.

The best wheat varieties are produced in areas favoured with cool, moist weather during the major portion of the growing period followed by dry, warm weather to enable the grain to ripen properly. The optimum temperature range for ideal germination of wheat seed is 20 to 25°C (68 to 77°F) though the seeds can germinate in the temperature range of 3.5 to 35°C (38 to 95°F).

Soils with a clay loam or loam texture, good structure and moderate water holding capacity are ideal for wheat cultivation. Soil must be well supplied with lime because wheat does not thrive on acid soils. The soils should have a p^H of not less than 5.8 or 6.0 for successful wheat cultivation. If the soil p^H is below 5.1 the crop may fail completely.

Wheat is the main crop of Punjab and Haryana. Districts Ludhiana, Jullundur, Faridkot and Sangrur come under very high category in terms of yield index in 1973-74. Faridkot and Sangrur show very high and rest showed the high in case of area index. Ludhiana maintained the yield index in 1968-69, while Sangrur in high and other in low category and that of area very high in Ludhiana and high in Jullunder and Faridkot. Ludhiana had the same position in 1964-65 also. Jullundur was in high category both in terms of yield and area index, while Sangrur low in yield and very high in terms of area index in 1964-65. Districts Mahendragarh, Hissar, Bhiwani, Gurgaon, Hoshiarpur and Ambala - all are in low and very low categories throughout the period in both area and yield.

The above analysis portrays the performance of different districts in spread and yield of the four crops at three points of time. It is quite clear that spread of a particular crop depends upon the soil and climatic region. The chestnut soil which includes northeast of Gurdaspur, Hoshiarpur, Ropar and north of Ambala is showing the higher spread of paddy and wheat.

The brown soil which occurs in south of Gurdaspur, west of Amritsar, Kapurthala, Jullundur, Ludhiana, Patiala, Ambala, Kurukshetra and half of Karnal is showing higher spread of maize and wheat. Karnal and Ambala are predominant in rice.

Districts Hissar, Bhiwani, Ferozepur constitute bajra-wheat belt which is of sierozem soil, and their spread index is quite high. The adjacent districts Gurgaon and Jind have high area index of bajra.

The desert soil is under bajra cereal mainly where west of Hissar, Bhiwani and Mahendragarh lie.

West of Amritsar, east of Faridkot and Ferozepur, Sangrur, Jind, north of Kurukshetra, Karnal, Sonepat, north of Rohtak and Gurgaon are, by and large popular for maize and wheat. This region lies in reddish brown soil.

Another important aspect of yield is that yield may be more, or less in that cropped region, e.g. area index of rice is less in Ludhiana district, but yield index is very high; same is in case of bajra. Its yield index is very high in most of the districts of Punjab but very poor area index. Similarly maize in Ferozepur, Sangrur and Patiala. Again in case of wheat, we find very low spread in Mahendragarh but high yield index.

Thus, it can be concluded that though agro-climatic factors have a significant effect on the area, they have a marginal effect on the yield of different crops. These agro-climatic factors effect the yield to a certain extent after which other technological factors such as fertilizer, irrigation, mechanization, use of high yielding variety seeds etc. become dominant factors influencing the yield of a particular crop.

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CHAPTER III

DECOMPOSITION OF AGRICULTURAL GROWTH

This section of our study deals with the components of agricultural growth. Agricultural growth can be broken down according to certain proximate and identifiable sources of growth, viz., extension of area under crops, changes in cropping pattern, increases in crop yield per unit of land and interaction of these three. Therefore, the following components of agricultural growth have been taken into consideration for the present study: (i) increase in area, (ii) yield, (iii) cropping pattern, and (iv) interaction. An examination of inter-regional agricultural growth with the help of these components provide valuable insights into the mechanism of agricultural growth. Keeping in view both these points- agricultural growth and performances of different components, Minhas and Vaidhyanathan[1] have formulated a method to study the agricultural growth and assess the contributions of respective components in the growth of crop output in India for the period of 1951-54 to 1958-61.

In the present study, the above mentioned technique has been used to analyse the inter-district variations in agricultural growth and performances of different components for the states of Punjab and Haryana for two points of time

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1 Minhas and Vaidhyanathan, "Growth of Crop Output in India, 1951-54 to 1958-61" in Pramit Choudhury, ed., Readings in Indian Agricultural Development (London, George Allen & Unwin Ltd., 1972), p. 50.

i.e. 1964-65 and 1973-74. Since the district boundaries in both the states have been frequently changing such an analysis could be attempted for the districts at two different points of time i.e. 1972-73 and 1973-74. A notational representation of the data used in this study is shown as follows;[2]

Crop	Weight	Proportion of area in years		Yield in year	
		0	t	0	t
c^1	w_1	c_{10}	c_{16}	y_{10}	y_{1t}
c_2	w_2	c_{20}	c_{2t}	y_{20}	y_{2t}
c_n	c_n	c_{no}	c_{nt}	y_{no}	y_{nt}

The district level analysis in the present study takes into account only four crops i.e. rice, wheat, maize and bajra, for the years 1972-73 and 1973-74. For the state level analysis for the years 1964-65 and 1972-74 nine major crops have been considered. These are rice, jowar, bajra, maize, wheat, barley, gram, sugarcane and rape and mustard.

W_i's are constant harvest prices for 1973-74 which have been assigned as weights to different crops. C_{io}'s

2 Ibid., p. 53.

and $C_{it's}$ are proportions of area occupied by different crops in year 0 and t to total area. This total area represents area under rice, maize, bajra and wheat for the period 1972-73 to 1973-74 and total cropped area for the period 1964-65 to 1973-74. $Y_{io's}$ and $Y_{it's}$ are base and final year yield of different crops.

The following symbols are used for output, area, cropping pattern and weights:

P_o = Crop output in year 0

P_t = Crop output in year t

A_0 = Gross crop area in year 0

A_t = Gross crop area in year t

W_i = Prices of i^{th} crop (harvest price)

C_{io} = Share of the i^{th} crop to total cropped in year 0

C_{it} = Share of the i^{th} crop to total cropped in year t

Y_{io} = Yield of the i^{th} crop in year 0

Y_{it} = Yield of the i^{th} crop in year t.

Definition -

$$P_o = A_o \Sigma W_i C_{io} Y_{io}$$

$$P_t = A_t \Sigma W_i C_{it} Y_{it}$$

We can split up the increases in crop production over the time period of our study into their component elements in the following manner:

$$P_t - P_o = (A_t - A_o)\sum_i W_i C_{io} Y_{io}$$
$$+ A_t \sum_i W_i C_{io} (Y_{it} - Y_{io})$$
$$+ A_t \sum_i W_i Y_{io} (C_{it} - C_{io})$$
$$+ A_t \sum_i W_i (Y_{it} - Y_{io}) (C_{it} - C_{io})$$

The first element of the right hand side of the equation is the area effect. The absence of this element will show the increase in output growth. The second is the yield effect in constant cropping pattern. Third element portrays the effect of changes in cropping patterns in the absence of any change in per acre yields. The last element measures the effect on output which could be attributed to interaction between per acre yield changes and the changes in cropping pattern.

These components are so chosen that their contributions to output growth are determined by more or less independent sets of factors. Each of these factors can again be separately analysed.

The change in gross cropped area may be derived right from extension of cultivation to new areas through reclamation of virgin lands, due to double cropped area, better crop rotations, irrigated area etc.[3] Similarly, yield depends entirely on the technological relations between inputs and outputs and the quantum of various inputs

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3 Ibid., p. 55.

(including fertilizer, water, seed and labour) used. We have not tried to estimate these technological production relations; analysis of factors responsible for past yield changes and assessment of technological possibilities of different areas will form a separate study.

The 'interaction' term is some sort of adjustment entry. Though yields of certain crops in a region may go down, at given constant relative prices, farmers may leave the acreage allocations at different crops as they were a distinct possibility in a region where an overall determination of soil fertility takes place - or they may switch acreages to crops where yields have increased. In different possible combinations of positive and negative yield changes, the cropping pattern automatically shifts.

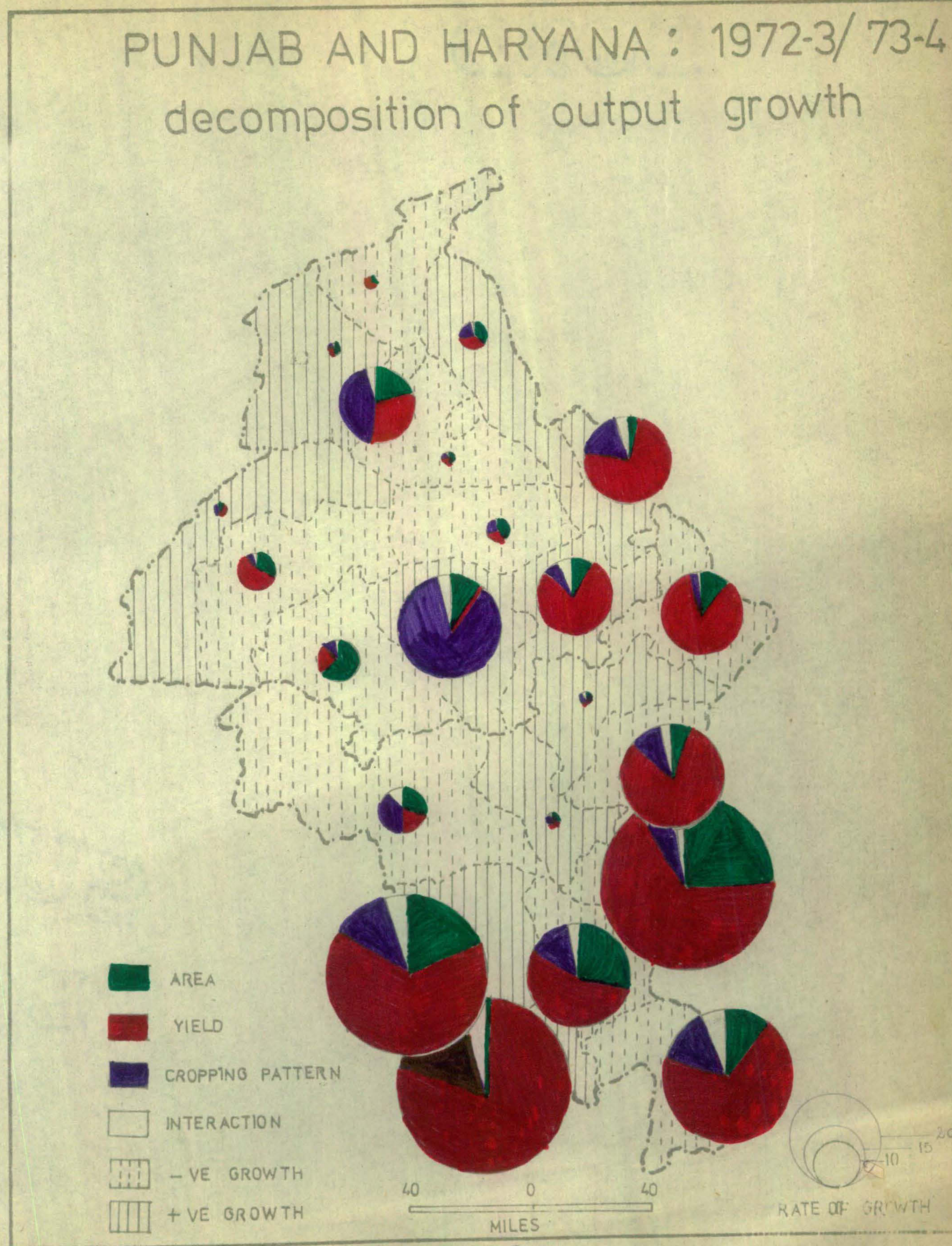
On the very outset a decomposition exercise has been attempted at the state level. Nine crops - rice, jowar, bajra, maize, wheat, barley, gram, sugarcane and rape - and mustard are taken into account to see the agricultural growth for the periods 1964-65 and 1973-74. During this period area under bajra and gram have declined in Punjab and that of bajra and jowar in case of Haryana. Yield of course has increased in all crops during this period except barley in both the states and gram and maize in Haryana. Detail figures are shown in appendix VII.

Table 3.1

Relative Contributions of Components to the Growth of Output

State	Area	Yield	Cropping Pattern	Interaction	Total	Overall rate of Growth
Haryana	17.76 (12.96)	16.91 (12.34)	72.65 (53.01)	-7.78 (-5.68)	100	72.64
Punjab	30.51 (17.80)	90.24 (52.64)	-7.59 (-4.43)	-13.16 (-7.68)	100	58.33

During this period, with the above mentioned crops, the growth rate of Punjab is found to be 58.33%, while that of Haryana is 72.64%. In Punjab, the maximum contribution is attributed to yield component, followed by area component while the contribution by cropping pattern and interaction is negative. The contribution by share of the crop is found to be maximum in case of Haryana State. This can be well observed when we find a tremendous increase in area under wheat and gram. Share of the area under wheat to total has increased from 0.16 to 0.22 and the share of the area under gram to total has shown an increase from 0.02 to 0.19 during this period. This sort of change is not found in case of Punjab. The contributions by area and yield are by and large same, while that of interaction has come out to be negative.



PUNJAB AND HARYANA : 1972-3/ 73-4
decomposition of output growth
AREA
YIELD
CROPPING PATTERN
INTERACTION
— VE GROWTH
+ VE GROWTH
40
0
40
MILES
20
15
10
RATE OF GROWTH

FIG. 8

During the period 1972-73 and 1973-74, production of foodgrains in this region has declined. The appendix VIII represents the production and area of four cereals. Both production and area of rice and bajra have increased. But those of wheat have decreased. Area under maize has increased, while the production has decreased. The area of cereal as a whole has increased in Punjab but production in Punjab and both area and production in Haryana have declined during this period. If both the states are taken together, both area and production of foodgrains have decreased during this period.

Results obtained are shown in the table 3.2 and is portrayed in the figure 8, with signs of growth rate and its components with the help of pie diagram.

During this one year period from 1972-73 to 1973-74 production of foodgrain has decreased from 7692 thousand m. tonnes to 7679 thousand m. tonnes in Punjab and from 4,073,000 tonnes to 3,836,000 tonnes in Haryana. Ten districts out of 22 are found to have positive growth rate. Mahendragarh has recorded the highest positive growth rate (36.99%), while that of Jind is the lowest (0.44%). District Sonepat placed itself at the bottom of the list with maximum negative growth rate (-42.86%). Districts of Haryana show more negative growth rate than Punjab.

Table 3.2

Relative Contributions of different elements to the Growth of Crops output - 1972-73 to 1973-74

Name of the district/ State	Percentage Income attained to Area	Yield	Cropping Pattern	Interaction	Total	Overall rate of Growth
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 Mahendragarh	-.05 (-.14)	43.64 (117.98)	-8.93 (-24.14)	2.33 (6.30)	100	36.99
2 Bhiwani	7.70 (2.40)	27.09 (84.42)	-4.55 (14.11)	1.86 (5.80)	100	32.09
3 Sangrur	-2.60 (-12.34)	-.16 (-.75)	23.44 (110.31)	.84 (3.95)	100	21.25
4 Rupar	.97 (5.25)	25.32 (136.94)	-6.30 (-34. 7)	-1.49 (-8.06)	100	18.49
5 Patiala	1.33 (8.18)	12.91 (79.40)	.86 (5.29)	1.17 (7.20)	100	16.26
6 Hoshiarpur	10.51 (162.19)	-10.87 (-167.75)	7.77 (119.91)	-.93 (-14.25)	100	6.48
7 Kurukshetra	1.08 (38.57)	10.26 (366.43)	6.59 (-235.36)	1.94 (-69.29)	100	2.80
8 Amritsar	8.12 (313.51)	-3.86 (149.83)	-2.78 (-107.33)	1.12 (43.24)	100	2.59
9 Ferozepur	-.29 (-23.02)	2.05 (162.70)	-.91 (-72.22)	.42 (33.33)	100	1.26
10 Jind	11.00 (2500.00)	5.55 (1261.36)	-21.33 (-4825.00)	4.24 (963.64)	100	0.44
11 Jullundur	2.86 (539.62)	-1.89 (-356.60)	-1.44 (-266.04)	-.09 (-16.98)	-100	-.53
12 Gurdaspur	-.73 (-29.43)	-1.75 (-70.56)	0 0	0 0	-100	-2.48
13 Ludhiana	-2.22 (-41.73)	-1.69 (-31.77)	-1.20 (-22.56)	-.20 (-3.76)	-100	-5.32

Table 3.2 contd.....

Relative Contributions of different elements to the Growth of Crops output - 1972-73 to 1973-74

(1)	(2)	(3)	(4)	(5)	(6)	(7)
14 Faridkot	-2.71 (-33.46)	-6.86 (-72.35)	.16 (1.98)	.31 (3.83)	-100	-8.10
15 Bhatinda	-9.86 (-111.04)	3.26 (36.71)	-1.95 (-21.96)	-.33 (-3.72)	-100	-8.88
16 Hissar	-3.45 (-35.79)	-2.64 (-27.39)	-4.93 (-51.14)	1.38 (14.32)	-100	-9.64
17 Kapurthala	6.31 (39.76)	-9.74 (-61.37)	-13.70 (-86.33)	1.26 (7.94)	-100	-15.87
18 Ambala	-1.90 (-11.25)	-15.40 (-91.18)	.34 (2.01)	.07 (.41)	-100	-16.89
19 Karnal	-1.35 (-6.53)	-17.89 (-86.51)	-2.01 (-9.72)	.57 (2.96)	-100	-20.68
20 Rohtak	-29.69 (-29.69)	-12.39 (-59.06)	-3.10 (-14.78)	.75 (3.57)	-100	-20.98
21 Gurgaon	- 3.29 (-12.03)	-21.75 (-79.55)	-4.07 (-14.89)	1.17 (6.47)	-100	-27.34
22 Sonepat	-10.84 (-25.30)	-30.73 (-71.72)	-2.03 (-4.74)	-.76 (-1.77)	-100	-42.85
Punjab	-.56 (-27.31)	- .92 (-44.87)	- .67 (-32.69)	.10 (4.87)	-100	-2.05
Haryana	-1.10 (-15.64)	-4.09 (-58.17)	-3.06 (-43.52)	1.23 (-17.49)	-100	-7.03
Punjab + Haryana	-.92 (-28.04)	-1.17 (-35.67)	- 1.39 (-42.37)	.20 (6.09)	-100	-3.28

Note; Figures within brackets are percentages to total growth.

Both in Punjab and Haryana, maximum negative contribution is claimed by negative yield, followed by cropping pattern and the area. The only positive contribution is through interaction. With the combination of both the states the maximum contribution went to cropping pattern which is -42.37%, next is by yield (-35.67%) and then by area (-28.94%).

In most of the districts the contributions of different components are found to be more than hundred per cent. It is because the other components have again negative effect. And thus the effect is neutralized.

The highest share in case of area is enjoyed by the district Jind (11.00%), while the lowest share by Rohtak (-29.69%). Again the maximum and minimum contribution of cropping pattern was enjoyed by the districts Sangrur (23.44%), and Jind (-21.33%) respectively.

These two components have very little effect on overall rate of growth. The same is true for interaction component also. The contribution of yield component is significant in explaining the growth rate. The highest overall growth rate was enjoyed by Mahendragarh district and this was the district where contribution of yield component was also maximum (43.64%). Similarly, maximum overall negative growth rate was accompanied by maximum negative contribution of yield (-30.73%) component in the district Sonepat.

The above findings raised the interest in finding out a correlation of the independent variable area (x_1), yield (x_2), cropping pattern (x_3) and interaction (x_4) on dependent variable growth (y).

The results found:

$rx_1\ y = .24$

$rx_2\ y = .86$

$rx_3\ y = -.32$

$rx_4\ y = .04$

These results show that yield is highly correlated with the growth rate followed by area, cropping. Pattern has a negative correlation and that of interaction is very negligible.

On the whole it is increase in yield which has contributed most to the growth.

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CHAPTER IV

SHARE OF AREA UNDER HIGH YIELDING VARIETY ON PRODUCTION

In this section we propose to assess the contribution of area under high yielding variety on production of rice, maize, bajra and wheat.

Agricultural production can be explained by the effects of interaction between man and nature. These may be categorised into technological, environmental and institutional factors. In studying the relations in the present study the following five variables are used viz. soil rating index, percentage of area under high yielding variety to total cropped area, percentage of gross area irrigated to total cropped area, tonnage of nitrogenous fertilizer per 100 hectares of gross area irrigated and mechanization index - first being environmental while rest four of them are technological. The institutional factors as affecting the productivity through HYV have not been considered here but the effect of HYV introduction on the institutional frame has been examined elsewhere[1] in the present study. District-wise data of Punjab and Haryana for the year 1970-71 have been used to see the extent of contributions of these factors on agricultural productivity in a year of normal weather condition.

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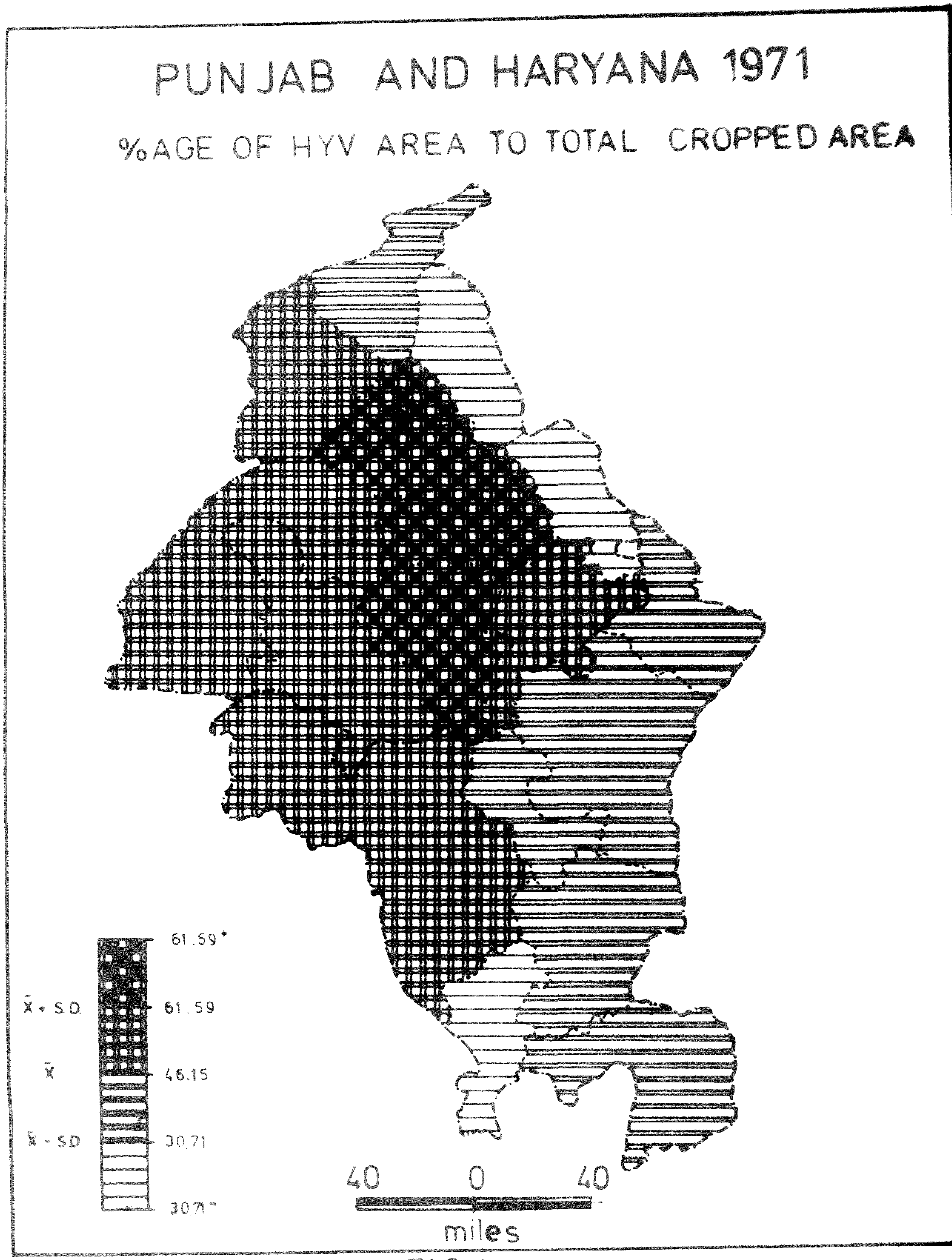
1 See Chapter V.


PUNJAB AND HARYANA 1971
%AGE OF HYV AREA TO TOTAL CROPPED AREA
61.59+
X̄ + S.D.
61.59
X̄
46.15
X̄ - SD
30.71
30.71-
40
0
40
miles
FIG. 9

In this part of the analysis an attempt has been made to see the nature of various variables chosen. The nature of each variable and the method by which the variable has been identified has been discussed separately.

Percentage of HYV Area to Total Cropped Area

Here we look at the area under four HYV crops, viz., rice, maize, bajra and wheat, as percentage of the total cropped area under these crops in each district under study. Probably, this factor contributes most to agricultural productivity. The agricultural production in several countries had a breakthrough with the introduction of HYV. The experience of Japan, Taiwan, Mexico etc. empirically supports our expectation.[2] The spatial distribution of this variable is portrayed on the map 9. (Table 4.1) The disparity in distribution is quite high - c.v. being 33.45%.

Soil Rating Index

The different characteristics of soil viz., permeability, degree of weathering and natural fertility, topography, texture and structure of soils, degree of climatic suitability, alkalinity and salinity, stoniness etc.

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2 K.N. Raj, "Some Questions Concerning Growth, Transformation and Planning of Agriculture in the Developing Countries", Comparative Experience of Agricultural Development in Developing Countries of Asia and the South-East Since World War II (The Indian Society of Agricultural Economics, 1971), p. 237.

Table 4.1

Statistics for Independent Variables

District	x_1	x_2	x_3	x_4	x_5
1 Gurdaspur	44.63	72.00	55.10	6.60	.31
2 Amritsar	59.39	73.50	94.00	4.53	2.40
3 Kapurthala	62.50	73.50	82.20	4.77	2.94
4 Jullundur	65.25	72.20	81.80	5.73	4.14
5 Hoshiarpur	30.39	76.20	35.00	6.74	2.85
6 Rupar	27.88	72.20	35.50	6.73	1.43
7 Ludhiana	68.21	72.20	81.70	5.65	3.29
8 Ferozepur	51.94	76.70	82.30	3.25	2.00
9 Bhatinda	60.55	69.40	75.20	2.58	1.19
10 Sangrur	64.63	69.40	81.40	3.19	1.79
11 Patiala	50.80	67.30	69.40	4.10	2.42
12 Hissar	48.16	68.40	49.60	1.61	0.35
13 Rohtak	31.18	68.40	40.30	1.73	0.84
14 Gurgaon	42.28	68.40	26.59	2.08	1.77
15 Karnal	42.36	57.60	70.80	4.09	2.29
16 Ambala	31.93	72.20	26.60	3.75	2.35
17 Jind	38.08	64.70	63.79	1.25	0.83
18 Mahendragarh	10.14	68.40	8.68	2.79	0.80

x_1 = % of area under HYV to total cropped area (four crops)

x_2 = % of rating index

x_3 = % of GAI to TCA

x_4 = Tonnage of nitrogenous fertilizer per 100 hec of GAI

x_5 = Mechanization index.

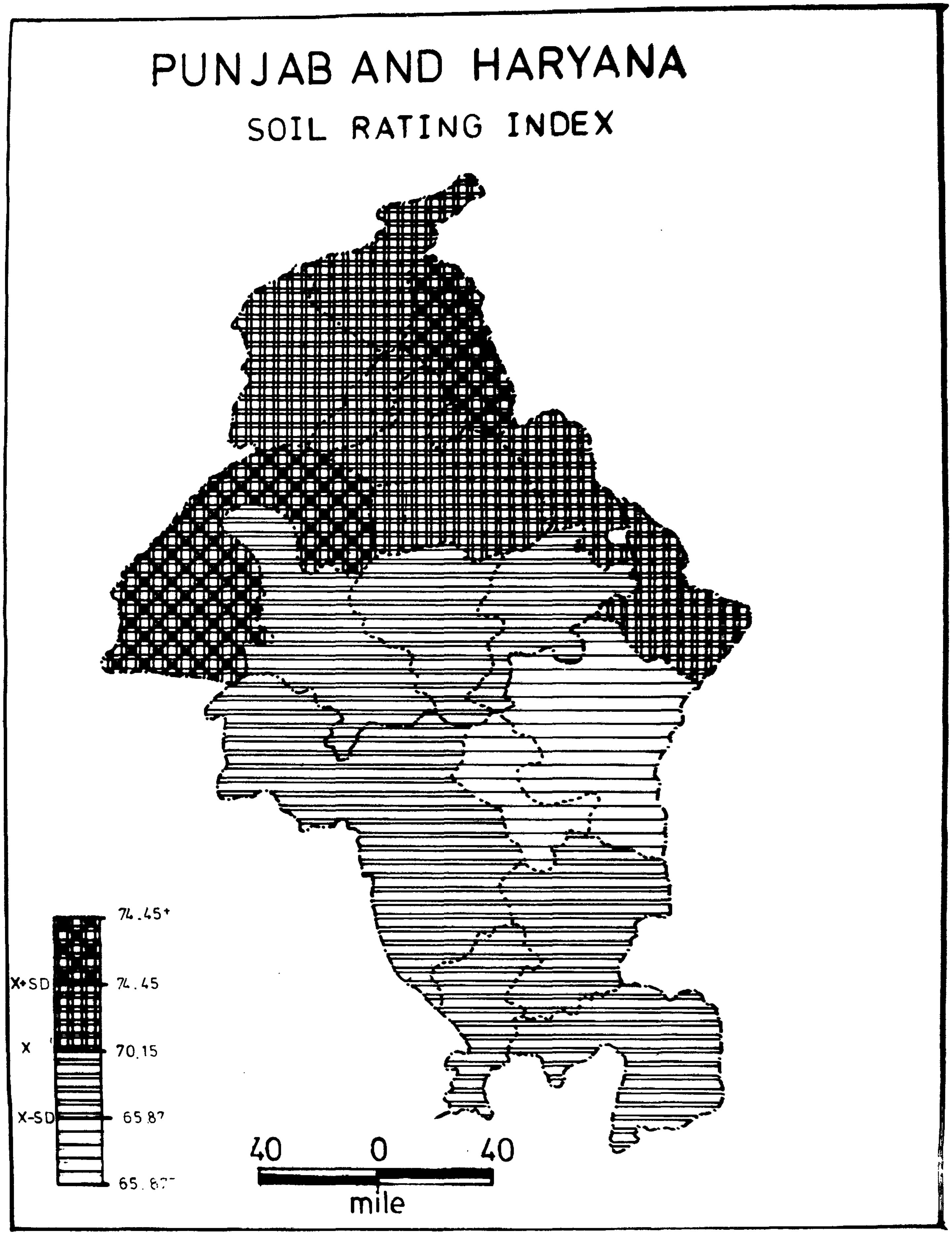
PUNJAB AND HARYANA
SOIL RATING INDEX
74.45+
X+SD
74.45
X
70.15
X-SD
65.87
65.87-
40
0
40
mile

FIG. 10

have direct effects on productivity of crops. It is very difficult to quantify the effects of these factors and bring them to a single index form. R.E. Storie developed a soil rating index based on two properties of soil viz. land's potential utilization, and productive capacity. S.P. Roychoudhuri[3] calculated the soil rating index for the Indian districts based on Storie's method. The same rating index has been used in this study. The method is as follows:

A = permeability, degree of weathering, natural fertility etc.

B = topography, texture and structure of soil

C = degree of climatic suitability, salinity, stoniness and tendency to erode.

Each of these factors is evaluated on the basis of 100% for the most favourable conditions. The soil rating index is then obtained by multiplying these three factors A x B x C and the index is expressed in percentage.

Raychoudhury found that the soil rating index is positively related to productivity.

The distribution of soil rating index has been portrayed in fig. 10 (Table 4.1). The disparity of this index is low - the c.v. being 6.10% only.

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3 S.P. Roychoudhury and K.B. Shome, "Ratings of Soils in India", Proceedings of the National Institute of Science of India, vol. XXVI(a), (1960), Supplement 1.

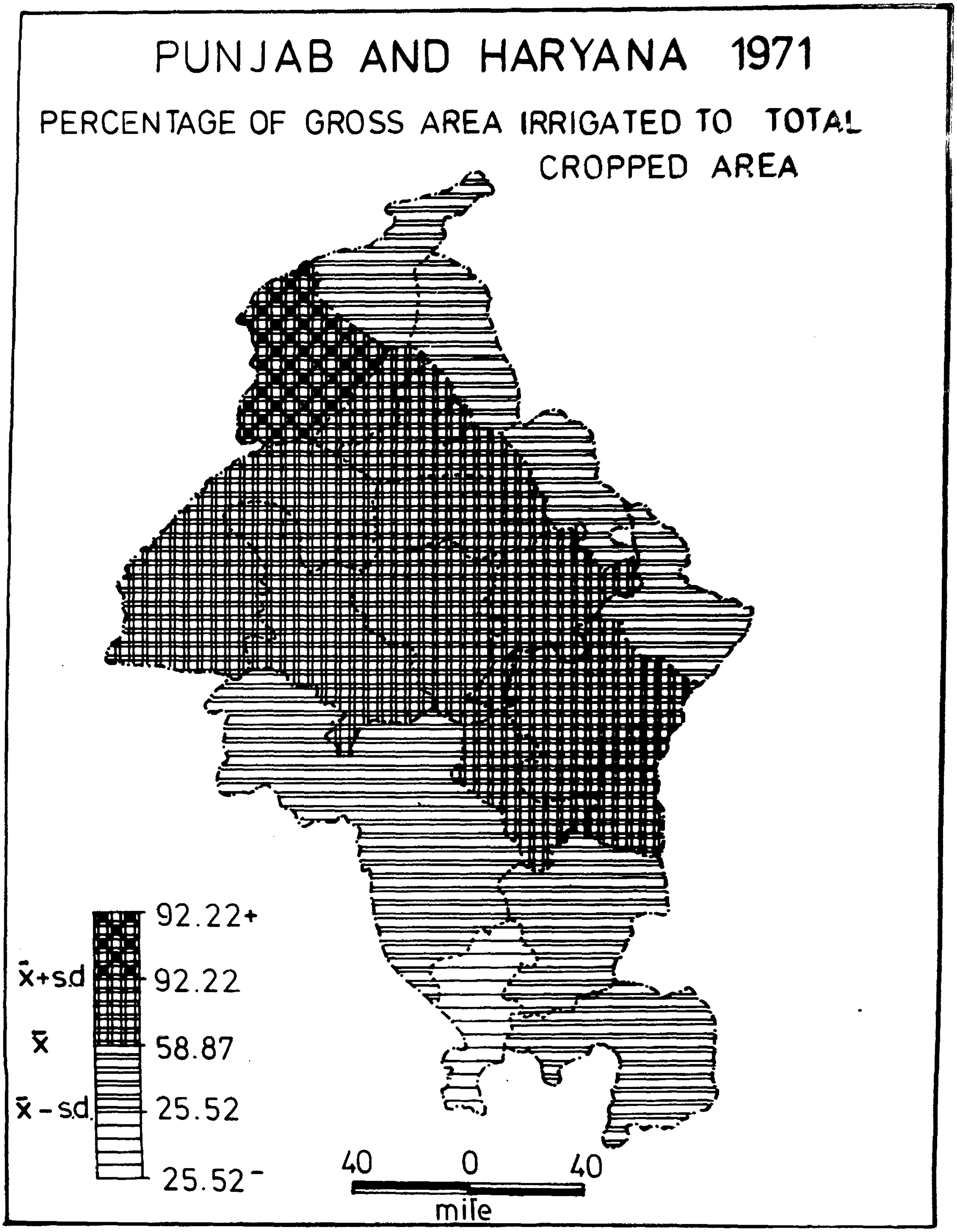
PUNJAB AND HARYANA 1971
PERCENTAGE OF GROSS AREA IRRIGATED TO TOTAL CROPPED AREA
92.22+
x̄+s.d
92.22
x̄
58.87
x̄ - s.d
25.52
25.52-
40
0
40
mile

FIG. 11

Irrigation

Irrigation enables the farmers to use better quality of seeds at the right time and to reap the bigger margins of profit.[4] Many scholars have studied the effect of irrigation on yield and found that it is basically irrigation which helps in adoption of HYV and thus increases the productivity.[5] A map of percentage of gross area irrigated to total cropped area has been prepared (fig. 11). The disparity of this variable has been found to be pretty higher - c.v. being 56.65%.

Fertilizer

The use of fertilizer, apart from irrigation is regarded as one of the surest ways of increasing productivity of crops.[6] Different fertilizers help the growth of crop in different ways. In this study only nitrogenous

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4 R.C. Arora, Development of Agriculture and Allied Sectors (New Delhi, 1976), p. 21.

5 Vishwanath, "A Comparative Study of Irrigated and Unirrigated Crop in Doharighat Block, Azamgarh District, U.P.", in Agricultural Situation in India, February 1969, p. 19.

(b) S.K. Rao, "Inter-regional Variations in Agricultural Growth, 1952-53 to 64-65 : A Tentative Analysis in Relation to Irrigation", Economic and Political Weekly, 3 July 1971, p. 1337.

6 D. Singh, J.K. Rahaja and S.R. Bapat, "Returns from Fertilizer on Farmers Yield", Indian Journal of Agricultural Economics, vol. XXV, no. 4, 1970, p. 29.

PUNJAB AND HARYANA 1971

TONNAGE OF NITROGENOUS FERTILIZER PER 100 HECTARES
OF GROSS AREA IRRIGATED

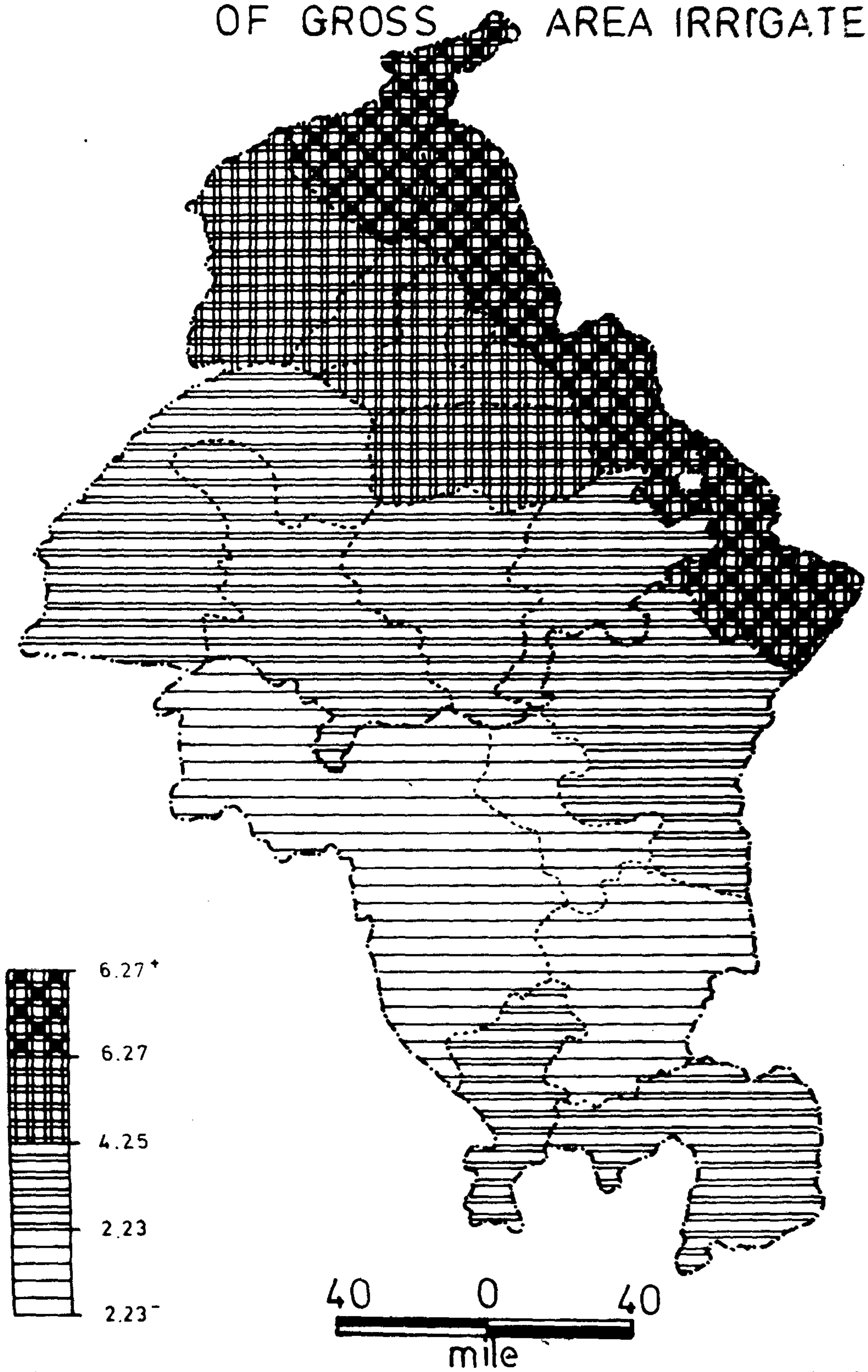

FIG. 12

fertilizer is considered because this is found to be the most popular fertilizer in the area of our study. Wherever, phosphorous and potassium fertilizers are used, these are used along with nitrogenous fertilizer. Functions of nitrogenous fertilizer are;

(1) It helps in vigorous vegetative growth;

(2) It is an important constituent of protein and chlorophyll; and

(3) It improves the quality of leafy vegetables.

Therefore, it is taken as an important variable for increase in productivity. The distribution of tonnage of nitrogenous fertilizer per 100 hectare of gross area irrigated is portrayed in fig. 12. The disparity on distribution is found to be very high (c.v. is 47.62%).

Mechanization Index

With the introduction of HYV a few changes in the cultivation routine came as change in cropping pattern, use of irrigation, use of fertilizers etc. etc. A quick and efficient service is necessary in all the steps from the ploughing the field to reaping the harvest. It is not a direct input, but is instrumental in increasing the productivity.

In this study, number of tubewells/pump-sets and number of tractors are taken to represent mechanization.

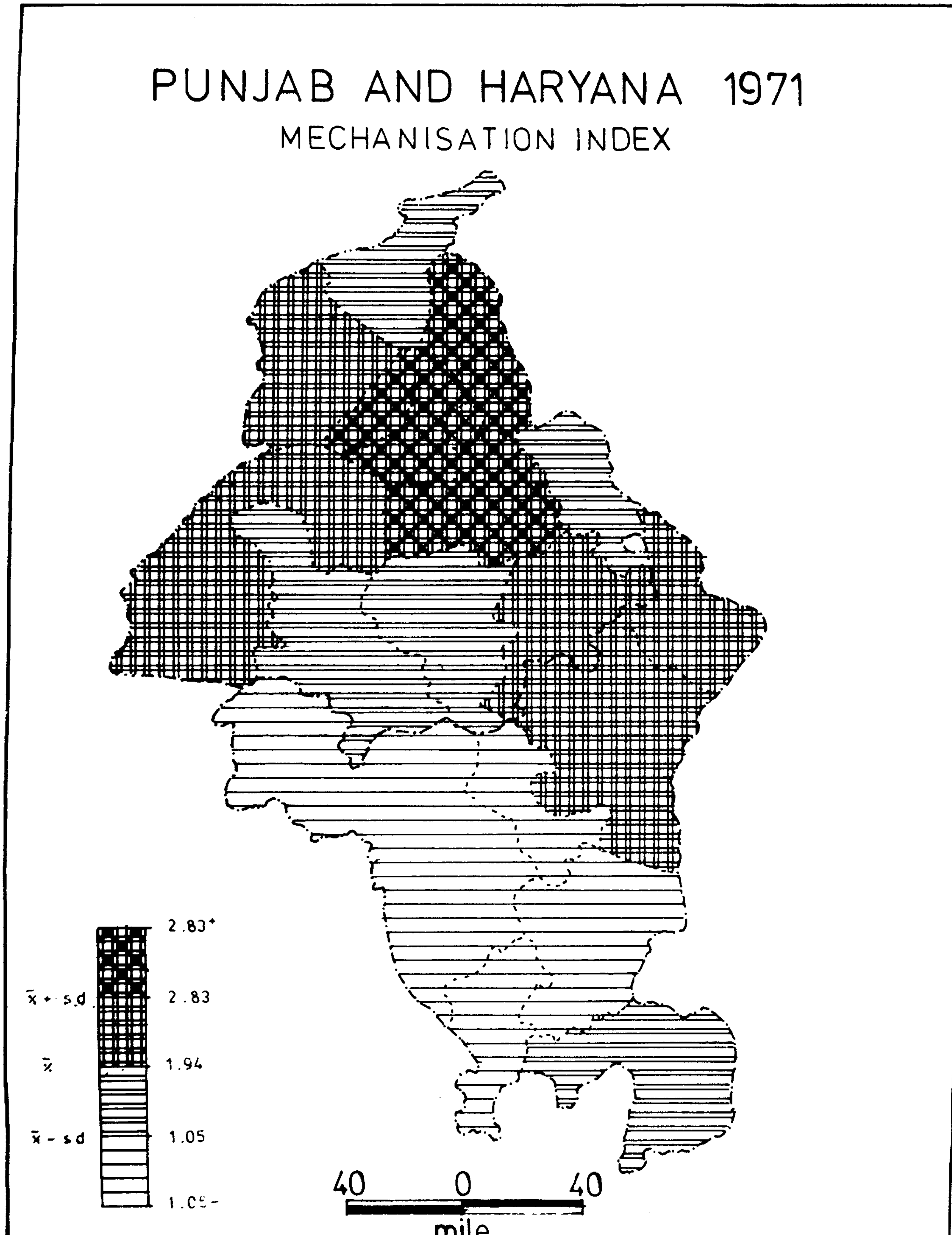
PUNJAB AND HARYANA 1971
MECHANISATION INDEX
2.83+
x̄ + s.d
2.83
x̄
1.94
x̄ - s.d
1.05
1.05-
40
0
40
mile

FIG. 13

The number of tubewells/pump-sets and tractors are taken separately for an index, as their efficiencies differ much. These two are put together and expressed in an index called mechanization index. It is found by 'division of mean'[7] method as follows. (see appendix IX)

The absolute data are standarized by working out number of wells/pump-sets per 1000 hectares of total cropped area and of the number of tractors per 100 hectare of total cropped area. The standard value is then divided by the mean of two sets and then added up. Thus the index has been found out. Many scholars found that higher is the mechanisation higher is the productivity.[8] The distribution of the index has been mapped on figure 13. The inter-district disparity of this variable is also pretty high. The coefficient of variance is 45.87%.

The method applied here for studying the importance of the above five variables is the principal component analysis, which, together with discriminent functions, yields a more rigorous system of weightages.[9]

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7 A. Kundu, "Construction of Indices for Regionalisation : An Enquiry into Methods of Analysis", Geographical Review of India, vol. 37, no. 1, 1975.

8 National Productivity Council, Productivity Trends in Iron and Steel in India (New Delhi, 1974), p. 1.

9 (a) M.N. Pal, "Regional Disparity in the Levels of Development in India", Indian Journal of Regional Science, vol. VII, no. 1, 1975.

(b) B. Das Gupta, "Socio-Economic Classification of Districts - A Statistical Approach", EPW, 14 August 1971.

The mathematical steps that have generally been followed in the principal component analysis are as follows (Appendix X).

At first we standardize the given data matrix to get the correlation matrix, $R = \frac{X' X}{n}$. For standardization, we substract the column mean from the individual value for all the observations given in the column and then divide them by the respective column standard deviations. The standardization of raw data eliminates the biasness of scale and the data becomes comparable. Then, with the help of characteristic equation $(R - \lambda I) K = 0$, we get the eigen values (λ values). Taking the highest eigen value which explains the highest variation, we get the corresponding eigen vector (k). The eigen vector represents the weights.

The logic behind this method is that it enables to determine a vector known as the first principal component (linearly dependent on the variables) having the maximum sum of squared correlations with the constituent variables while finding composite indices.

In the process of factor leading for composite indices, two conditions are always taken care of. These are: (i) All variables should be important, and (ii) there should not be bipolarity among the variables.

Bipolarity cannot be a barrier here as we are interested in finding weightages only not a composite index.

A complete picture of the variables and the correlation matrix are given in the appendix XI.

The latent roots or eigen values of the correlation matrix are;

2.411 1.600 .665 .220 .104

The highest eigen value is 2.411 which explains 48.2% variance. With this the factor loadings are found to be;

Area under HYV = 540

Soil rating index = 0.302

% of GIA to TCA = 0.507

Tonnage of nitrogenous fertilizer for 100 hectares of GAI = 0.207

Mechanization Index =0.535

The maximum lead is enjoyed by percentage of area under high yielding variety to total (0.540) and next comes mechanization index (0.535). Another almost same lead is found in case of percentage of GAI to TCA. Thus we find that the percentage of area under HYV is taking the top position in explaining the production.

CHAPTER V

SPATIAL DISTRIBUTION OF AREA UNDER HIGH YIELDING VARIETIES

From the previous sections it is evident that (i) Yield has the highest effect on agricultural growth, and (ii) effect of area under high yielding variety is the highest on agricultural productivity.

In this section an attempt has been made to explain the variations in area under high yielding variety by some variables. For this purpose, eight variables are selected to explain the spatial variations of percentage of HYV area to total cropped area. These variables are soil rating index, percentage of gross area irrigated to total cropped area, tonnage of nitrogenous fertilizer per 100 hectare of gross area irrigated, mechanisation index, per hectare productivity in money terms, percentage of agricultural labour to total agricultural worker, percentage of rural scheduled caste to total rural population and percentage of literate population to total population. The first one belongs to environmental, second three are technological and rests are institutional in nature. The independent variable is calculated by taking the percentage of the sum of high yielding variety area under rice, bajra, maize and wheat to total cropped area of the same crops. An attempt has been made to explain the reasons for the choice of the variables. This study is based on the year 1970-71.

PERCENTAGE OF HYV AREA TO TOTAL CROPPED AREA

Four cereals are chosen on the basis of the spread which dominates the area under high yielding variety. Jowar is available in Haryana but it is omitted because of its negligible share in Punjab. The variable is taken as dependent variable.

Choice of Explanatory Variables

Spread of area under HYV is an effect of the interaction between man and nature. The natural environment exercises its influence through the variations in relief and soil and in the whole set of climatic parameters. The human effort is constrained by institutional factors and levels of technological development. These three interact between themselves, affecting the spread of HYV and generate variations in space. Thus regional differences in HYV reflect the magnitude and the nature of interaction among these three factors.

Each of these factors act on the spread of HYV crops in its own way. Permeability, degree of weathering and natural fertility, topography, texture and structure of soils, degree of climatic suitability, alkalinity have direct or indirect effect on the cultivation and suitability of high yielding variety of different crops.

Rainfall as such has no impact on area under the high yielding variety. It is true that water is a must for HYV. But it needs water at certain stages of crop growth.

Indian monsoon is not at all dependable and adequate in most of the areas. It would be foolish if one attributes one's HYV crop upon the availability of rain water. On this basis, rainfall is not taken as an explanatory variable while soil rating index has been used for the above mentioned qualities of soil.

Water, seed and fertilizer - this trio contributes the core of yield increasing technology. Traditional irrigation, traditional seeds and no fertilizer - this was the pattern of agriculture till sixties.[1]

These three are closely inter related. One has to be explained by the other two. Therefore, two variables - percentage of gross area irrigated to total cropped area and tonnage of nitrogenous fertilizer per 100 hectare of gross area irrigated, are taken to explain the spread of area under high yielding variety.

There are some other technological factors viz. use of tractors, use of pump sets, use of pesticides, weedicides etc. In this case only number of tractors and pump sets are used as a mechanisation index, because of the non-availability of data for other factors.

Use of HYV depends upon some institutional factors. Sometimes technological innovations fail when cultivators are reluctant to adopt them. The socio-economic and political perspectives show the background of Indian cultivators and it is reflected by land tenure system, average size of land holding

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1 Sudhir Sen, A Richer Harvest (1975), p. 248.

and caste-tribe affiliation, banking facilities and literate and educated population. Agricultural labour is important both from economic and sociological point of views. It is an important economic factor because it is directly related to productivity and is an important sociological factor because it is related to the land tenure or landlessness. Keeping this in mind two variables are selected. These are; (i) Percentage of agricultural labour to total agricultural worker, and (ii) percentage of rural scheduled caste to total rural population. Scheduled caste population is an indicator of social deprivation operating as an institutional constraints on the effective exploitation of agricultural resource base. The overall economic condition of farmers is measured by calculating productivity in money terms. It is not the potential alone, farmers must know the use of HYV and how to secure the soil, the method of sowing and the best procedure of harvesting. Therefore, educated and literate percentage to total population is also taken as a possible explanatory factor.

Soil

When the high yielding variety of cereals are raised on the field, the first thing the user considers is the status of soil present on the land. A variety of questions arise in his mind, as regards to the prospects of successful cropping. Is the soil fertile enough for cultivation of high yielding or hybrid variety? Can it bear this crop? Is the soil with high porosily that the plant roots can grow and develop satisfactorily? Does the soil possess the properties for storing the moisture supplied through rainfall or irrigation so that the crop is raised with minimum of labour and cost? Are there any harmful conditions present which may effect the normal growth of the crops? These and a number of other questions are posed but it is very difficult to measure these points and bring them to a single index. Soil fertility results from physical and chemical conditions of the soil. So it varies spatially very widely. Many scholars tried to find out some index for soil fertility. The soil rating index as prepered by Ray Choudhury[2] based on Stories method has been taken for the present analysis.

It is assumed here that higher the soil rating index higher is the spread of area under high yielding variety.

Irrigation

Availability of perennial irrigation encourages the farmers to adopt more scientific techniques as well as intensive cultivation. It provides him to use the best quality of high yielding varieties of seeds at the right time and to reap the bigger margins of profit.[3] The basic water requirement of the various crops is the sum total of the water required for preparation of fields, percolation

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2 Ray Choudhuri, op. cit.

3 R.C. Arora, Development of Agriculture and Allied Sectors (New Delhi, 1976), p. 21.

and evapotranspiration.

Plants need certain amount of water at certain stages. Farmers of India cannot depend upon the vagaries of monsoon. Since rainfall is not always reliable and that too not optimum, an artificial means of watering is necessary which in other words is known as irrigation. "Without water, the seeds of green revolution will not germinate; H_2O in right doses must have precedence over N_2, P_2O_5, K_2O and other nutriants."[4]

Different persons made several studies on the growth of output. It is basically irrigation which helps in adoption of HYV and thus higher output.[5]

Quantification of benefits from irrigation is not easy, as (a) crop response to irrigation is dependent largely on weather conditions, and (b) the timing of irrigation is often more crucial than the total quantity of water applied. Because of these limitations, the percentage of gross irrigated area to gross cultivated area has been taken here as an explanatory variable. It is expected that irrigation is directly related with the area under high yielding variety.

Fertilizer

The fertilizer hungry dwarfs must be nurtured

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4 S. Sen, A Richer Harvest (1975), p. 209.

5 (a) A. Vishwanath, op. cit.

(b) P.P. Pillai, "Towards a Planning Yardsticks for Irrigation of Rice in Kerala" Agricultural Situation in India, April 1969.

skillfully, and fed adequately if they are to fulfil the promise of a richer harvest.[6] The use of fertilizers, apart from irrigation, is regarded as one of the quickest ways of increasing productivity of crops.[7]

Soils on which rice is cultivated in India are considered to be generally deficient in nitrogen and moderately deficient in phosphorous but well supplied with potash. The use of farm-yard manure, compost, oil-cakes, fish manure etc. though prevalent, have not appreciably lifted the soil quality.[8] Contents of the soil should be analysed in relation to the requirements of the particular crops grown and necessary fertilizers should be provided.

There are many studies on the high fertilizer response of high yielding variety. Crops remove different quantities of each nutrient from the soil. This nutrient removal by crops from the soil depends on the availability of nutrients in the soil and on the nature of the crops. Out of the essential elements nitrogen, phosphorous and potash are removed in large quantities. In this study, only nitrogenous fertilizer is taken into consideration. The chosen variable is tonnage of nitrogenous fertilizer consumption per 100 hectares of gross area irrigated (GAI) in a district.

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6 S. Sudhir, op. cit.

7 D. Singh, S.K. Raheja, S.R. Bapat, op. cit.

8 Fertilizer Association of India, Fertilizer Use on Selected Crops in India (New Delhi, 1975), p. 11.

The phosphorous and potassium fertilizers are omitted here because in Punjab and Haryana regions, K_2O and P_2O_5 are applied along with nitrogen.

It is expected here that there is direct relationship between the fertilizer consumption and the spread of high yielding variety area. There are many studies observing high correlation between fertilizer consumption and agricultural productivity.[9]

Mechanization

Mechanization in its broad sense, can be defined as the use of improved types of hand-tools, animal-driven implements and power-driven equipments.[10] It is not a direct input but is instrumental in raising the spreads of area under HYV seeds.

Both man-power and animal-power have long been used for lift irrigation. But they are being rapidly replaced by diesel engines and electric motors which are faster, cheaper and of course, technically more suitable when water has to be lifted from a relatively greater depth. Once an engine,

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9 (a) R.W. Herdt, "The Impact of Purchased Inputs on Paddy yields of selected Cultivates in Tanjavur District, 1961-62", Indian Journal of Agricultural Economics, vol. XIX, no. 384, 1960.

(b) A.K. Choudhury and A.S. Sirohi, "Allocation of Fertilizers among Crops and Regions in UP", Indian Journal of Agricultural Economics, vol. XXVIII, no. 3, 1974, p. 47.

10 Indian Society of Agricultural Economics, Seminar on Problems of Farm Mechanization (1972), p. 3.

diesel or electrical, is introduced as a prime mover, it can be put to a number of other uses - to drive threshers, grinders, chaff-cutters and other mechanical uses.

HYV not only gives high yields, but does so within a much short period; since HYV grows in short duration, continuous cropping can be started. As multiple cropping spreads, timeliness in harvesting, tillage and planting becomes a critical factor. Loss of time between harvesting a mature crop and planting a new one means a corresponding loss in terms of output and income. The time constraints will persist even if there is no labour constraint. Farm machinery will be needed to do a number of critical jobs relating to harvesting, threshing, ploughing and sowing.

The HYV needs machinery for another reason, viz. greater precision in cultural practices. To achieve optimum results of the HYV, fertilizers should be placed at right time, at right depth. In the plant protection measures too, mechanical sprayers and other equipments enable the farmer to apply pesticides uniformly in correct doses and at right time.

It is clear enough that machinery must be regarded as an essential element for the spread of high yielding variety.

The present study considers only number of tubewells/pump-sets and number of tractors to represent mechanization, as complete data for only these three variables are available. Number of tubewells/pump-sets and number of tractors are taken separately for an index, as their efficiencies differ much. These two are put together and expressed in an index, called mechanization index. It is found by "division by mean"[11] method. Many mechanical implements like tillers, reapers, sprayers, and threshers which are also widely being used, are not included here in the formulation of index for lack of data.

It is expected that the higher the mechanization index, the higher is the adoption of high yielding variety. A study has been made relating mechanization with agricultural productivity.[12]

Productivity

Productivity, as a general concept, may broadly be defined as the efficiency with which resources are converted into goods and services. It can be expressed in case of agriculture, in three ways: (1) Output per unit area; (yield); (2) Output per man-hour, and (3) Input-output ratio.

In this study, productivity of all crops in terms of rupees per unit area has been calculated for the year 1970-71 at the district level. Input figures and output per man hour data are not easy to get. On the other hand, price[13] and yield of the crops are easily available.

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11 A. Kundu, op. cit.

12 National Productivity Council, op. cit.

13 Price of different crops are taken from Statistical Abstract published by Directorate of Economic and Statistics of the respective Governments.

There are many crops in a district. Therefore, yield per hectare of each crop is multiplied by the price of the crop in terms of rupees (see in appendix XII). The price taken, here, is harvest price[14] of Punjab and Haryana State.

The productivity in rupees shows the overall economic condition of the farmers of the district and it is assumed that the better the economic capacity, higher is the extent of HYV adoption.

Agricultural Labour

Human labour is the primary factor for production in traditional agricultural process. Manpower is used in modern agriculture, in the different stages of different crop cultivation for multiple cropping which is an effect of introduction of high yielding variety.

In the rural working force in India, the number of cultivators and "other workers" (artisans etc.) has decreased, while the number of agricultural labourers has significantly increased.[15]

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14 We have taken the harvest price, since it is this price which the bulk of the farmers actually earn income and which determines their decision for the next sowing season.

15 V.S. Vyas, "Structural Change in Agriculture and the Small Farm Sector", Presidential Address at the 7th Annual Conference of the Gujarat Economic Association held under the auspices of Shree Nootan Kelvani Mandal, Valsala, 15 November 1975.

The increase in number of agricultural labourers may be due to:

(i) a natural increase in the population of the labourer's households and the lack of alternative employment opportunities for them;

(ii) the increase in the number of agricultural workers could be due to rise in the number of the dispossessed small farmers;

(iii) the increase in the number of agricultural labourers could result from the fact that additional workers could not get adequate employment on their own farms;

(iv) the increase could also be due to the fact that artisans and other workers did not get enough employment in their traditional occupations and therefore, joined the ranks of the agricultural workers.

There are many studies which show that the lighter share of agricultural labour leads to higher productivity. The farm management studies conducted in Tanjavur district during 1966-67 place additional demand for labourer at 26% due to introduction of new paddy variety, ADT-27. The studies estimate that the labour requirements for high yielding irrigated crops is about three times the labour-input for the unirrigated crops.[16] If the labour force is not available at the required level and at required time, the use of HYV

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16 C. Muthiah, "The Agricultural Labour Problem in Tanjavur and the New Agricultural Strategy", Indian Journal of Agricultural Economics, vol. xxv, no. 3, 1970, p. 20.

may be adversely affected.

A brief note is being made with concentration of holding in different size classes with tube-well area irrigated in appendix XV. This aspect is omitted from the main study assuming adoption of technology is size neutral.

In this study, the agricultural labour is taken as a percentage to total agricultural worker. Our hypothesis is that there is a positive relation between the agricultural labour and spread of HYV area.

Scheduled Caste

Indian society is inter-crossed by a network of caste. Casteism is so much prevalent in Indian villages that it roots in mode of domestic and social life, cultural patterns and occupational characteristics of the people.[17] Therefore, it roots to agricultural development also. Scheduled caste represent those communities which suffer or have suffered from intouchability in one form or other. Chiefly by birth or caste or by the profession which they practice and have been subjected to social disabilities. Scheduled tribes live in a remote areas of isolation in more or less seclusion. They are very much backward even though they play an important role in agricultural activities.

It is seen that scheduled caste and scheduled tribes people do not want to take the risk for use of HYV as they

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17 A.R. Desai, Rural Sociology in India, p. 92.

are financially poor and traditional minded.[18]

In Punjab and Haryana only scheduled caste population is found and not the scheduled tribes. According to 1971 census the population of scheduled castes in Punjab was about 1/4 of the total population of the State. Most of the scheduled castes live in rural areas and follow hereditary professions like shoe-making, leather tanning, weaving, scavenging etc. Members of these castes have also taken to cultivation either as tenants or as agricultural labourers. Only a small number of such cultivators possess land of their own.[19] In this study, it is assumed that areas with good percentage of scheduled caste may not show high adoption of high yielding variety.

Education and Literacy

The improvement of technical and manual skill and dexterity derived from education, has its economic returns that improve cumulatively with the introduction and dissemination of education and technology carefully adjusted to the requirements of advancing agriculture and industry.[20] Educated

18 The Economic Adviser to Government of Punjab, Chandigarh. Socio-Economic Review of Punjab (1975).

19 Ibid., p. 98.

20 Baljit Singh, Education as Investment (1967), p. 1.

and literate persons help the illiterate, innocent farmers in bringing consciousness about advanced methods of farming.

A positive association between education and agricultural growth has been established by several studies.[21]

In case of use of HYV, the extension education should have been taken into consideration. Extension education helps the farmers to convert the unfelt needs to felt need. The number of demonstrations would have been very much appropriate. But data are not in easy reach. In this study, the percentage of literate and educated person to total population has been taken. The hypothesis underlying here is the higher the percentage of educated and literate people higher is the spread of HYV area.

Distribution of Variables

A spatial distribution of the explanatory variables are given below in order to build up the explanations for the relationships to the dependent variable (Table 5.1)

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21 (a) K.M. Choudhury and M. Maharaja, "Acceptance of Improved Agricultural Practices and their Diffusion among Wheat Growers, in Pali District of Rajasthan", Indian Journal of Agricultural Economics, vol. 21, 1966.

(b) NCAER, "Factors Affecting Fertilizer Consumption" (New Delhi, 1967).

(c) N.K. Nair, "Education in Production : The Case of Indian Agricultural" Productivity, October-December 1974.

Table 5.1

Statistics for Dependent and Independent Variables - 1971

District	% of HYV to total cropped area	Soil rating index	% of GAI to T C A	Amount of fertilizer/ 100 ha GAI	Mechanization index	Per hectare productivity in Rs.	% of agr. lab. to total agr. worker	% of rural S.C. to total	% of lit. & educated population to total
Gurdaspur	44.63	72.0	55.1	6.60	1.31	13,396.73	32.68	22.97	34.23
Amritsar	59.39	73.50	94.0	4.53	2.40	18,860.09	36.53	26.93	35.32
Kapurthala	62.50	75.50	82.2	4.77	2.94	14,855.73	25.03	26.78	35.70
Jullundur	65.25	72.20	81.8	5.73	4.14	18,779.48	35.54	37.30	41.30
Hoshiarpur	30.39	76.20	35.0	6.74	2.85	15,224.34	29.09	30.57	40.88
Rupar	27.88	72.20	35.5	6.73	1.43	16,312.49	25.25	23.81	37.17
Ludhiana	68.21	72.20	81.7	5.55	3.29	21,207.58	35.32	30.83	42.63
Ferozepur	51.94	76.70	82.3	3.25	2.00	17,763.79	32.97	24.37	27.79
Bhatinda	60.55	69.40	75.2	2.58	1.19	16,292.53	29.71	28.78	23.60
Sangrur	64.63	69.40	81.4	3.19	1.79	17,023.44	28.69	25.63	24.22
Patiala	50.80	67.30	69.4	4.10	2.42	23,347.28	32.43	25.03	31.51
Hissar	48.16	68.40	49.6	1.61	0.35	19,734.88	23.53	49.83	35.54
Rohtak	31.18	68.40	40.3	1.73	0.84	20,094.00	25.28	39.59	30.75
Gurgaon	42.25	68.40	26.5	2.68	1.77	16,365.21	18.40	37.23	28.11
Karnal	42.36	57.60	70.8	4.09	2.29	19,764.26	44.90	45.30	24.81
Ambala	31.93	72.20	26.6	8.75	2.35	16,591.90	32.49	61.25	35.54
Jind	38.68	64.70	63.7	1.25	0.83	14,586.49	22.28	43.88	18.51
Mahendragarh	10.14	68.40	8.6	2.79	0.80	5,994.45	15.96	31.92	26.03
Mean =	46.15	70.15	58.87	4.25	1.94	17,010.81	29.23	34.63	31.86
Std. Deviation	15.44	4.28	23.35	2.02	0.89	3,644.76	6.86	14.49	6.75
C.V.	33.45	6.10	56.65	47.52	45.87	21.42	23.47	33.17	21.18

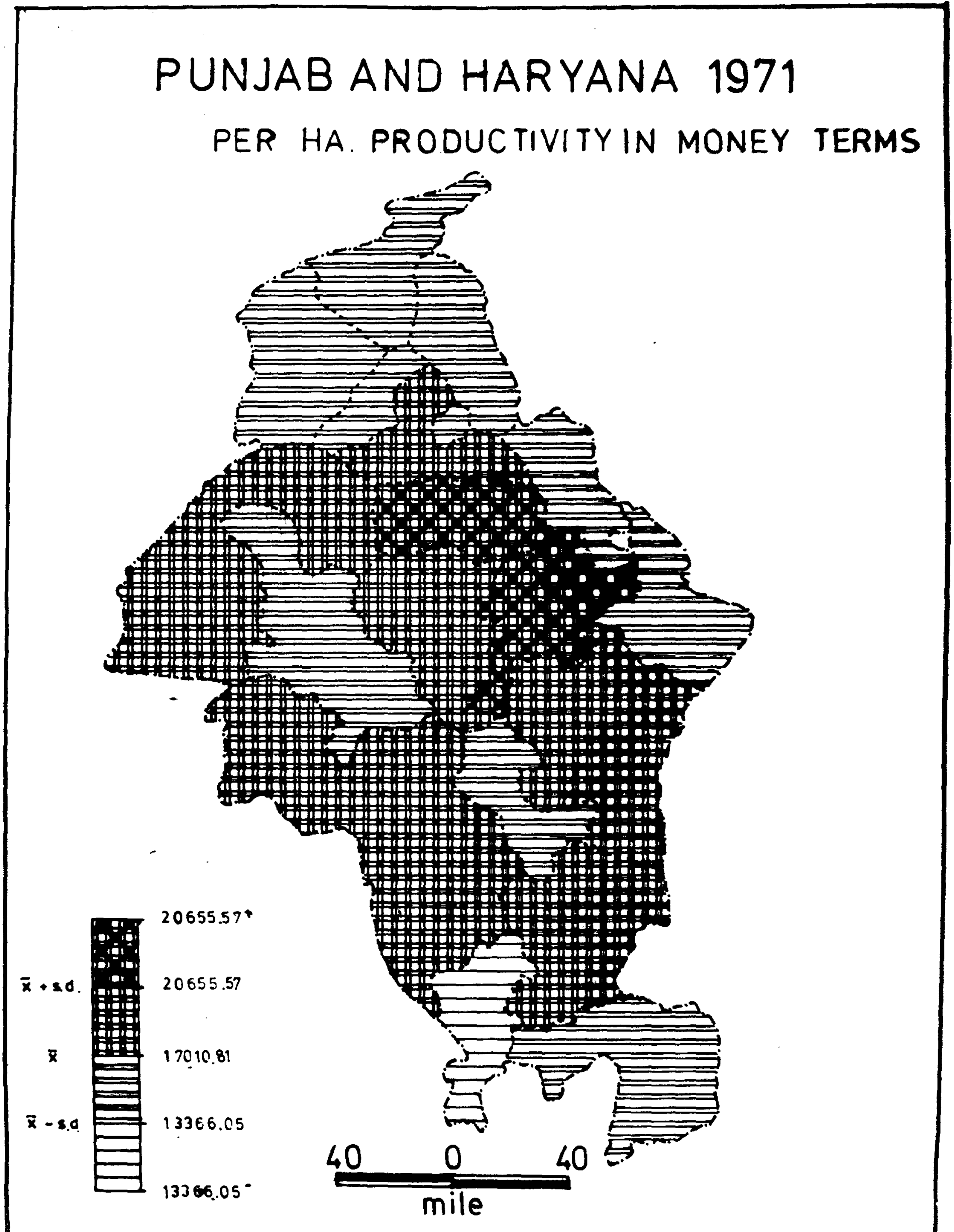
PUNJAB AND HARYANA 1971
PER HA. PRODUCTIVITY IN MONEY TERMS
20655.57+
x̄ + s.d.
20655.57
x̄
17010.81
x̄ - s.d
13366.05
13366.05-
40
0
40
mile

FIG. 14

Soil Rating Index

It is almost uniform throughout the region; the co-efficient of variance being 6.10 per cent. Districts of Punjab are of higher index while it is less in case of districts of Haryana. Mahendragarh has the lowest index (10.14%) (fig. 10).

Percentage of GAI to GCA

This disparity for the variable is found to be very high. The C.V. is as high as 56.65%. There are some districts viz. Amritsar, Ludhiana, Kapurthala, which show more than 80% and there are some districts like Mahendragarh which have only 8.6% irrigated area to total cropped area (fig. 11).

Tonnage of Nitrogenous Fertilizers per 100 hectare of GAI

Disparity due to this variable is also pretty high. The C.V. is 47.52%. Districts Gurdaspur, Hoshiarpur, Rupar, and Ambala lie in the very high category while Hissar, Rohtak, and Jind show very low use of fertilizers (fig. 12).

Per Hectare Productivity in Rupees

Very high per hectare productivity is seen in Ludhiana and Patiala districts. Gurdaspur, Amritsar, Kapurthala, Hoshiarpur, Rupar, Bhatinda, Gurgaon, Ambala and Jind lie in low category. Its C.V. is found to be 21.42% (fig.14).

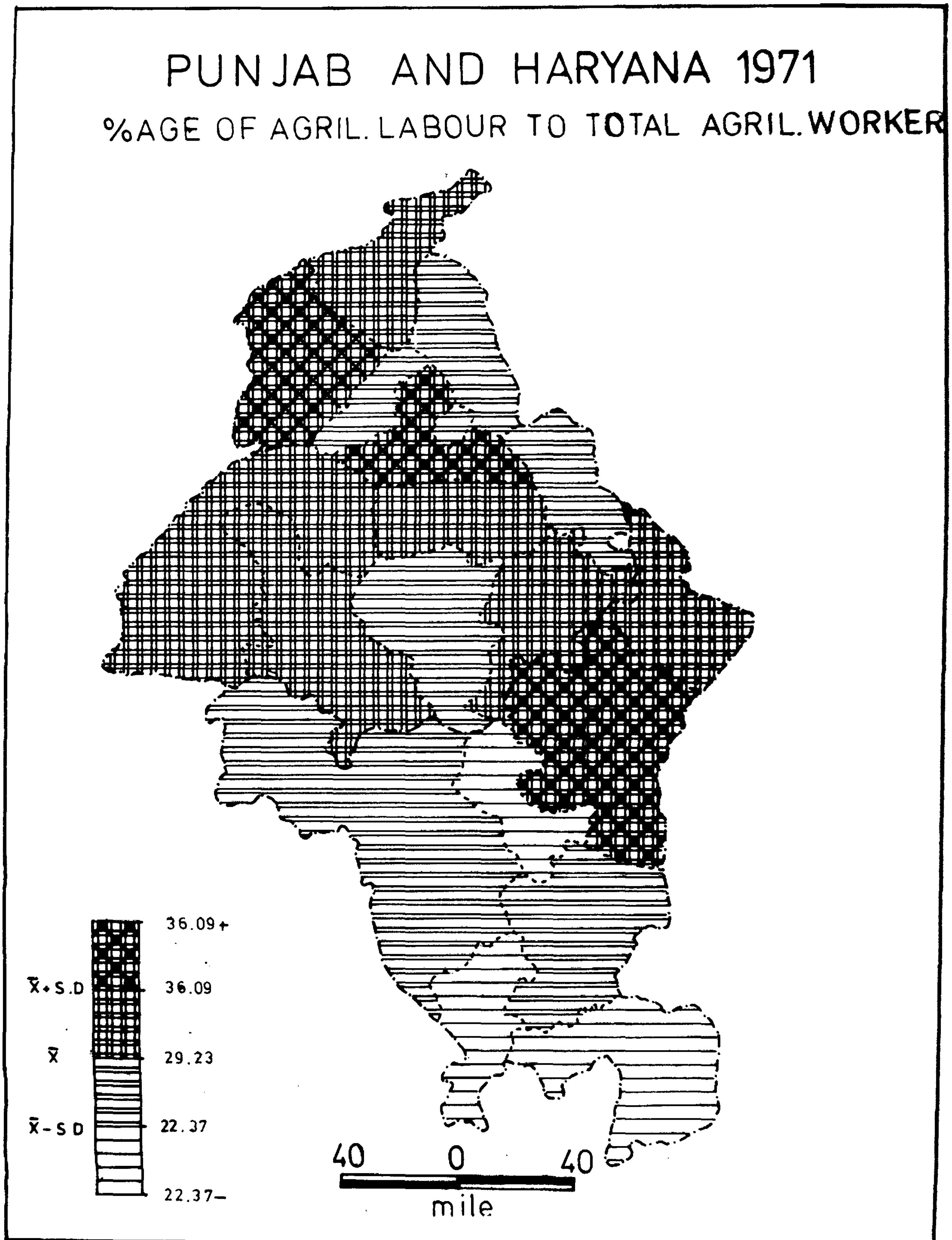
PUNJAB AND HARYANA 1971
%AGE OF AGRIL. LABOUR TO TOTAL AGRIL. WORKER
36.09+
X̄+S.D
36.09
X̄
29.23
X̄-SD
22.37
22.37-
40
0
40
mile

FIG. 15

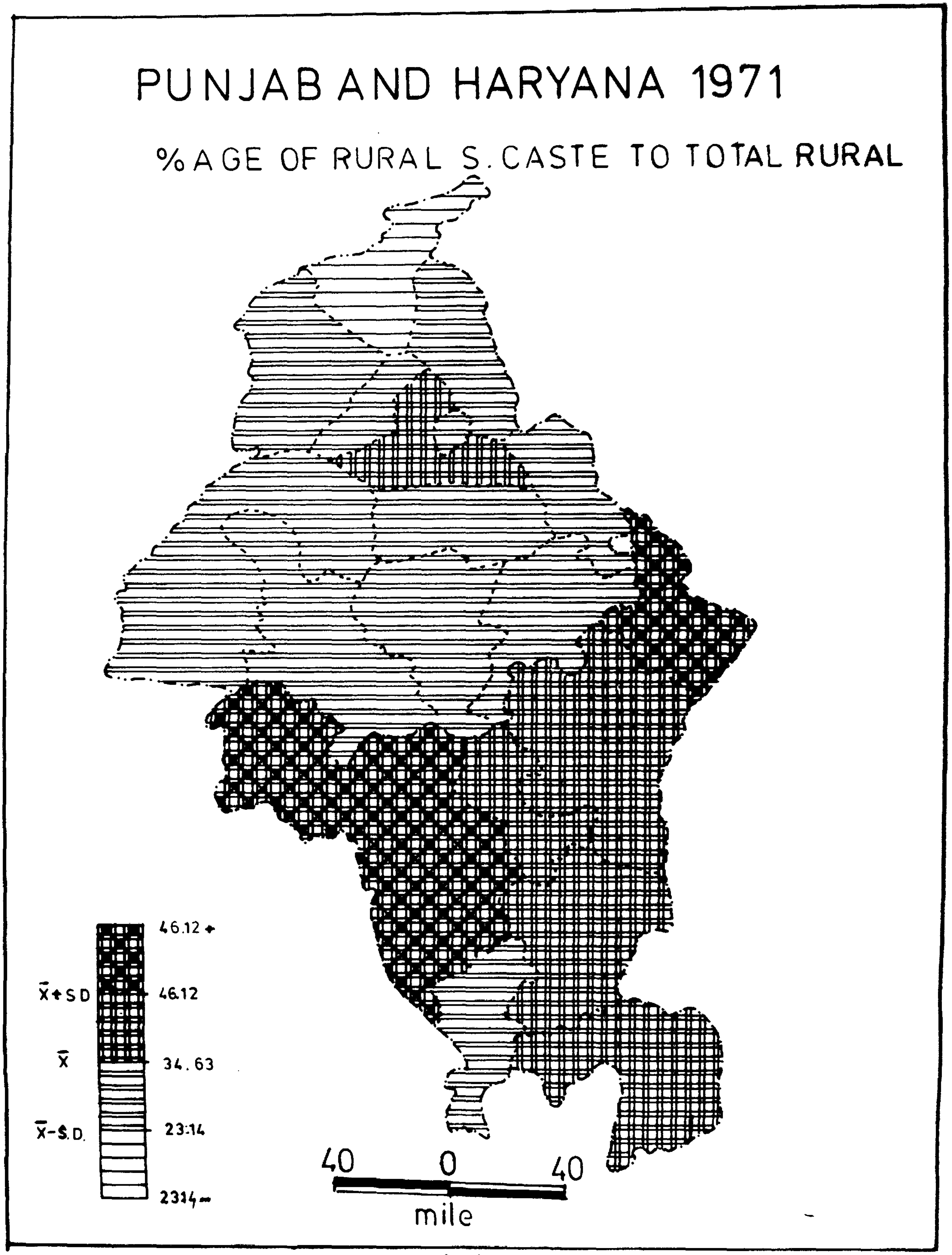
PUNJAB AND HARYANA 1971
%AGE OF RURAL S.CASTE TO TOTAL RURAL
46.12 +
X̄+SD
46.12
X̄
34.63
X̄-S.D.
23:14
2314 —
40
0
40
mile

FIG. 16

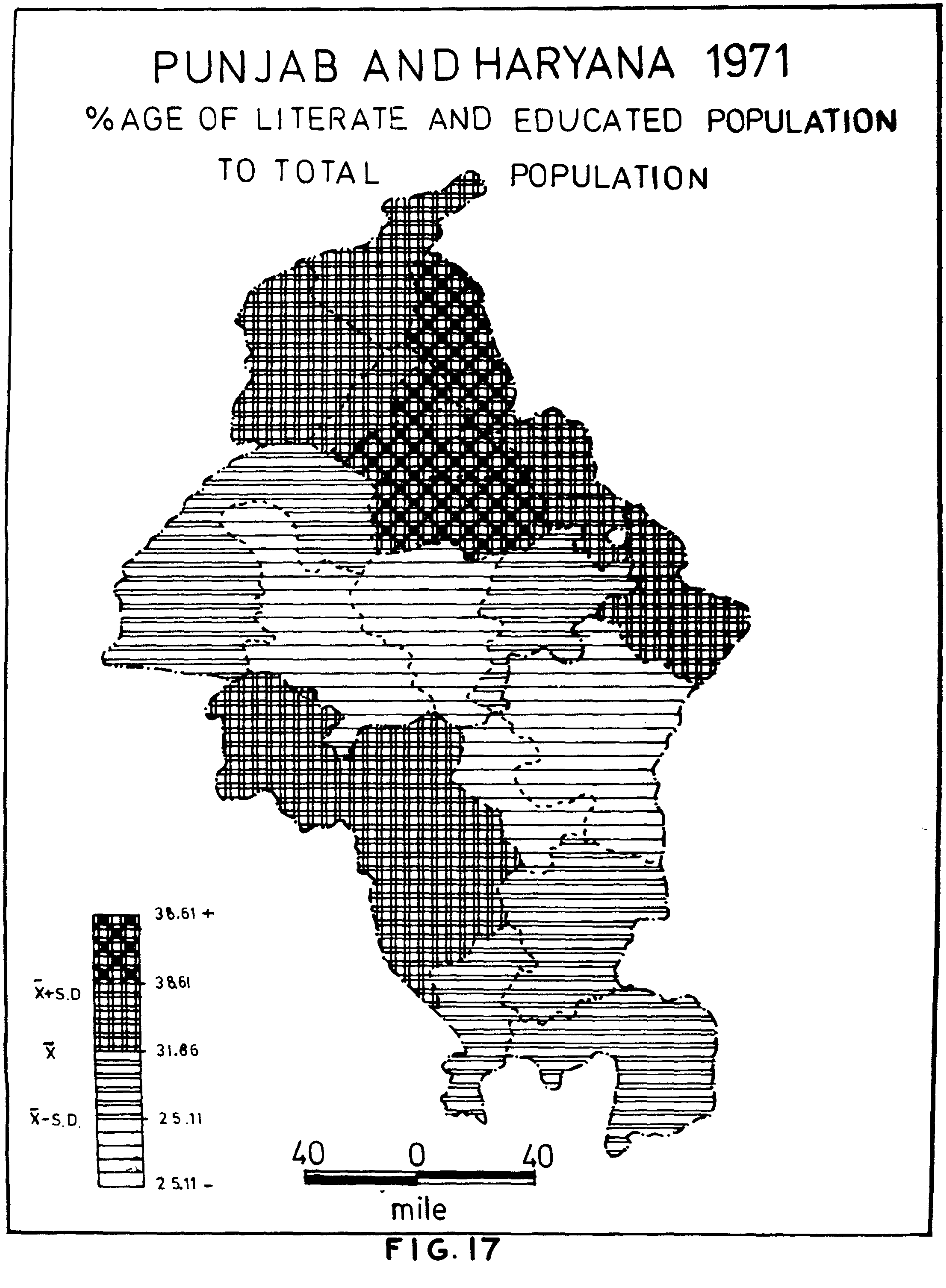
PUNJAB AND HARYANA 1971
%AGE OF LITERATE AND EDUCATED POPULATION
TO TOTAL POPULATION
38.61 +
X̄+S.D
38.61
X̄
31.86
X̄-S.D.
25.11
25.11 -
40
0
40
mile

FIG. 17

Mechanization Index

Quite a high disparity is seen in case of this variable. The coefficient of variation is as high as 45.87%. Districts which show very high are Kapurthala, Jullundur, Hoshiarpur, Ludhiana, and showing low are Hissar, Rohtak, Jind and Mahendragarh (fig. 13).

Percentage of Agricultural Labour to Total Agricultural Worker

The average percentage of this variable is found to be 29.23. There are districts like Karnal with as high as 44% while districts like Mahendragarh show only 15.26%. The disparity in terms of coefficient of variance is found to be 23.47%.

Percentage of Rural Scheduled Caste to Total Rural Population

The scheduled caste population is quite high in some districts like Ambala (61.25%). On an average it is found to be 34.63% in this region. Ambala, Hissar lie in the highest category while Gurdaspur lies in the lowest category. The coefficient of variance is 33.17% (fig. 16).

Percentage of Literate and Educated Population to Total Population

The average percentage of literate and educated population to total in this region is 31.86%. The coefficient of variance is found to be 21.18% (fig. 17). The highest percentage is found in Ludhiana (42.63%) and lowest in district Jind (18.51%).

DETERMINANTS OF AREA UNDER HIGH YIELDING VARIETY : A STEP-WISE REGRESSION

A step-wise regression procedure is followed to identify the influential determinants for the inter-district variations in area under high yielding variety. It starts with a simple correlation matrix (appendix XIII) which has to be gone through, as it will help to interpret the regression results.

Correlation Matrix

The correlation matrix shows simply the relations between the variables. Percentage of area under HYV to total cropped area under these four crops is highly co-rrelated with percentage of GAI to TCA and moderately with mechanization, per hectare productivity in money terms and percentage of agricultural labour to total agricultural workers. It has got a weak negative correlation with percentage of rural scheduled caste to total rural population and tonnage of nitrogenous fertilizer per 100 hectare of gross area irrigated. It is wonder to see a negative correlation with tonnage of nitrogenous fertilizer per 100 hectare of GAI, anyhow it is very weak.

Some of the explanatory variables are inter-correlated also. Soil rating index and percentage of literate and educated population to total population are moderately correlated, which may be a spurious correlation. Percentage of GAI to TCA with per hectare productivity and percentage of agricultural labour to total agricultural worker, mechanization with percentage of agricultural labour to agricultural worker and percentage of literate and educated population to total population, and per hectare productivity with percentage of agricultural labour to total workers are all moderately correlated.

Step-wise Regression

Step-wise regression is a multiple regression analysis. It helps to get the best possible variables by which maximum variations on area under HYV could be explained. In the step-wise regression, a series of intermediate regression equations are obtained, one for each addition of variable, until all variables are added. The variables are added in order of their improvement to the overall goodness of fit and the intermediate regression equations provide the best values of the co-efficients for the specific variables included in the equation. Thus at each step, a regression equation is provided, which is the optimum for the included variables.[22] The cumulative sum of squares of the multiple 'R' and the standard error of the estimates are also provided at each step, thus indicating the variance included and the confidence limits. The standard error of the estimate for the equation can be treated as a standard

22 D.P. Hauser, "Some Problems in the Use of Step-wise Regression Techniques in Geographical Research", The Canadian Geographer, vol. XVIII, no. 2, 1974, p. 148.

deviation and there is a 95% possibility that actual values will differ from the regression values by not more than twice the standard error of the estimate.

Eight variables are taken and related with percentage of area under HYV to total cropped area one by one in the step-wise regression procedure. They are;

X_2 = Soil rating index

X_3 = Percentage of gross area irrigated to total cropped area

X_4 = Tonnage of nitrogenous fertilizer per 100 hectare of gross area irrigated

X_5 = Mechanization index

X_6 = Per hectare productivity in money terms

X_7 = Percentage of agricultural labour to total agricultural worker

X_8 = Percentage of rural scheduled caste to total population

X_9 = Percentage of literate and educated population to total population.

The first predictor introduced is the percentage of GAI to TCA with which the variable gets highest correlation (o.890).

The order in which the independent variables are added is given in appendix XIV. In the above table 5.2 the second column shows the variables in order of their goodness of fit; the third, the cumulative multiple correlation coefficient, the fourth, the square of the

Table 5.2

Order of Variables Added

Included Variables	Variable	R	R^2x100	Increase in R^2x100	S.E. of Estimate
X_3	X_3	.890	79.2	-	61.034
X_3 X_9	X_9	.900	81.0	1.8	32.003
X_3 X_9 X_7	X_7	.910	82.9	1.9	22.744
X_3 X_9 X_7 X_6	X_6	.919	84.4	1.5	17.697
X_3 X_9 X_7 X_6 X_5	X_5	.925	85.6	1.2	14.363
X_3 X_9 X_7 X_6 X_5 X_4	X_4	.930	86.5	0.9	11.769
X_3 X_9 X_7 X_6 X_5 X_4 X_8	X_8	.935	87.6	1.1	10.100
X_3 X_9 X_7 X_6 X_5 X_4 X_8 X_2	X_2	.937	87.8	0.2	8.104

multiple correlation coefficient which is equivalent to the proportion of total variance accounted for by the equation and 'R' is expressed in percentage; the fifth, the increase of total variance expressed in percentage; and the last the standard error of the estimates for the respective equation.

The initial variable accounted for 79.2% of the total variance. The second variable shows the additional increase of 1.9%; the third 1.9% and the fourth 1.5%; and the rest less than 1.5%. The first variable itself gives the maximum 'R'. It is to be specified that percentage of nitrogenous fertilizer per 100 hectare of GAI are negatively related with percentage of area under HYV to total cropped area in all the steps. The percentage of GAI accounts for 90% of the variations explained by all the predictors and as such, there is no appreciable increase in 'R' after it. Further, it is highly significant (at 1% level) in all steps. No other variable is significant.

The S.E. falls down rapidly through the steps, from 64.03% in the first step to 8.104 in the last, but, however, reduction is not much after the fourth step. The range of residues as seen in table 5.3 is high and remains almost at the same level in the first three steps, then gets reduced to half of that in the three steps and then starts increasing.

As the above discussion outlines, the results are not satisfactory after the fourth step and as such the fourth equation seems to be a best possible one.

Table 5.3

Range of Residuals

District	% of GAI to TCA	% of lit & edu to total pop	% of agr. lab to total agr.	Per hec. productivity	Mechanisation	Amount of N fertiliser/100 ha. GAI	% of rural S.C. to total	Soil rating index
Gurdaspur	1.36	.18	3.65	9.95	16.28	17.96	21.92	22.18
Amritsar	-11.23	-12.87	-12 .56	-11.03	- 8.63	- 9.01	- 8.89	- 9.35
Kapurthala	4.99	3.34	- 2.73	.15	- 2.19	- 2.60	- 4.02	- 3.39
Jullundur	9.35	5.39	5.56	6.71	2.36	1.96	- .58	- .24
Hoshiarpur	- 7.38	-22.18	-21.65	-17.59	-17.40	-16.29	-13.67	-13.31
Rupar	-18.07	-22.58	-24.00	-25.86	-21.91	-16.80	- 6.52	- 5.71
Ludhiana	13.36	9.04	8.90	7.67	6.99	7.43	7.68	8.15
Ferozepur	-14.42	-11.94	-11.35	-10.49	-10.24	-11.96	-10.30	-14.01
Bhatinda	8.48	12.35	12.03	13.00	14.93	13.19	13.58	13.02
Sangrur	8.83	12.14	10.38	10.74	10.15	9.11	9.91	9.72
Patiala	- 2.60	2.26	- 1.00	- 7.97	-10.62	-10.35	- 5.28	- 4.49
Hissar	15.06	13.26	9.10	3.59	11.47	9.67	1.89	2.49
Rohtak	-14.29	-12.70	-13.14	-23.39	-19.38	-22.89	-21.17	-21.55
Gurgaon	34.15	37.18	33.02	28.01	21.15	18.69	19.66	19.47
Karnal	-24.92	-20.15	- 5.07	- 4.81	- 5.74	- 8.08	-10.42	- 7.33
Ambala	12.69	10.27	21.07	20.56	16.44	22.50	14.72	10.30
Jind	-26.40	-16.60	-21.73	-21.11	-21.32	- 9.79	-12.13	-10.86
Mahendragarh	-74.34	-55.34	-67.82	-29.93	-35.11	-54.69	-55.99	-52.04
Range of Residual	108.49	92.52	100.84	57.94	56.26	77.49	77.91	74.22

DISTRIBUTION OF RESIDUALS IN FOURTH STEP

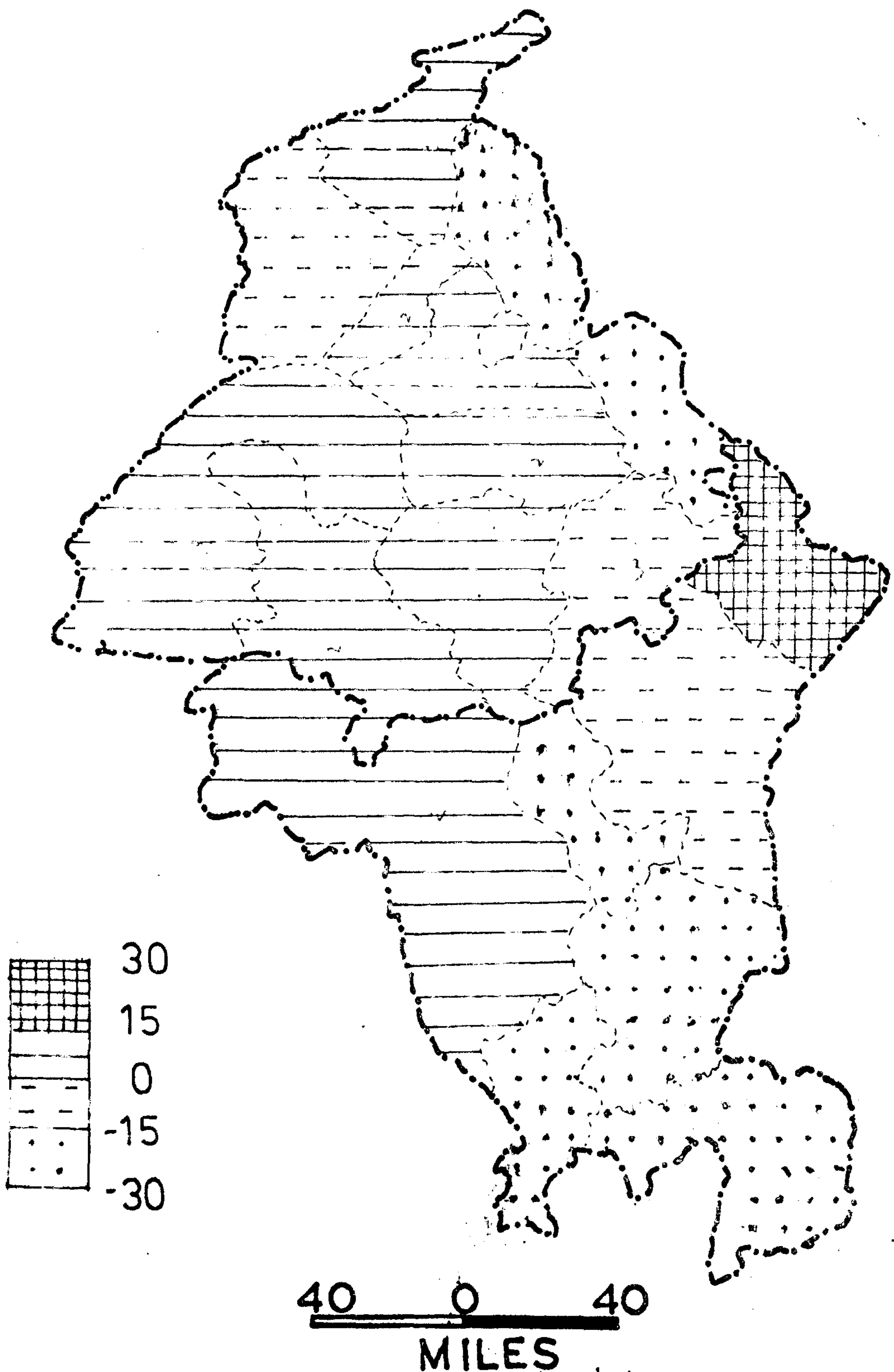

FIG. 18

$$\bar{Y} = a + b_3 X_3 + b_9 X_9 + b_7 X_7 + b_6 X_6 + e \text{ with } R^2 = .829$$

$$\bar{Y} = 4.201 + .613 X_3 + .321 X_9 - .543 X_7 + .001 X_{36} + e$$

The validity of the model that how far this model holds good in different districts can be evaluated by looking into the distribution of residual (map 18). Residuals expressed in percentage are nothing but the unexplained variations by the model in equation. The residual ranges from -29.83 to 28.01%. 9 districts show positive residuals and other nine districts negative. If an allowance around 15% (either positive or negative) is given this model explains the inter-district variations in area under HYV satisfactory for eleven districts.

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CHAPTER VI

INTER-DISTRICT VARIATION OF FOUR HYV CEREALS AND THEIR QUOTIENT OF CROP SIGNIFICANCE

In the previous sections the following four main observations have been made;

(i) In Punjab and Haryana, it has been empirically found that the agro-climatic factors have only a marginal influence on the yield of a crop.

(ii) Among the four components of agricultural growth, yield component has the maximum contribution in the explanation of agricultural growth.

(iii) HYV plays the most important role in determining the agricultural productivity.

(iv) Irrigation explains about 80% of the variance of the extension of HYV in Punjab and Haryana.

In this chapter, we shall discuss the spread of HYV of four cereals i.e. rice, maize, bajra and wheat, in different districts of Punjab and Haryana at two points of time, viz. 1968-69 and 1973-74.

Total area under HYV has increased quite satisfactorily during the period of the study. The percentage share of area under HYV to total cropped area in the state of Punjab and Haryana together has increased from 32% in 1968-69 to 1973-74. But while a combined study of these two states gives an enthusiastic picture of the extension of HYV, a statewise study reveals that the picture was not very rosy in case of Haryana where district Karnal topped the list with only 22.8%

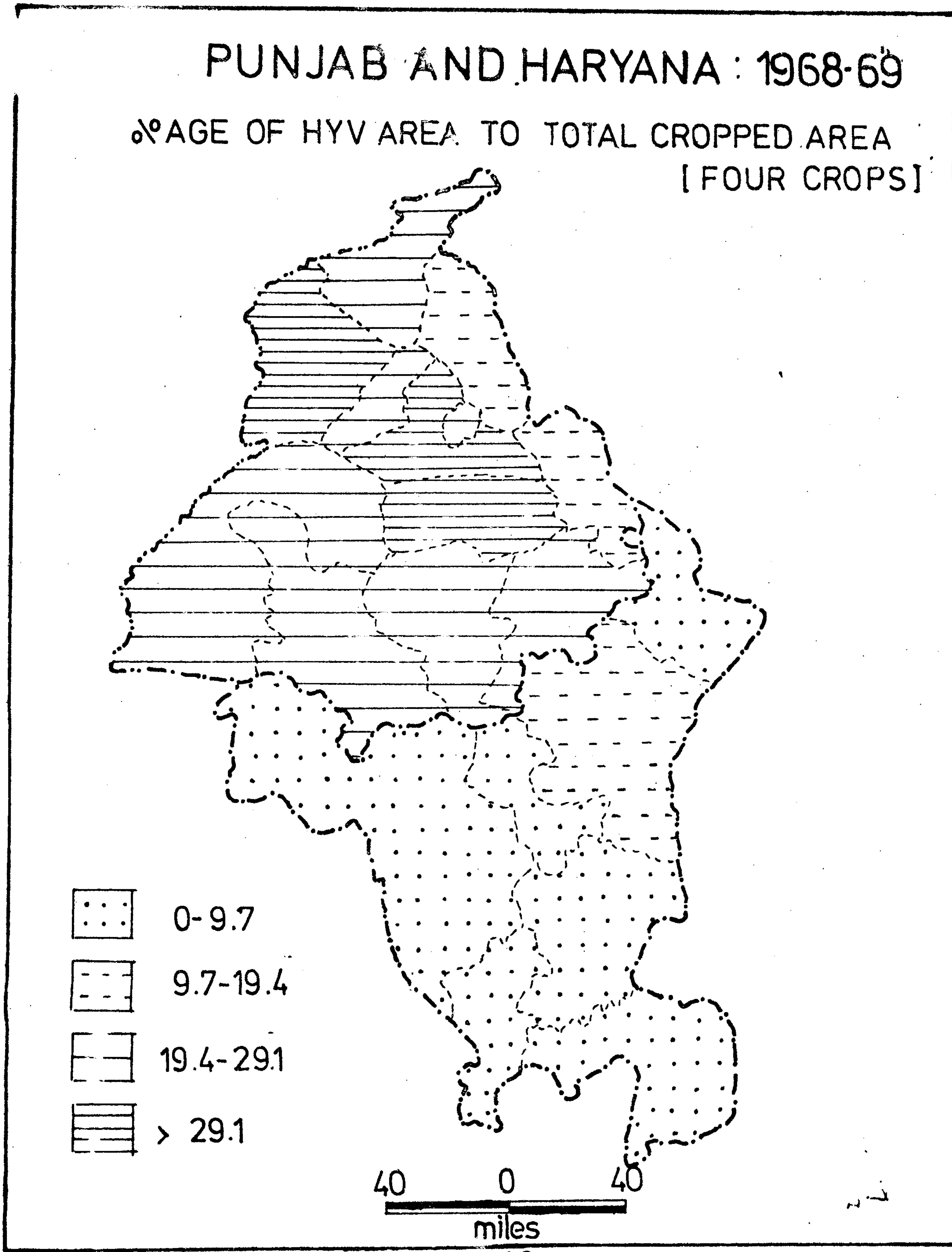
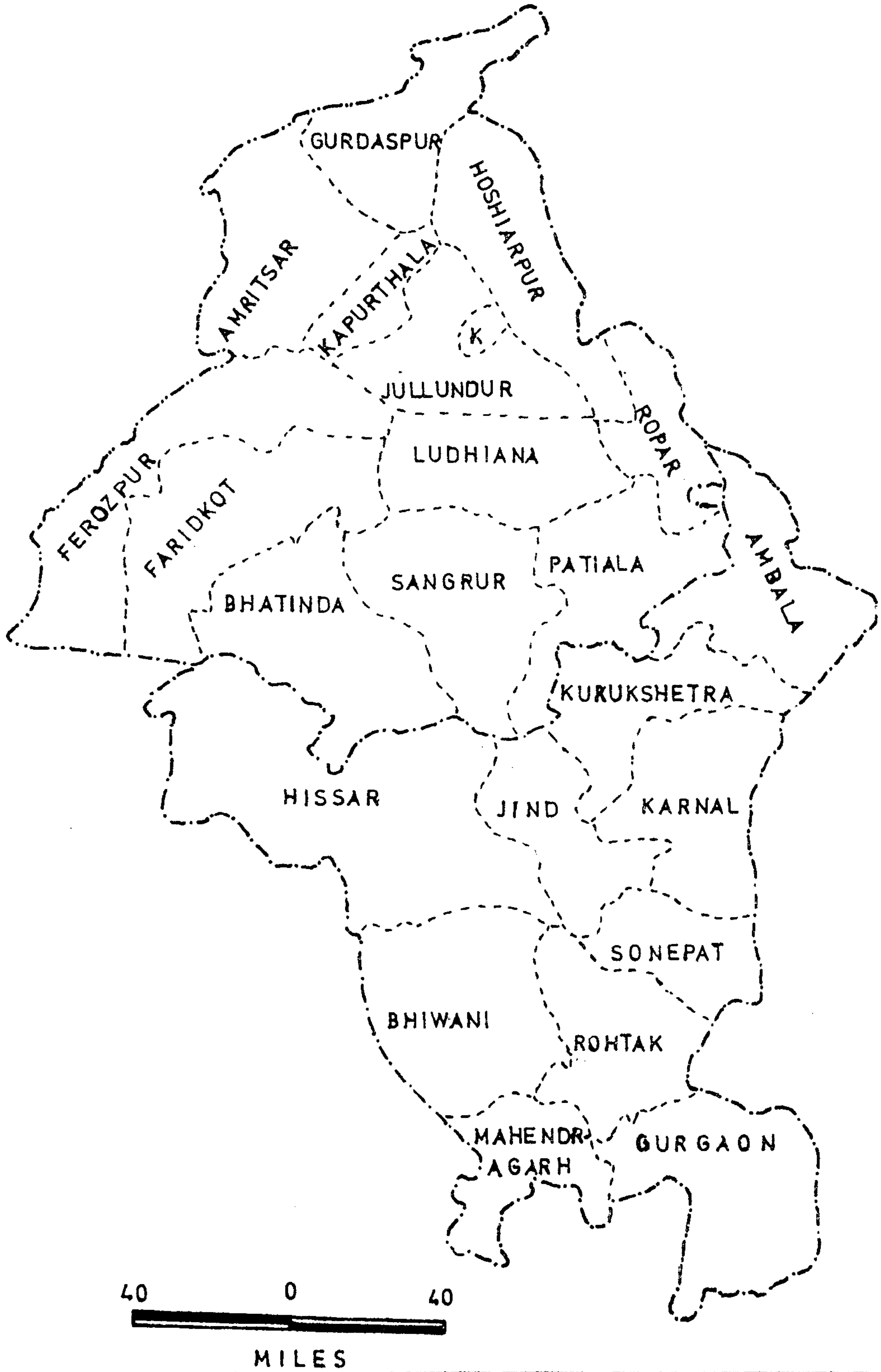

PUNJAB AND HARYANA : 1968-69
%AGE OF HYV AREA TO TOTAL CROPPED AREA
[FOUR CROPS]
0-9.7
9.7-19.4
19.4-29.1
> 29.1
40
0
40
miles

FIG. 19

DISTRICTS OF PUNJAB AND HARYANA 1972



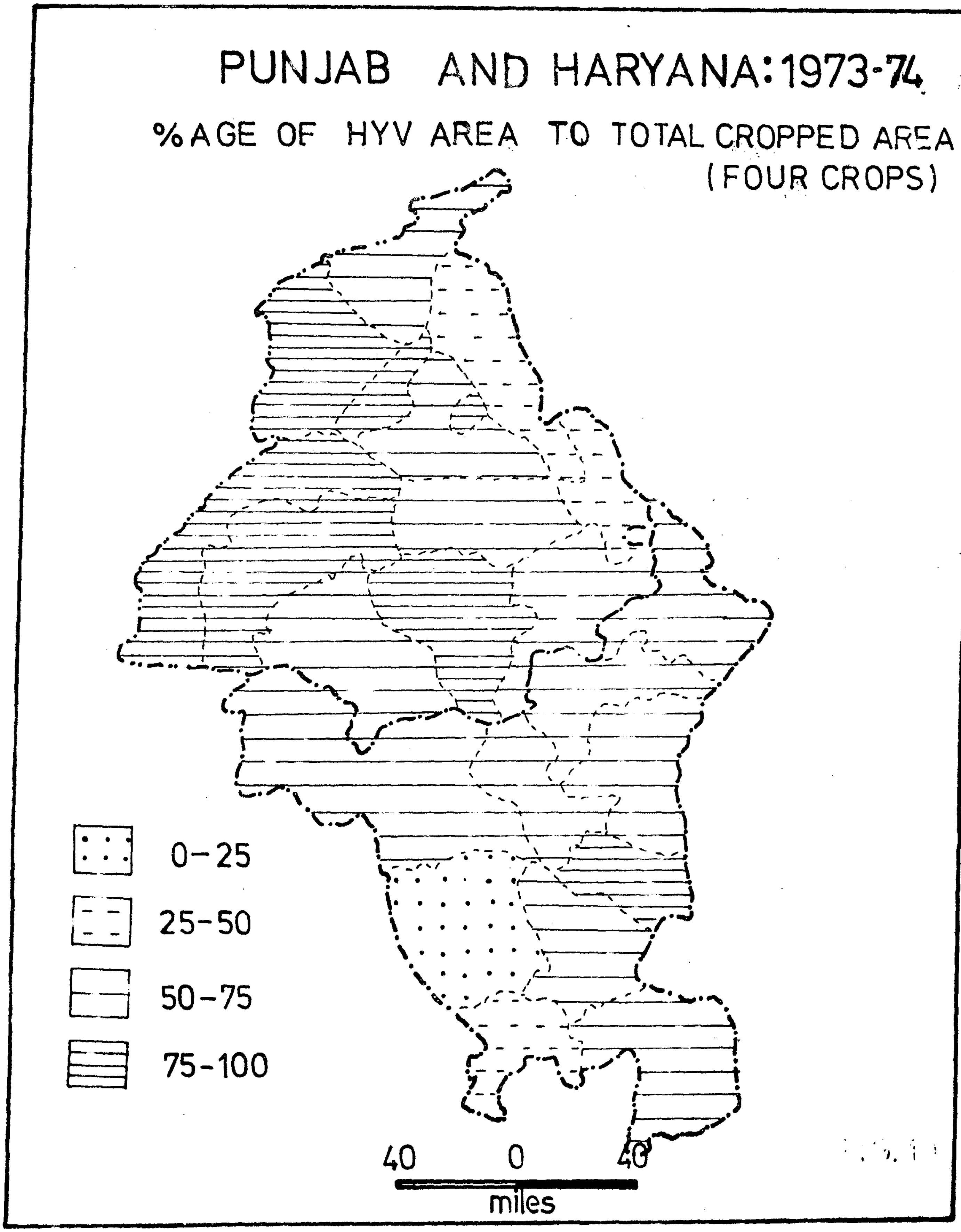

PUNJAB AND HARYANA: 1973-74
%AGE OF HYV AREA TO TOTAL CROPPED AREA
(FOUR CROPS)
0-25
25-50
50-75
75-100
40 0 40
miles

FIG. 20

of its total area under HYV in 1968-69. The performance of Punjab districts were highly satisfactorily where as many as 8 districts had more than 40% of their total area under HYV. Compared to Haryana, except Rupar all the districts of Punjab had a higher share (of area under HYV to total cropped area) than the district Karnal which topped the list in Haryana in 1968-69.

An interesting feature to note here (figs. 19 and 20) is the decrease of inter-district disparities of the extension of HYV in this region. Measuring the disparities in terms of coefficient of variation we find that disparities decreased over time as coefficient of variation decreased to 33.46% in 1973-74 from 55.01% in 1968-69.

A crop-wise study is made here to see the performance of different districts in details. The results of our study is portrayed on maps. Districts are divided into four groups according to their performance in each crop. The method used for such categorization of district is to find the mean and standard deviation of the column and grouped as mean, plus minus standard deviation.

Wheat

The popular wheat varieties in this region are Kalyan 227, PV-18 and S-308. Few other varieties are in the process of becoming popular are; Lerma Rojo, Senora 64, Sharbati Sonara, Sonalika, Chhoti Lerma, Safed Lerma, Mukth, W.G. 377, WG 357, HD 1981. A detailed description of some of these varieties is given in the appendix.

Venkataraman[1] prescribed the optimum and prevalent dates of sowing of wheat in Haryana and Punjab, as under:

Tract	Optimum dates	Prevalent average date
Haryana	End October	II Week of November
North Punjab	End December	II Week of November
South Punjab	End October or End December	Ist week of November

House et al[2] observed the duration of different varieties of wheat as under:

1 S. Venkataraman, "Climatic Considerations in Cropping Patterns" in ICAR, Proceeding of the Symposium on Cropping Patterns in India (New Delhi, 1972), p. 251.

2 L.R. House, B.C. Wright, O.B. Baird, "New Cropping Patterns in Indian Agriculture", ibid., p. 289.

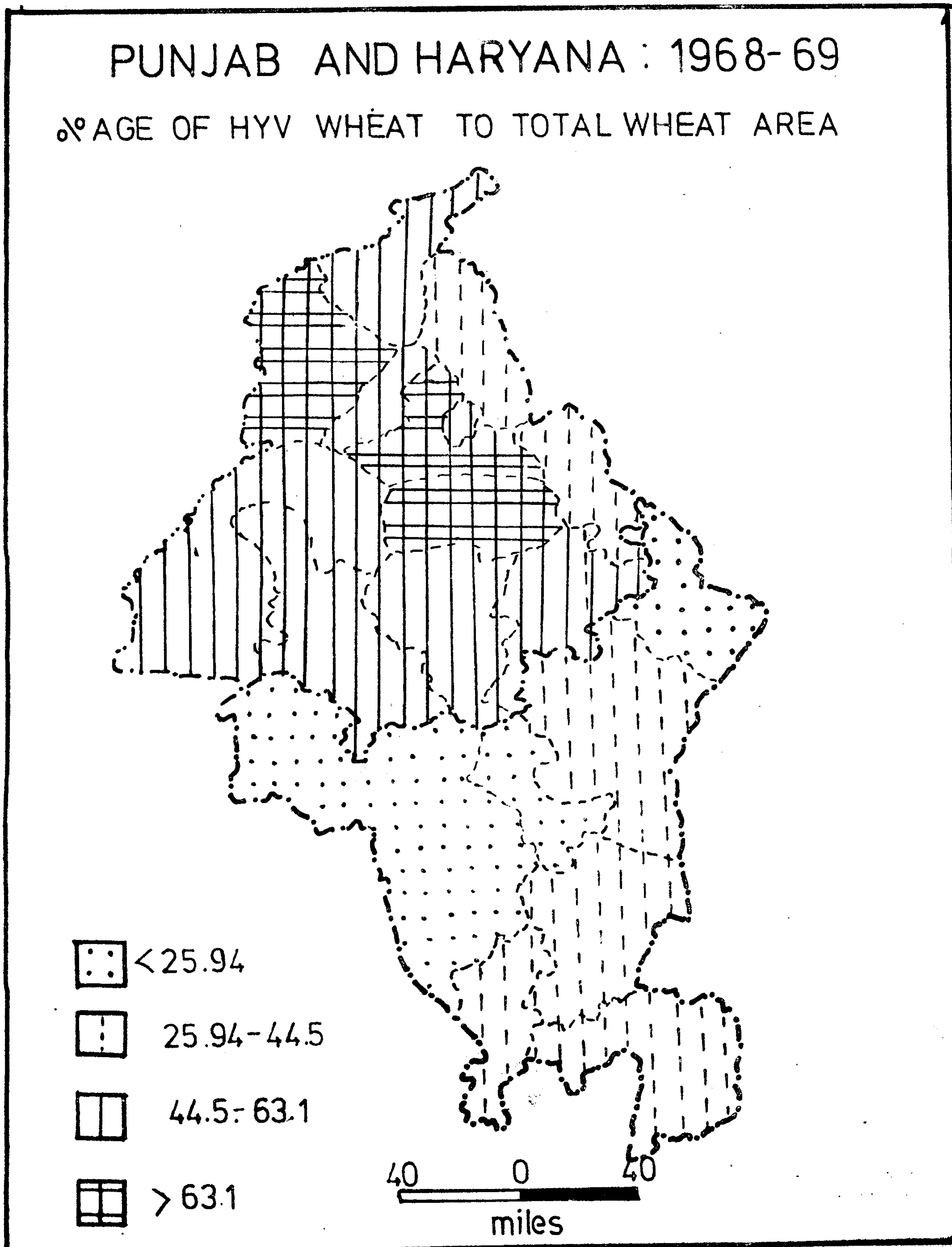

PUNJAB AND HARYANA : 1968-69
%AGE OF HYV WHEAT TO TOTAL WHEAT AREA
< 25.94
25.94-44.5
44.5-63.1
> 63.1
40
0
40
miles

FIG. 21a

PUNJAB AND HARYANA: 1973-74

%AGE OF HYV WHEAT TO TOTAL WHEAT AREA

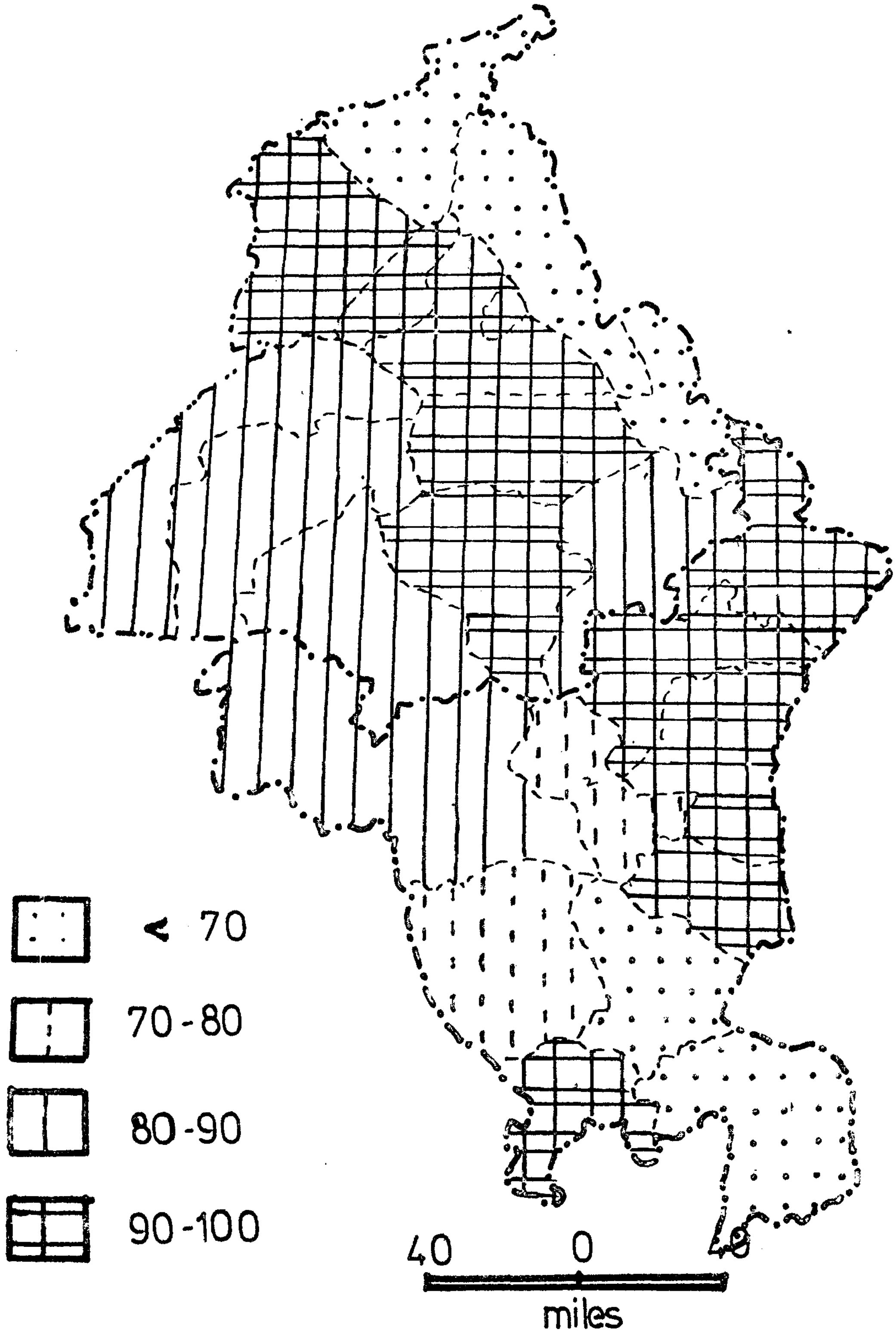


FIG. 22a

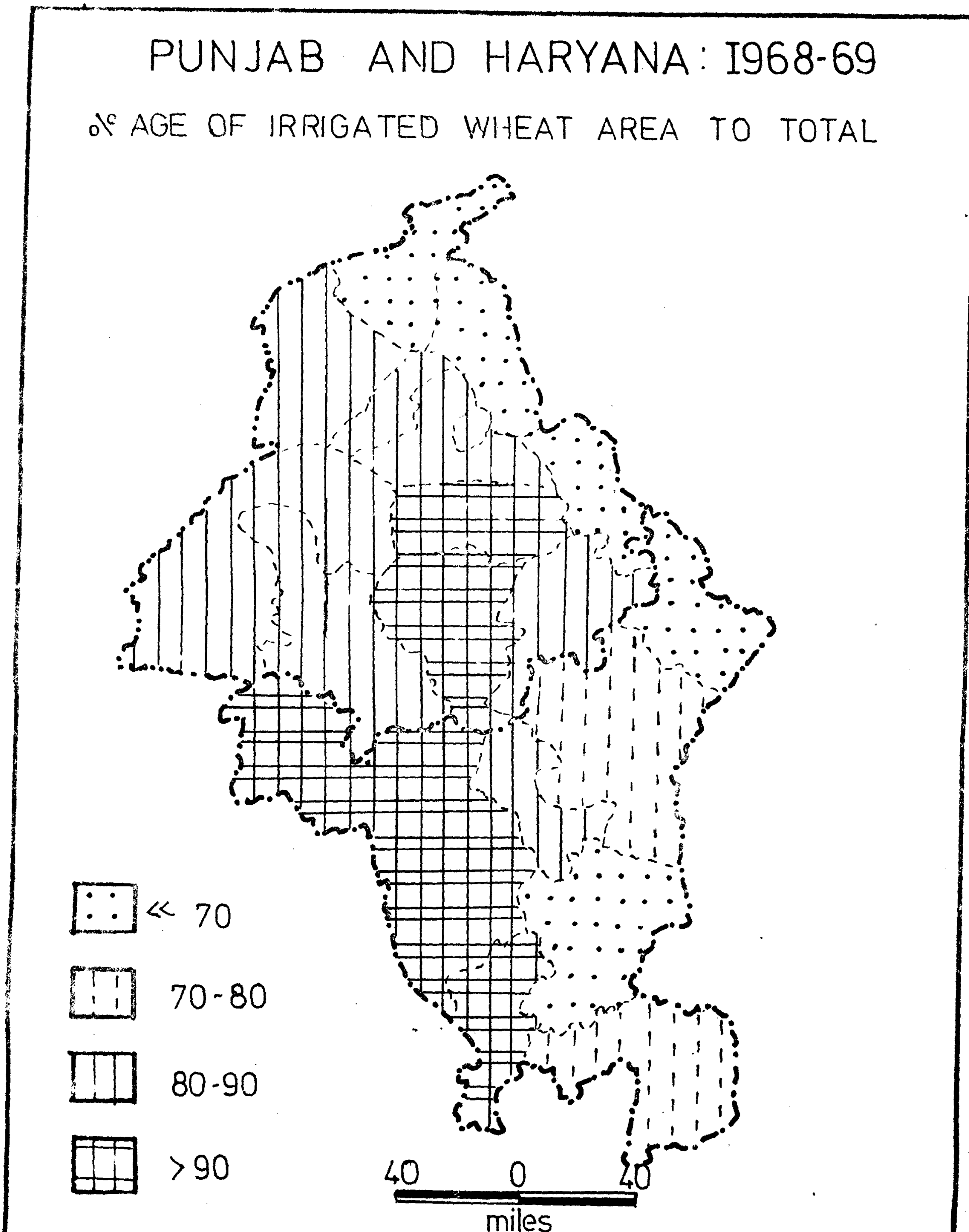

PUNJAB AND HARYANA: 1968-69
% AGE OF IRRIGATED WHEAT AREA TO TOTAL
<< 70
70-80
80-90
>90
40 0 40
miles

FIG. 23a

Crop	Variety	Approximate duration	Time of Sowing
Wheat	Sonora	110-120 days	
	Sharbati Sonora	110-120 days	2nd fortnight of Nov.
	Sonalika	110-120 days	2nd -do-
	Lerma Rojo	130-140 days	
	S - 331	130-140 days	Ist -do-
	Safed Lerma	130-140 days	Ist -do-
	Kalyan Sona	140-150 days	Ist -do-
	PV - 18	140-150	

These photoinsensitive high yielding varieties of wheat show a fairly good yield, under irrigated conditions even if the sowing is delayed up to the end of December.

HYV wheats are short stemmed and possess a stiff stalk which resists lodging. The maximum temperature during March over most of North India ranges from 29°c to 32°c and hot dry winds usually start blowing at this time. This increases evaporation from the soil and transpiration from the plants resulting in reduced moisture availability to the ripening wheat crop. While the normal ... tall varieties will lodge if irrigation is provided under conditions, even more so if the crop has been fertilised adequately to increase yields, the dwarf varieties which are highly fertilizer responsive can safely stand irrigation and can be benefited by it.

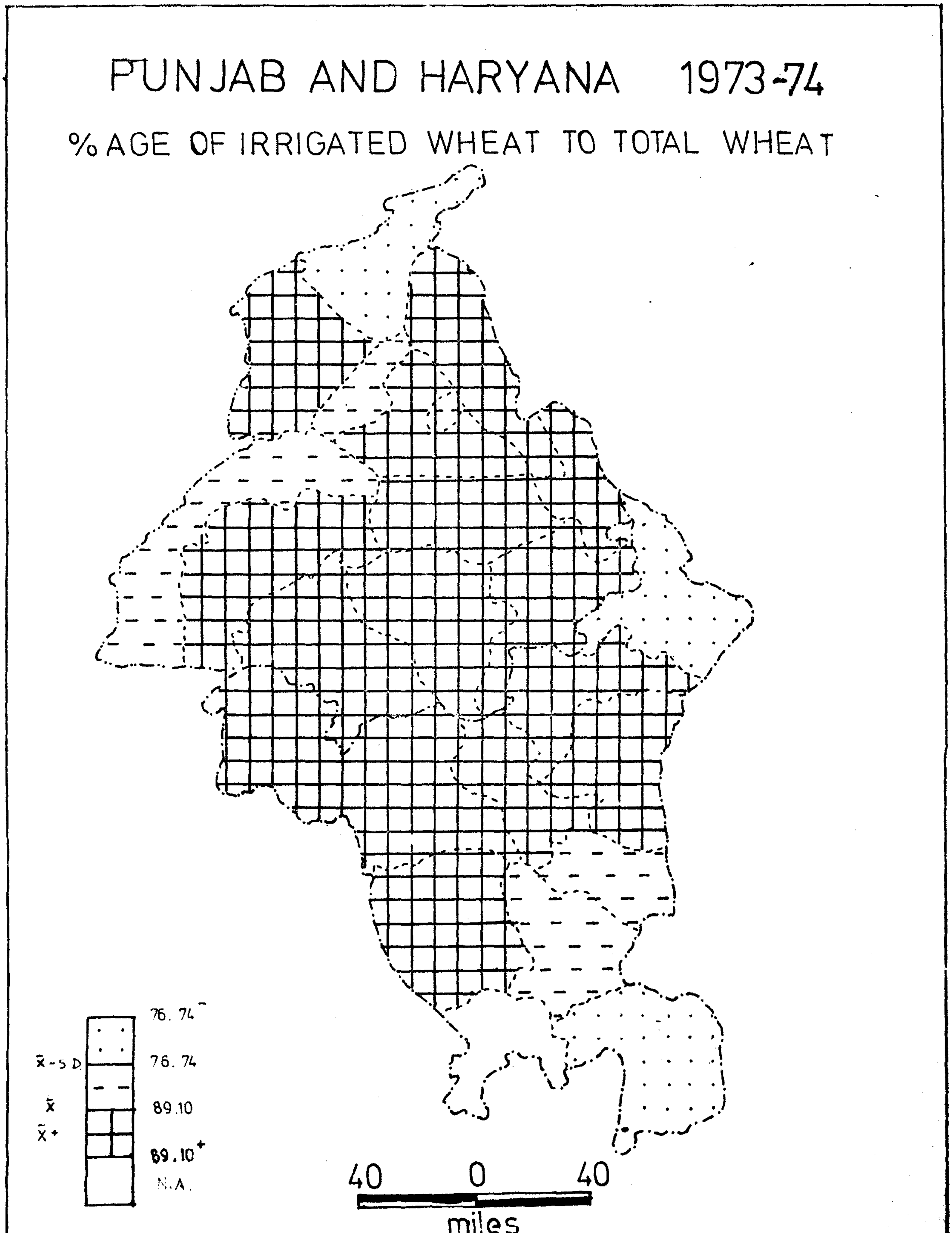

PUNJAB AND HARYANA 1973-74
% AGE OF IRRIGATED WHEAT TO TOTAL WHEAT
76.74⁻
x̄ - S.D.
76.74
x̄
89.10
x̄ +
89.10⁺
N.A.
40
0
40
miles

FIG. 24a

It is possible to adopt multiple or relay cropping with HYV wheat which increases production per unit area per year. HYVs being genetically high yielding are fertilizer responsive and can efficiently utilize high doses of fertilizer. The productivity of dwarf wheat per day is higher than that of tall varieties. The dwarf wheats have a broad spectrum of resistance to a number of races of rusts prevalent in India.

There is a consequent rise of yield of wheat in this region since 1964-65. The yield has increased to 19,511.11 kg/ha in 1968-69 from 1,415.88 kg/ha in 1964-65 and it has recorded yield rate of 1827.27 kg/ha in 1973-74 (see Table v). The inter-district disparities of yield rate measured in terms of the coefficient of variance has decreased during this period as c.v. has decreased from 41.76% in 1968-69 to 16.64% in 1973-74.

Districts Jullundur, Ludhiana and Amritsar lie in the highest category of percentage of HYV wheat to total wheat area (more than 63.1%) in 1968-69 while in 1973-74 excepting Hoshiarpur and Rupar (48.98% and 57.14%) all districts are above 63% and nine districts--Amritsar, Kapurthala, Jullundur, Ludhiana, Sangrur, Ambala, Kurukshetra, Karnal and Sonepat--are as high as 90 per cent [figs. 21(a) and 22(a)] (Tables 6.3. and 6.4.).

The average percentage of wheat irrigated area to total wheat is 75% in 1968-69 [fig. 23(a)] and that in

1973-74 went up to 89 per cent [Fig. 24(a)]. The inter-district variation also reduced in 1973-74, C.V. being 14% from 1968-69, C.V. being 29 per cent. (Tables 6.5 and 6.6)

Rice

Rice is grown in kharif season in Punjab and Haryana regions. The major HYV of rice is TN-1 and I-R8 which take 110-120 days and 110-130 days respectively. These varieties are weekly thermo-sensitive.

In kharif season, the highest yields of paddy variety, IR-8, are obtained by taking up transplanting as early as possible in July. While seedlings of 25 to 30 days are transplanted for getting good yields, the physiological age of the seedlings is more important than the actual age of the seedlings. Seedlings having four to five leaves are most suitable for transplanting.

Water should not be allowed to stand at the time of planting. A thin layer of 2 to 3 cm water should be allowed to stand in the field starting from three to five days after planting till final topdressing. Before the final topdressing, water should be drained completely and the fields dried till cracks develop. After the final topdressing, 5-6 cm water should be allowed to stand in the field till the crop matures. Water should be completely drained out a week before harvesting.

TN-1 and IR-8 are highly susceptible to pests particularly leaf-hoppers, stem-borers, gall-midge, hispa and cutworms.

PUNJAB AND HARYANA : 1968-69

%AGE OF HYV RICE TO TOTAL RICE AREA

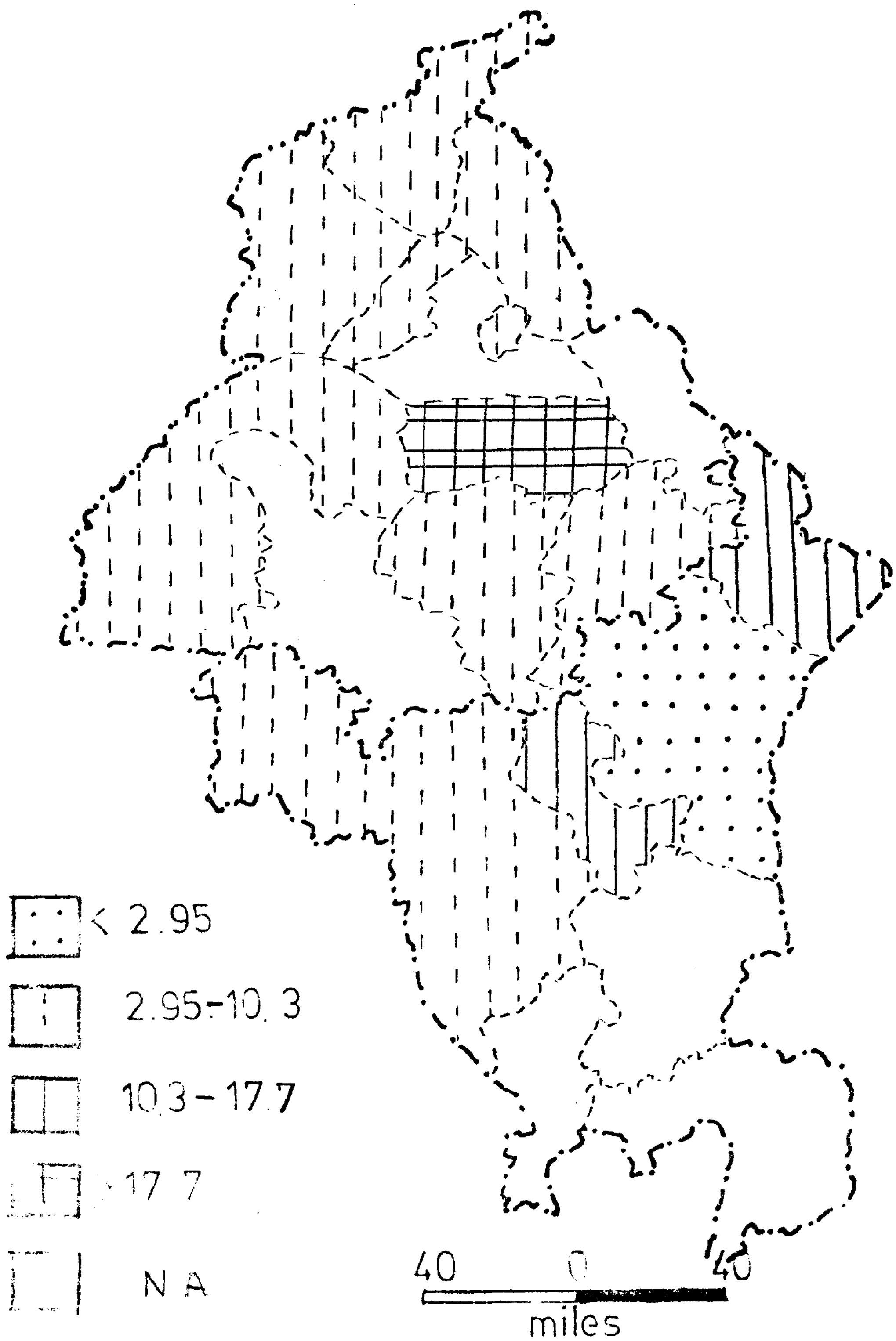


FIG. 21b

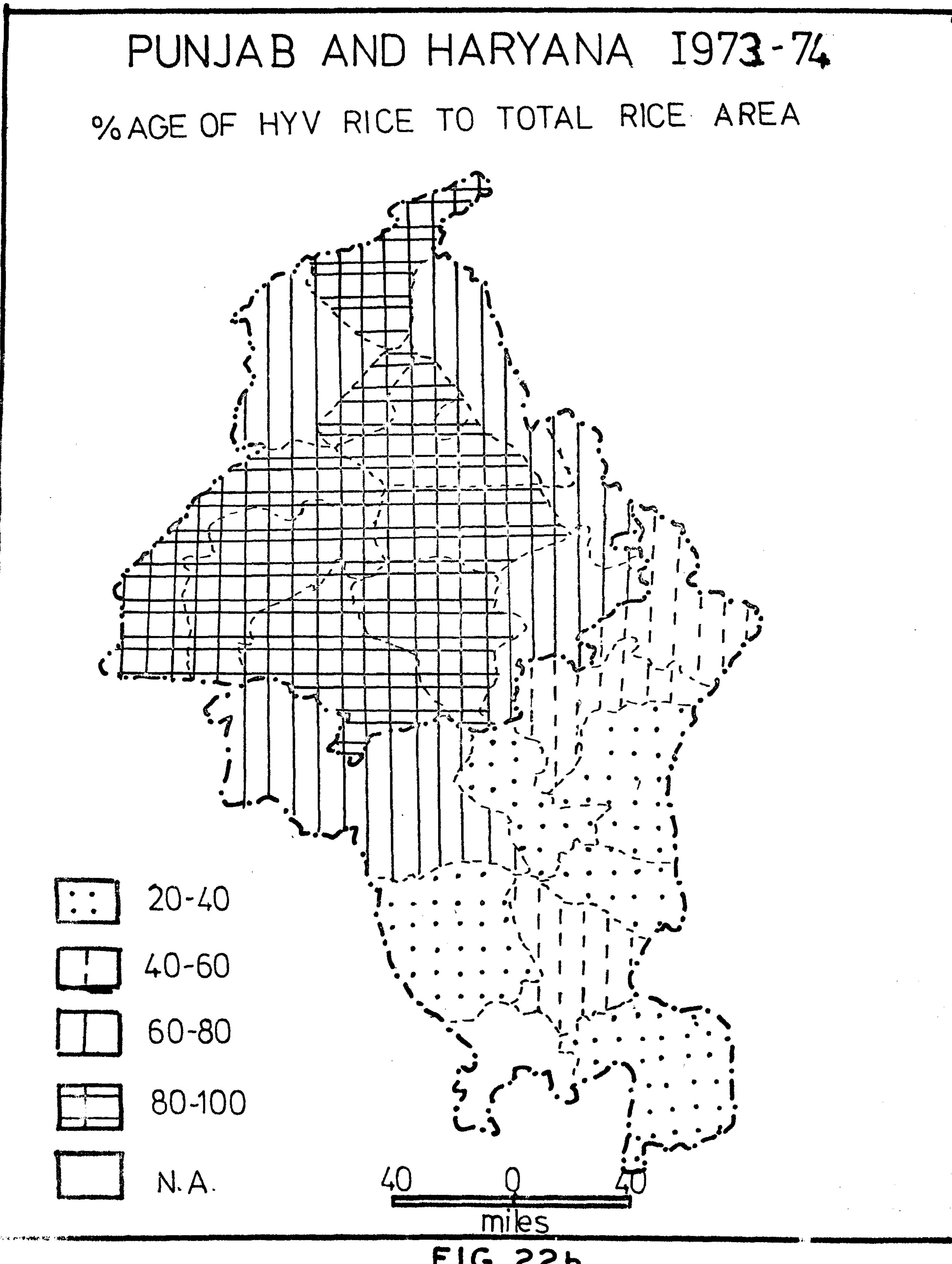

PUNJAB AND HARYANA 1973-74
%AGE OF HYV RICE TO TOTAL RICE AREA
20-40
40-60
60-80
80-100
N.A.
40 0 40
miles

FIG. 22b

PUNJAB AND HARYANA : 1968-69

% AGE OF IRRIGATED RICE AREA TO TOTAL RICE

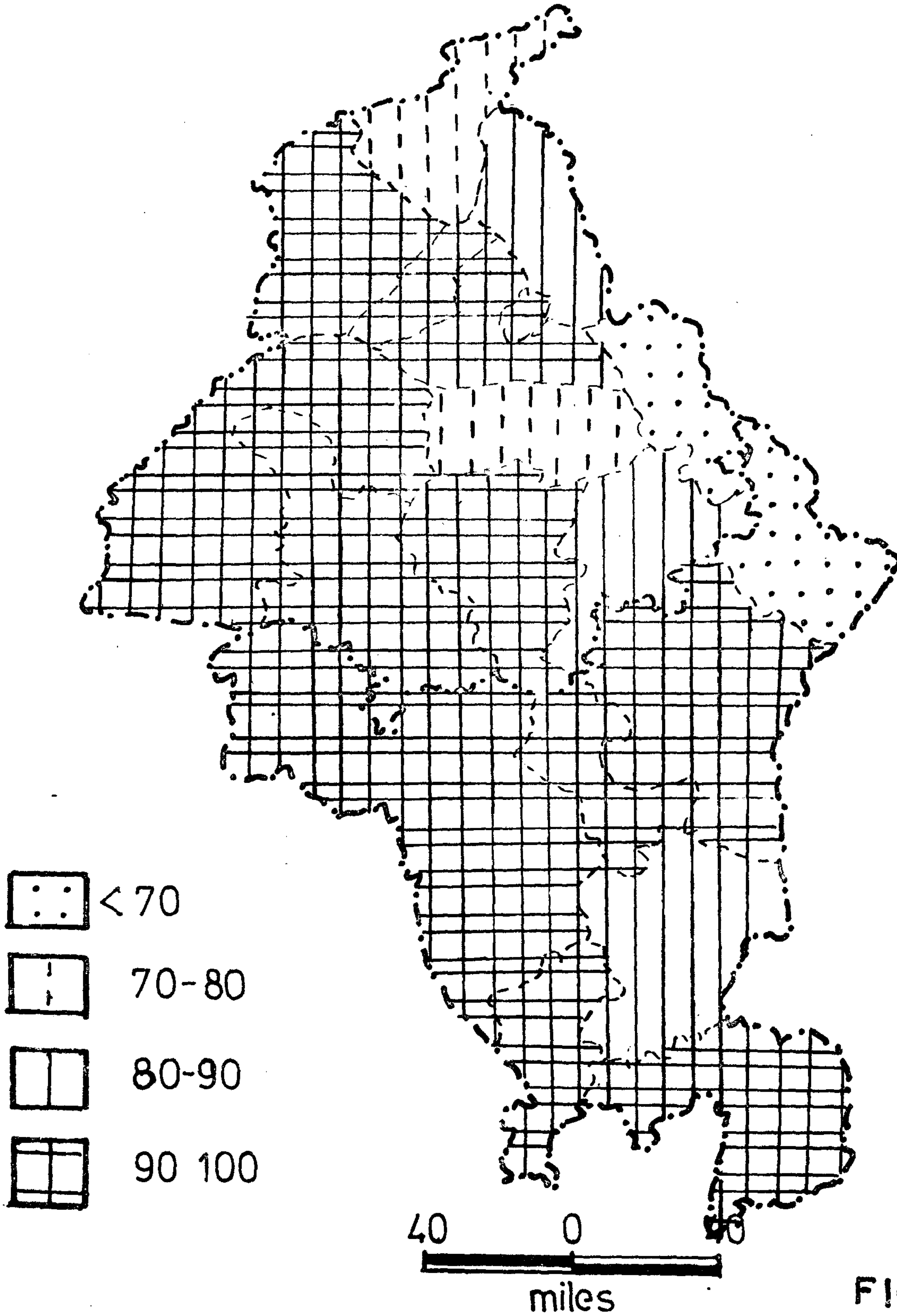


FIG. 23 b

The average yield of rice in this region was 1262.12 kg/ha. in 1964-65, while that in 1968-69 remained almost same (1259.47 kg/ha.), but during 1973-74 it has increased to 2088.60 kg per hectare.

During 1968-69 the percentage of HYV rice to total rice area was highest in district Ludhiana (33.3) and lowest in Karnal (fig. 21(b)). Karnal is prominantly a rice growing district. Popularity of HYV rice was very poor at this period. During the same period districts like Hoshiarpur, Rupar, Sangrur, Rohtak, Gurgaon and Mahendragarh were either with no HYV or less than 50 hectares. The variation of distribution of HYV rice during this period was as high as 71.44% of coefficient of variance.

The popularity of HYV rice has increased significantly in 1973-74 and percentage of HYV rice to total rice area has reacted as high as 80% in the districts like Kapurthala, Gurdaspur, Jullundur, [illegible], Faridkot, Ferozepur, Ludhiana, Sangrur and Patiala (fig. 22(b)). There are some districts like Kapurthala, Jullundur, Ludhiana, Faridkot, Bhatinda and Sangrur which are showing rice area completely under HYV rice. During this period, all districts were above 20%, while excepting Ludhiana no districts reached beyond this point. There is no substantial area in district Mahendragarh.

The average irrigated rice area to total rice in this region is quite favourable [fig. 23(b), and 24(b)]. The area irrigated has increased to about 90% during 1973-74 from 80% of 1968-69. The disparity for this variable has reduced in 1973-74 (c.v. being 19.14%) from 1968-69 coefficient of variance being 26.89 per cent.

Maize

Maize is an important kharif crop in Punjab and Haryana. The popular high yielding varieties are Ganga 101, Ganga 3, Vikram, composities - Vijay, Kisan, Sona etc. The yield of maize is very low compared to USA. The main reason for such low yields is that open pollinated low yielding varieties are grown in 90% of the total maize area in this region. The maize production has not yet felt as high as it should be though some very high yield responsive varieties have been released as early as in 1961. In the beginning, the slow coverage under the high yielding hybrid maize varieties has been probably due to the apathy of the farmers to buy costly seed every year.

Sharma, et al (1972)[3] stress that the coverage of large areas under HYV seems to be possible only by changing the hybrid approach to the development of composite varieties. The experimental results in Mexico and in India on the yield levels of composites have clearly shown that the composite

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3 D. Sharma, Satish Kumar, and O.P. Singh, The Performance of Composite and Hybrid Varieties of Maize in Punjab and Haryana.

varieties are capable of yielding as high as the present day hybrids. The seed production and multiplication of these varieties are much easier than those of the hybrid varieties. Also the spread of composite variety is much faster over a large area, since the cultivators, who had once procured the foundation seed stock from a reliable source, can further produce their own seed and can distribute their fellow farmers. Even since the composite varieties have been made available for the first time. The people are having doubts with regard to their yield performance of hybrid and composite maize variety at several locations in the states of Punjab and Haryana.

Sharma *et al* after experimenting in Hoshiarpur, Ludhiana, Jullundur, Amritsar, Patiala and Sangrur districts on hybrid Ganga 101, Ganga 3, and composites Vijay and local, found that the three varieties are equal in phenotypic stability and, therefore, it is difficult to say on the basis of one season's data on somewhat similar locations whether the composite varieties are more stable under a wide range of seasonal and locational differences. Actually, the double cross hybrids themselves have considerable amounts of seasonal and locational differences. Actually, the double cross hybrids themselves have considerable amounts of genetic variability and therefore, on the basis of limited data, it is difficult to differentiate between the phenotypic stability of the composites which supposedly have higher genetic variability than the double-cross hybrids. Because

PUNJAB AND HARYANA: 1968-69

%AGE OF HYV MAIZE TO TOTAL MAIZE AREA

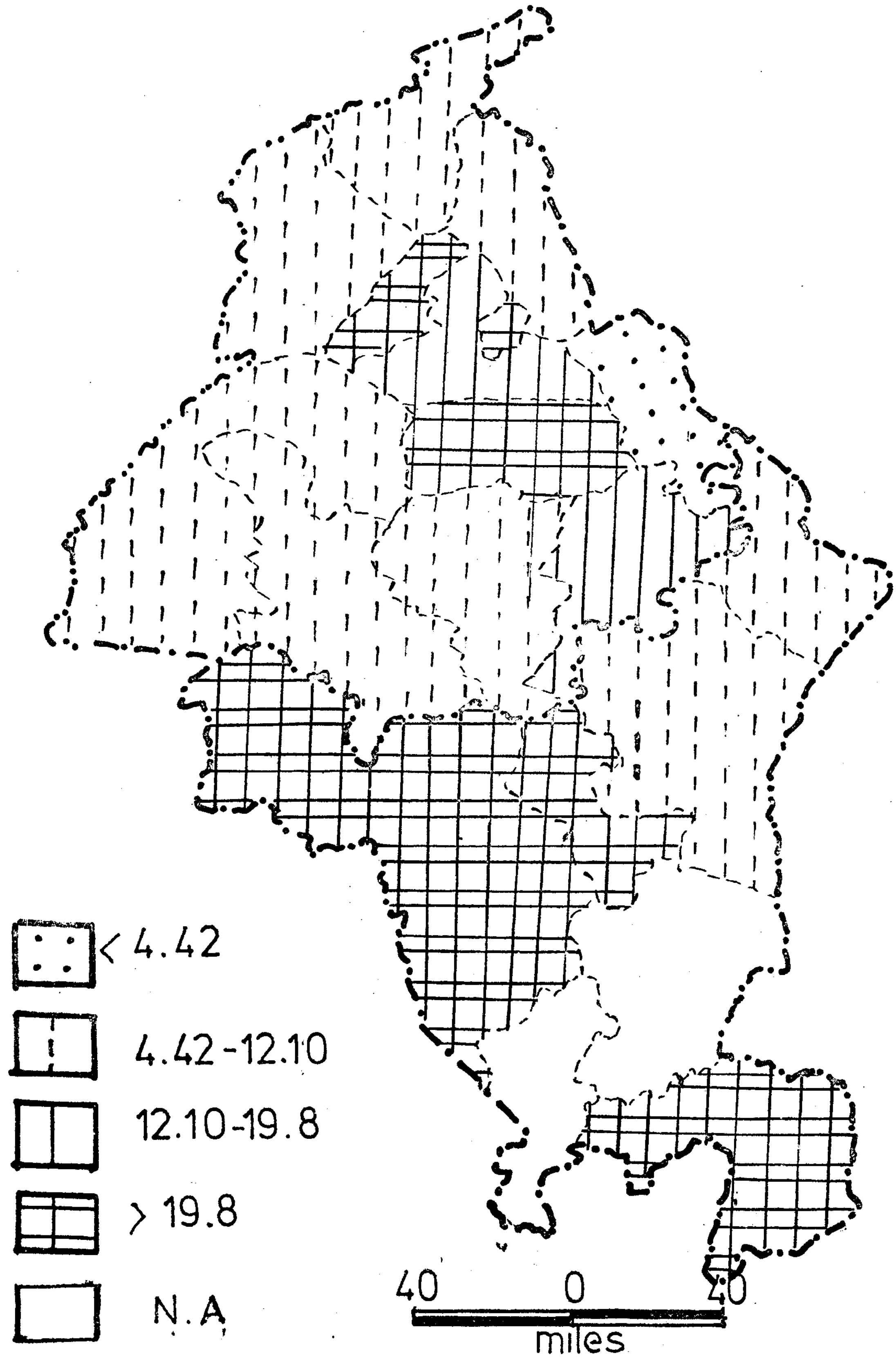
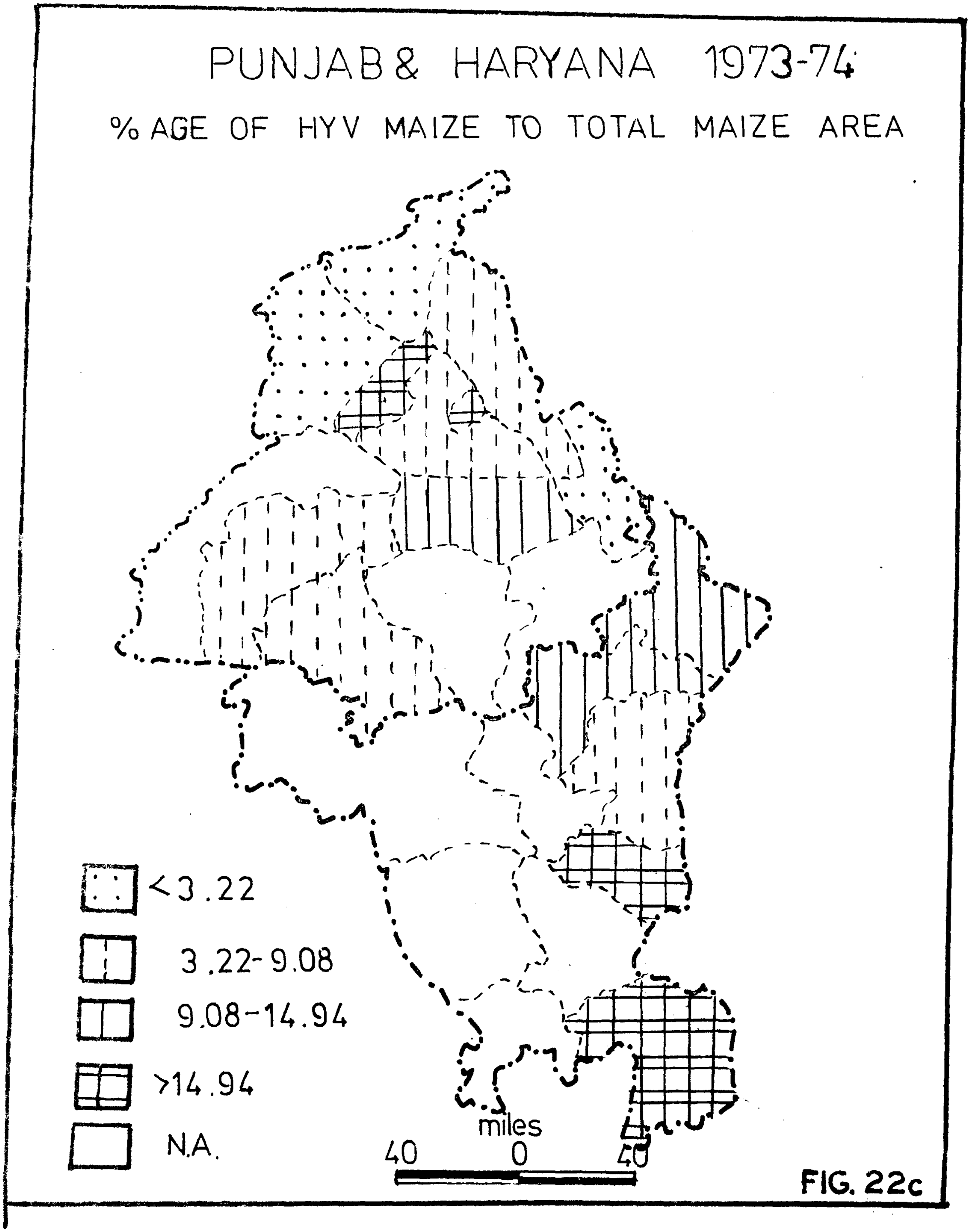


FIG. 21c


PUNJAB & HARYANA 1973-74
% AGE OF HYV MAIZE TO TOTAL MAIZE AREA
< 3.22
3.22-9.08
9.08-14.94
>14.94
N.A.
miles
40 0 40
FIG. 22c

PUNJAB AND HARYANA : 1968-69

%AGE OF MAIZE IRRIGATED TO TOTAL MAIZE AREA

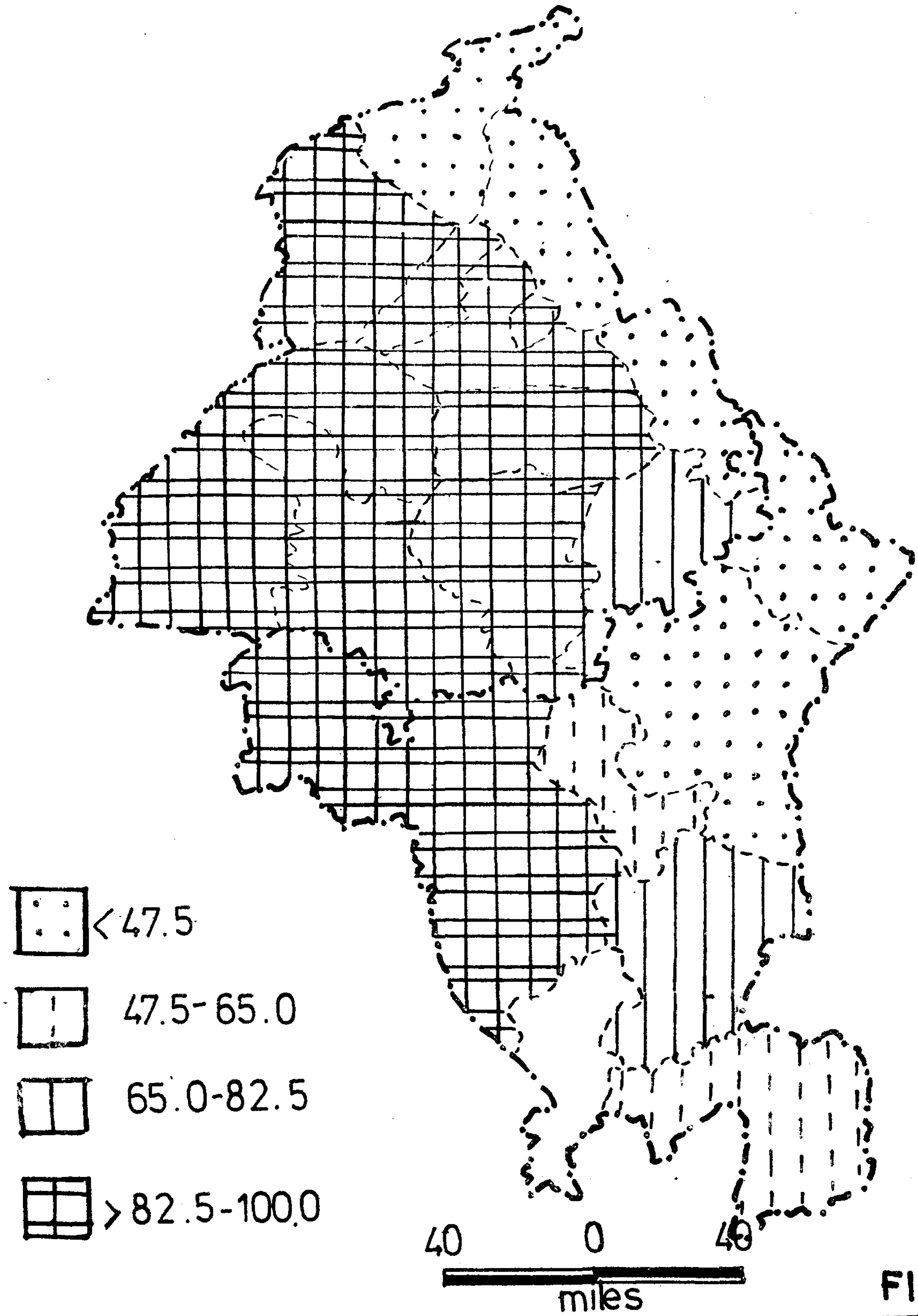


FIG. 23 c

PUNJAB AND HARYANA 1973-74

% AGE OF MAIZE IRRIGATED TO TOTAL MAIZE

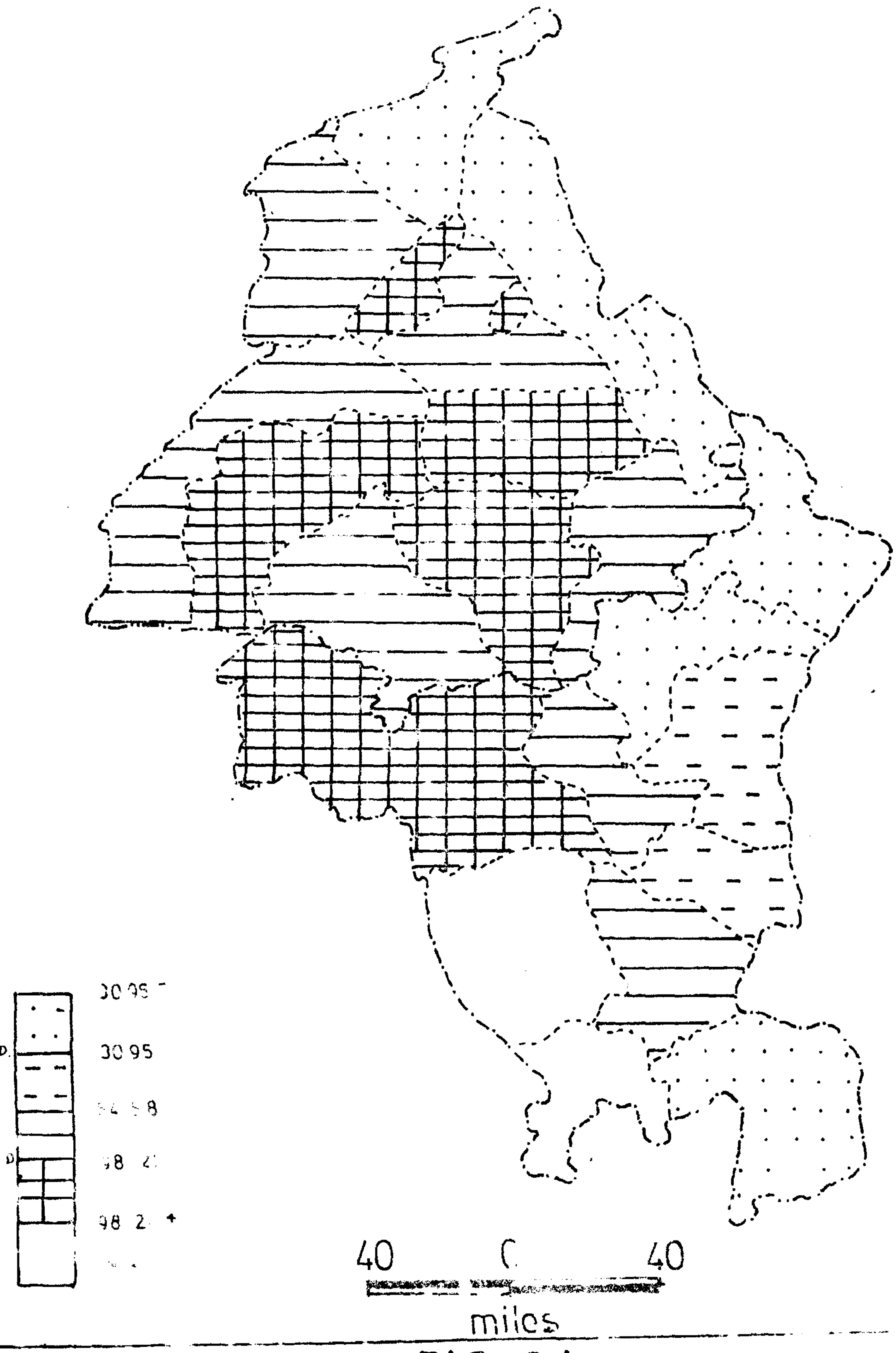


FIG. 24c

of this reason, area under both hybrid and composite varieties of maize are taken in this study.

The average yield rate of maize of this region is 1123 kg, 1168 kg and 1146 kg/ha. during 1964-66, 1968-69, and 1973-74 respectively. The yield rate remained almost the same.

In districts Sangrur and Patiala, HYV maize was available in 1968-69 but no HYV maize data in these districts in 1973-74. Districts Ferozepur and Hissar have been bifurcated into Ferozepur, Faridkot and Hissar and Bhiwani respectively, and it might be so that the maize belt lies in the other districts for which data for HYV maize is not available in the later year. [Fig. 21(c) and 22(c)]. In many districts, the HYV area has gone down. The coefficient of variance remained same in both the points of time (63.63% during 1968-69 and 64.53% during 1973-74).

Composite varieties also need irrigation. The mean percentage of irrigated maize area to total maize is 66.15% during 1968-69 and slightly less (64.58%) during 1973-74 [Fig. 23(C) and 24(c)].

Bajra

Bajra is an important kharif crop in this region specially in Haryana. The optimum time for sowing hybrid bajra is around mid July.

Although requirements of water for hybrid bajra crop as compared with other important crops are comparatively

PUNJAB AND HARYANA : 1968-69

%AGE OF HYV BAJRA TO TOTAL BAJRA AREA

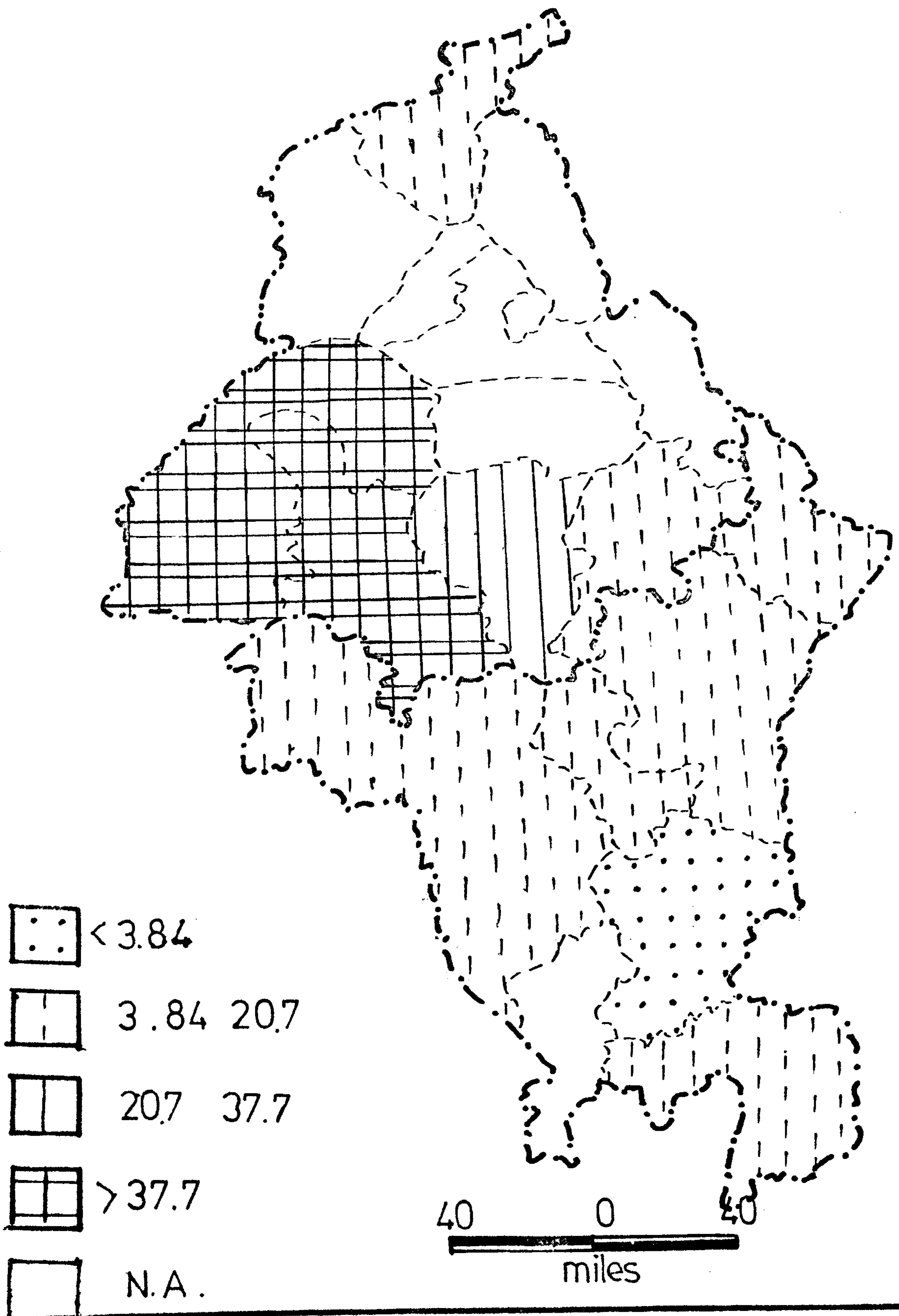


FIG. 21d

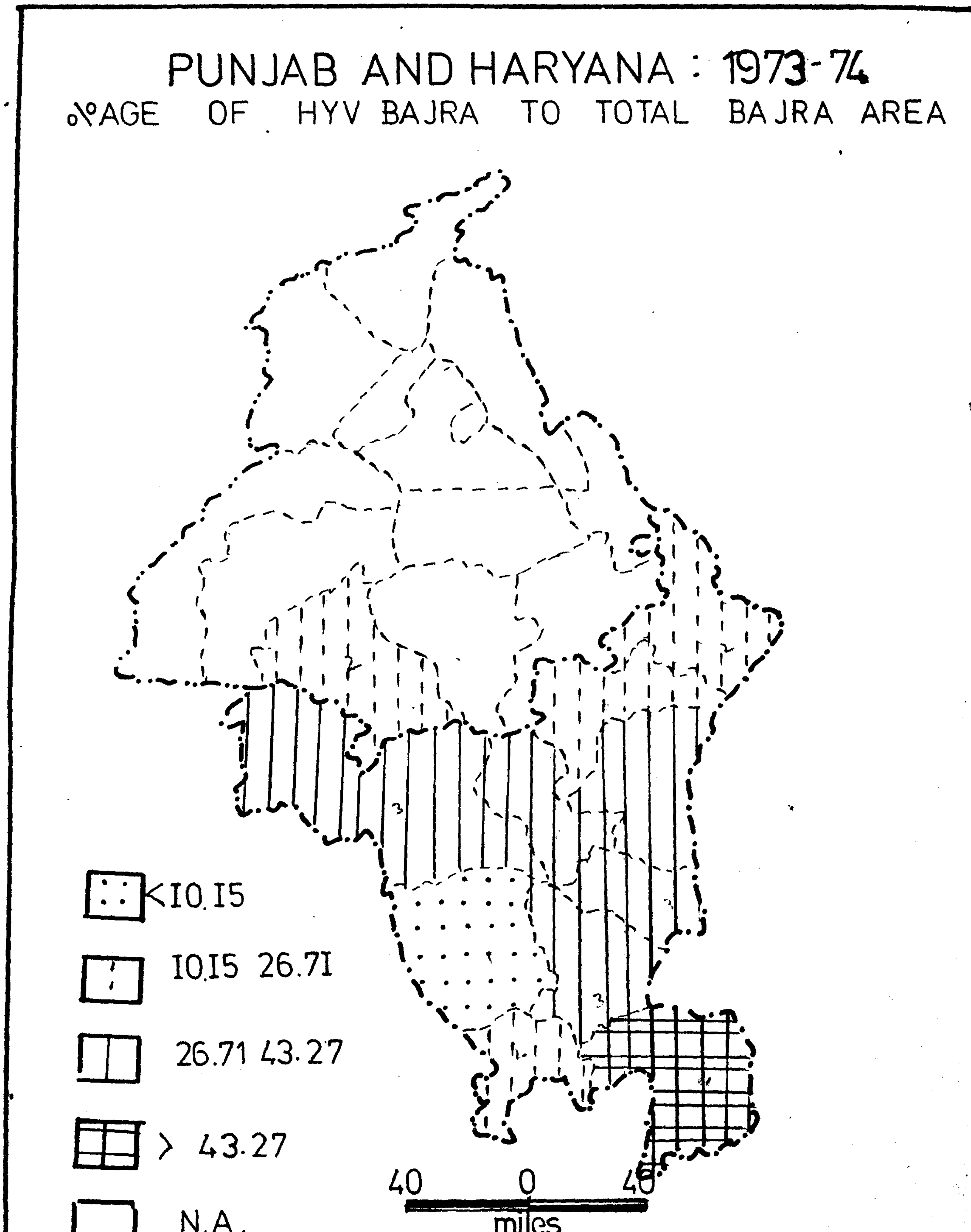
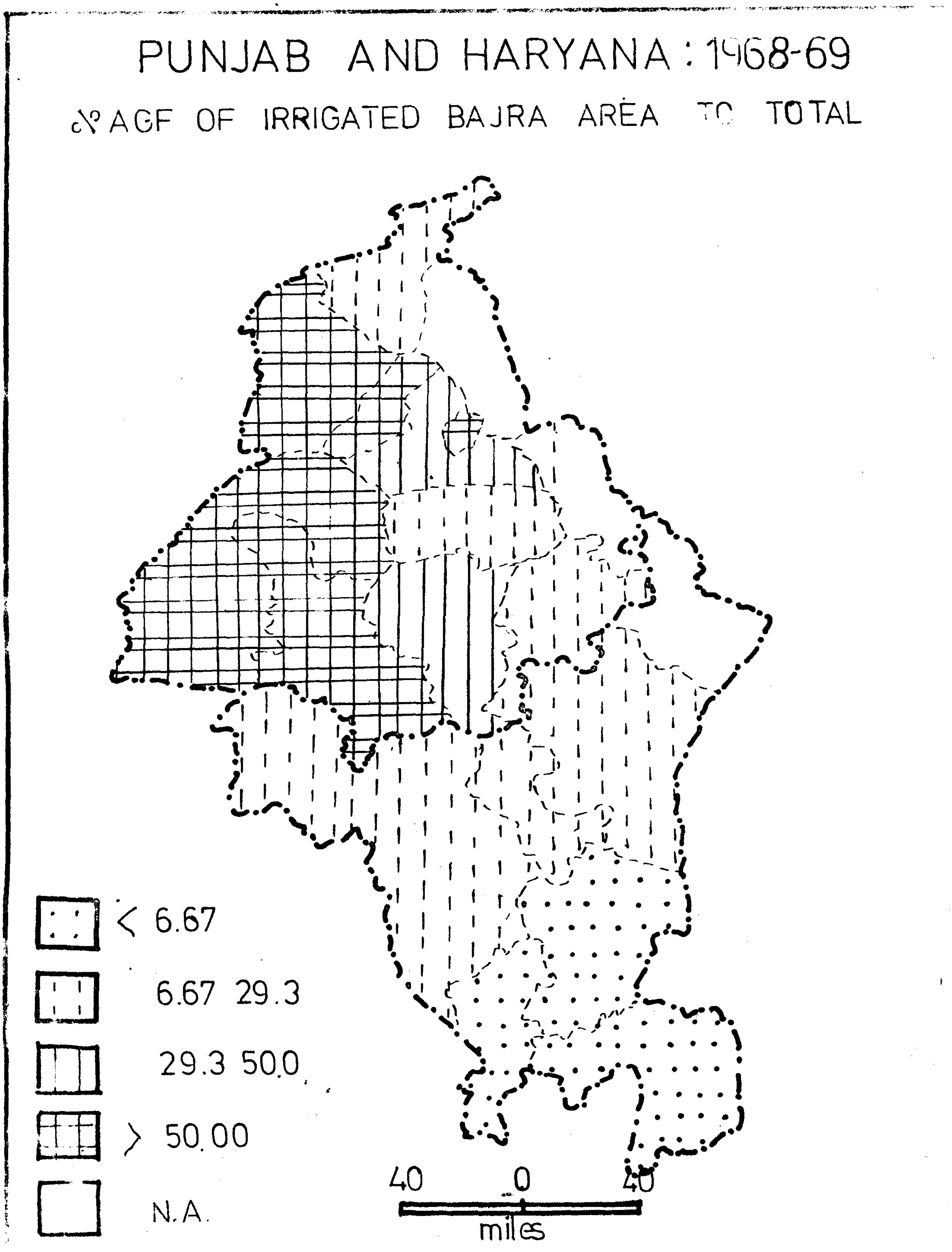

PUNJAB AND HARYANA : 1973-74
%AGE OF HYV BAJRA TO TOTAL BAJRA AREA
<10.15
10.15 26.71
26.71 43.27
> 43.27
N.A.
40 0 40
miles

FIG. 22d



PUNJAB AND HARYANA : 1968-69
%AGE OF IRRIGATED BAJRA AREA TO TOTAL
< 6.67
6.67 29.3
29.3 50.0
> 50.00
N.A.
40 0 40
miles

FIG. 23d

PUNJAB AND HARYANA 1973-74

%AGE OF BAJRA IRRIGATED TO TOTAL BAJRA AREA

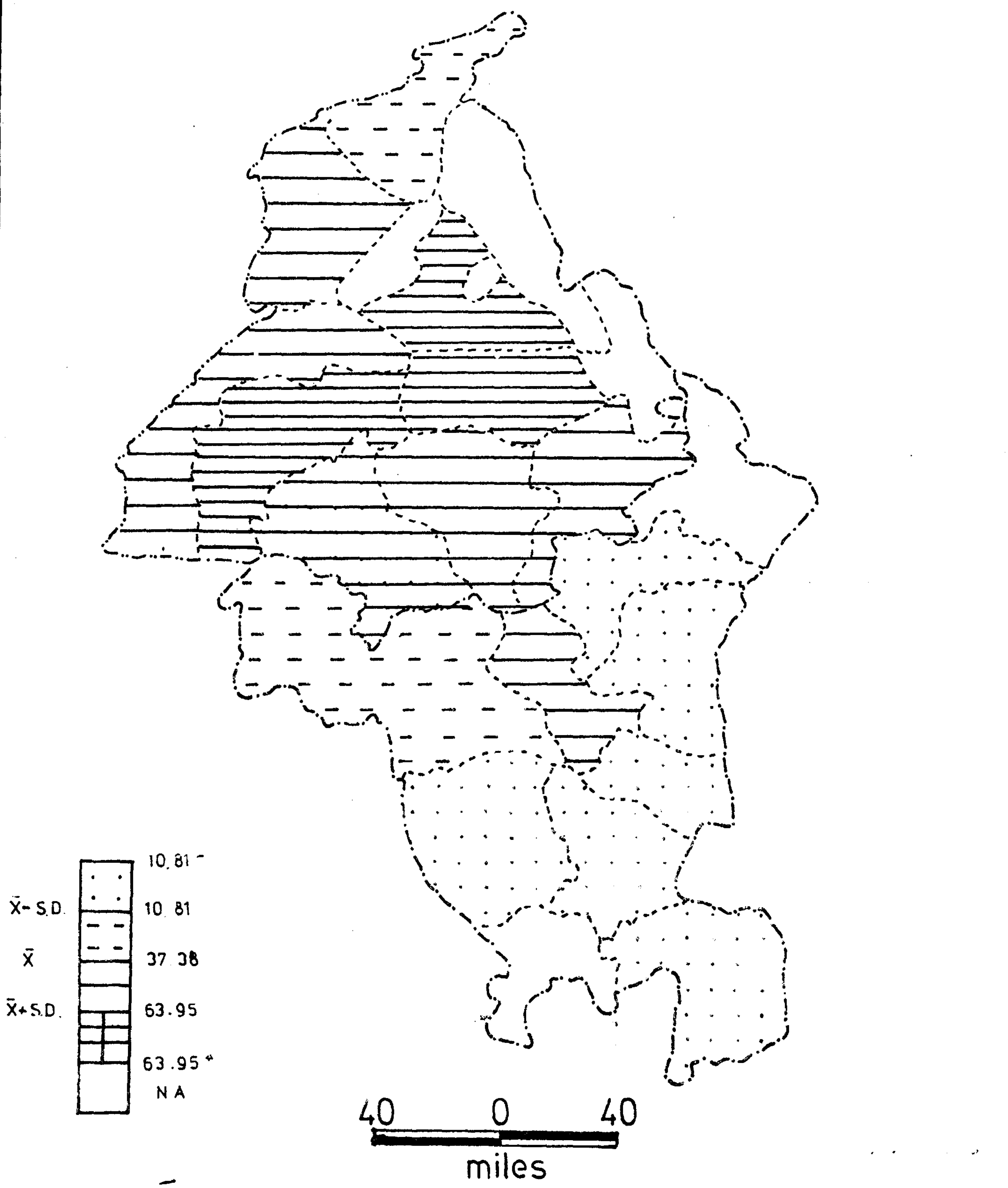


FIG. 24 d

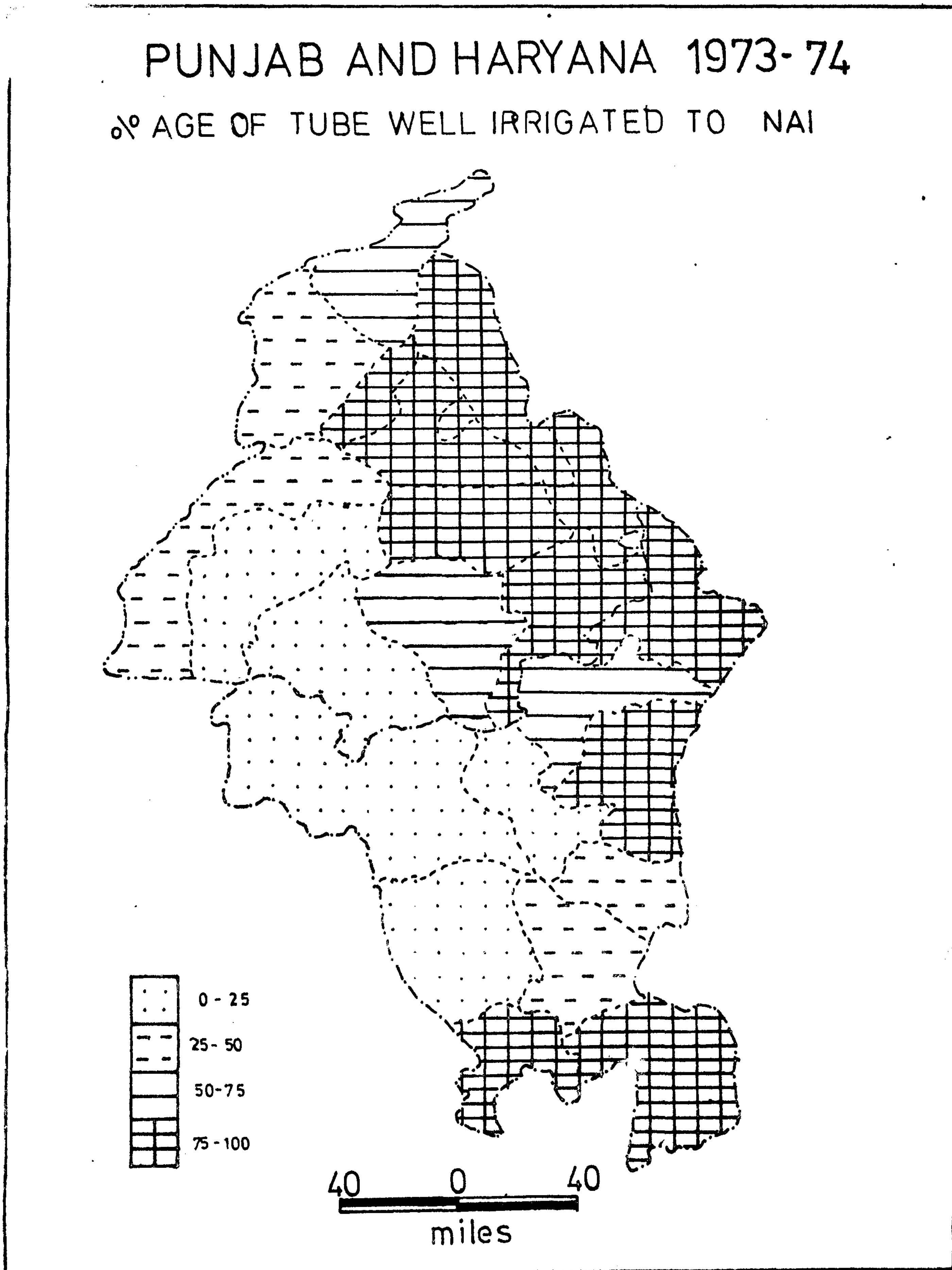

PUNJAB AND HARYANA 1973-74
%AGE OF TUBE WELL IRRIGATED TO NAI
0 - 25
25 - 50
50-75
75 - 100
40
0
40
miles

FIG. 25

less, yet timely and adequate supply of water is necessary for obtaining luxuriant growth of the crop. The lower yield realised than expected from the hybrid bajra crop affected unfavourably the coverage of area under this variety.

The trend of yield rate of bajra is quite good. It increased from 380.07 kg in 1964-65 to 611.63 kg in 1968-69 and to 888.22 kg per hectare during 1973-74.

Districts Ferozepur and Bhatinda are found to be in the highest category during 1968-69 (55% and 48% respectively). District Bhatinda shows a decline in area coverage in 1973-74 (10.36%). The percentage of area irrigated remains same in both points of time. (figs. 21(d), 22(d), 23 (d), and 24(d)7. Like maize, many districts are found with blank column and quite a few with less than 50 hectares.

The irrigated area described above includes water from all sources. As it has been already mentioned, HYV crops depend upon timely water supply. Timely watering depends mainly upon well irrigation; water from canal is not assured.

The percentage of tubewell irrigated area to net area irrigated is shown in map 25, during 1973-74. Districts Hoshiarpur, Kapurthala, Jullundur, Ludhiana, Rupar, Patiala, Ambala, Karnal, Mahendragarh are found in the highest quartile i.e. between 75 and 100 per cent. It is always found that one or the other HYV crop is grown in the districts where tubewell irrigated area is sufficiently high.

From the interpretation of above maps, it is clearly seen that all HYV cereals are not distributed equally. HYV of certain crop is higher than the other crops. The difference in change of area under HYV of a particular crop with respect to area under HYV of all crops is also important.

To measure this point, an index has been found out as "quotient of HYV crop significance" which is equal to

$$\frac{\text{\% of HYV } i^{th} \text{ crop to total cropped area}}{\text{\% of HYV of four crops to total cropped area}} \times 100$$

This has been calculated for two points of time, 1968-69 and 1973-74 in district level for these four crops.

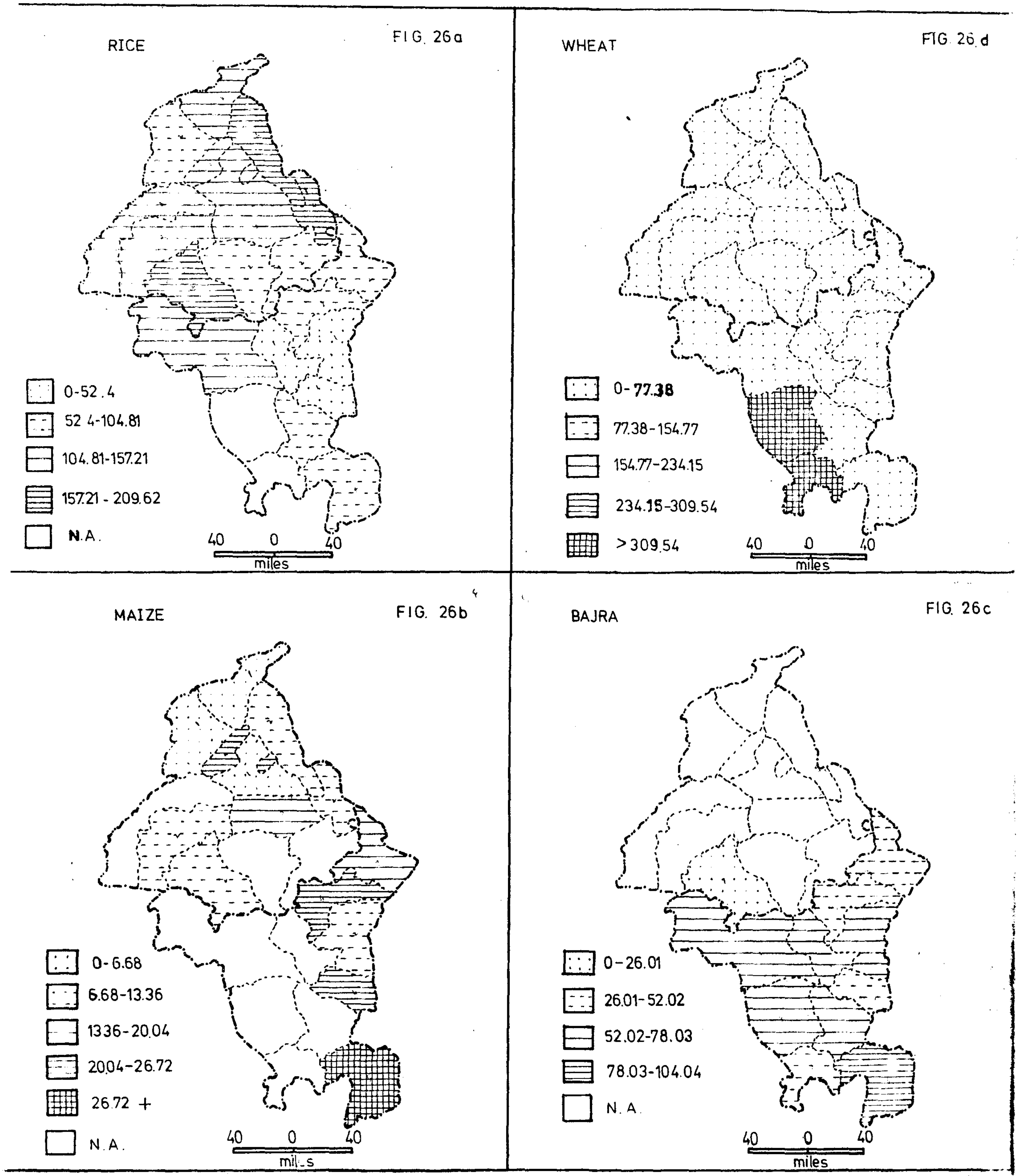
From the above table, it is found that all districts except Jind enjoys highest quotient of crops significance in case of wheat in 1968-69. Next comes rice, maize and then bajra.

District Ferozepur, Bhatinda, Ambala and Sangrur are enjoying HYV wheat and bajra almost equal share while districts Hissar and Gurgaon are found equal share in maize and wheat HYV crop area significance.

District Mahendragarh shows only wheat which is the only crop with HYV.

In case of rice, quotient of HYV significance is found to be highest in district Jind and lowest in Karnal during 1968-69.

PUNJAB AND HARYANA DISTRICTWISE INDIVIDUAL QUOTIENT OF HYV CROP SIGNIFICANCE : 1973-74



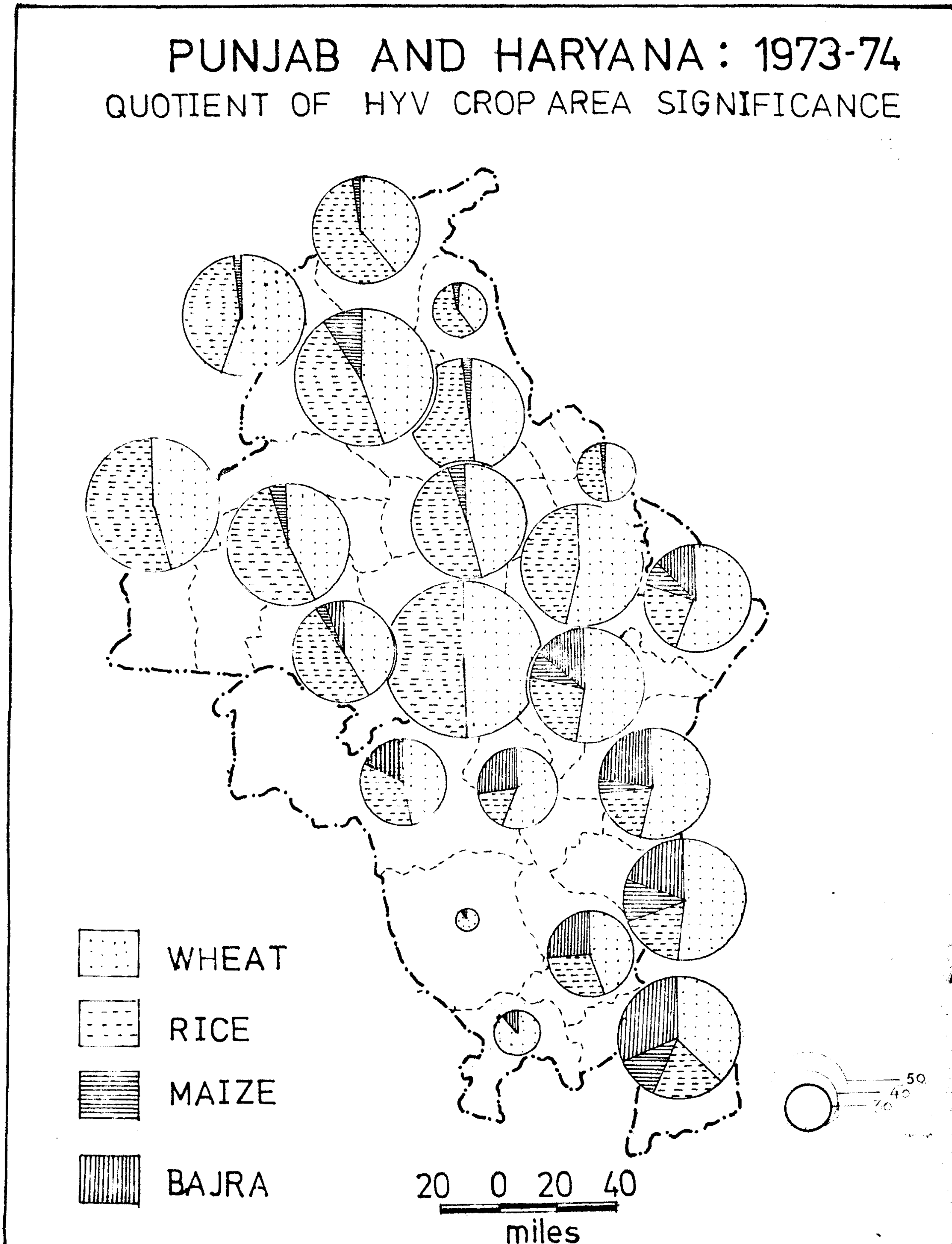

PUNJAB AND HARYANA: 1973-74
QUOTIENT OF HYV CROP AREA SIGNIFICANCE
WHEAT
RICE
MAIZE
BAJRA
20 0 20 40
miles

FIG. 27

Quotient of maize is found to be highest in case of District Jind. Except Jind, Hissar and Gurgaon all are found to be less than 100 points. It is very negligible in districts like Sangrur, Bhatinda and Ferozepur.

In case of bajra, district Ferozepur, Bhatinda, Ambala and Jind are showing high points.

The same sort of computation has been done for the period of 1973-74. The quotient of HYV rice significance has increased quite significantly and even more than HYV wheat in some districts of the region. (Fig 26 & 27).

Districts Gurdaspur, Kapurthala, Jullundur, Hoshiarpur, Rupar, Ludhiana, Ferozepur, Faridkot, Bhatinda and Sangrur show more in rice than wheat, while these were found to be so in case of wheat during 1968-69.

Very high quotient of wheat HYV crop significance is found in case of Bhiwani as other HYV crops are not popular. Data of HYV bajra was not mentioned in Punjab Statistical Abstract. Among districts of Haryana, Mahendragarh shows sufficiently high.

To sum up the above discussion, the standard deviation and co-efficient of variance are calculated in the following table:

Table 6.1

Quotient of HYV Crop Significance

	1968-69				1973-74			
	Rice	Wheat	Maize	Bajra	Rice	Wheat	Maize	Bajra
Mean	37.95	237.28	51.88	69.40	104.82	154.77	13.36	52.01
Standard Deviation	28.05	403.46	59.34	40.55	43.67	107.28	8.09	20.92
Number of Districts	12	18	16	11	20	22	14	11
Coefficient of Variation	73.93	170.03	114.39	58.44	41.66	69.32	60.37	40.22

From the above table, it is found that the inter-district disparities of quotient of HYV crop significance has decreased in 1973-74 over 1968-69 for each crop. The disparity was very high in the first period for wheat and maize. Coefficient of variance being 170 and 114 per cent respectively. The disparity was lowest for bajra - c.v. being 58 per cent. In the second period, the disparity has decreased significantly for each crop, and the position of different crop remains the same.

The mean quotient of HYV crop significance was highest in wheat in 1968-69 and lowest in case of rice (237.28% and 37.95% respectively) and that of maize and bajra were 51.88% and 69.45% respectively. But interestingly enough, the same has gone up to 104.82% in case of rice during 1973-74 and rest has come down quite significantly. This shows, overall the percentage of HYV rice to total rice area to percentage of HYV of four crops to total cropped area has increased while that of wheat, maize and bajra has decreased.

From the above analysis, it has been found that in Punjab and Haryana the extension of HYV rice is most popular among the four crops - the study deals with. This study has very little scope to identify definite reasons for such phenomena. Nevertheless, some tentative reasons may be put forward on the basis of cost pattern of different HYV cultivation of different crops.

The economic adviser to Government of Punjab, Chandigarh, has issued three reports on "Economics of Tractor Cultivation and Economies of Production and Cultivation Practices of High Yielding Varieties of Wheat, Maize and Paddy in Punjab", for the years 1969-70, 1970-71 and 1971-72.

They have given the cost of cultivation per acre by different cost concepts. The cost of cultivation per acre in rupees of wheat, maize and paddy is given in the following table;

Table 6.2

Cost* of Cultivation Per Acre
(in Rs.)

	1969-70		1970-71		1971-72	
	HYV	Desi	HYV	Desi	HYV	Desi
Wheat	626.63	571.98	650.30	579.30	692.24	693.79
Maize	603.80	574.98	628.92	591.17	673.25	641.13
Paddy	594.73	536.47	597.29	544.21	648.58	602.23

* This cost includes - Cost A_1 + cost A_2 + Cost B + Cost C. Cost A_1 includes hired human labour, owned and hired bullock labour and tractor, seeds, manure, fertilizers, insecticides, depreciation and interest on farm buildings, tractor accessories and implements, land revenue and other taxes, irrigation charges, other miscellaneous charges, interest on working capital and hiring of other machinery.

Cost A_2 - Cost A_1 plus actual rent paid
Cost B - Cost A_2 plus evaluated rental value of owned land and interest on fixed capital (excluding land)
Cost C - Cost B plus the imputed value of family (human) labour.

The cost per acre of HYV rice cultivation was Rs.594.73 in 1969-70 while that of maize and wheat was Rs.663.80 and Rs.626.63 respectively in Punjab. The lowest per acre cost of HYV rice cultivation was true for rest of years also. Probably this cost pattern of different HYV cultivation made it economically viable to extend HYV rice most.

Table 6.3

Area under HYV of four cereals - Rice, Maize, Bajra and Wheat on Punjab and Haryana, 1968-69

(1) S. No.	(2) District	(3) Total area under HYV of rice + maize+bajra +wheat in '000 hec.	(4) Total cropped area (rice+ maize+ bajra+ wheat) in '000 hec.	(5) % of (3) to (4)	(6) % of HYV to total rice	(7) % of HYV wheat to total wheat	(8) % of HYV maize to total maize	(9) % of HYV bajra to total bajra	(10) $\frac{(6)}{(5)} \times 100$ Crop Rice	(11) $\frac{(7)}{(5)} \times 100$ Area Wheat	(12) $\frac{(8)}{(5)} \times 100$ Significance Maize	(13) $\frac{(9)}{(5)} \times 100$ Bajra
1	Gurdaspur	74	236.80	31.25	7.89	51.18	10.34	(a)	24.28	163.77	23.08	(a)
2	Amritsar	150	342.60	45.78	5.47	65.88	8.16	15.15	12.49	150.47	18.63	34.60
3	Kapurthala	42	102.70	14.90	8.33	60.65	20.00	-	20.36	148.28	48.89	-
4	Jullundur	128	241.40	53.02	(a)	72.28	12.69	(a)	(a)	136.32	23.33	(a)
5	Hoshiarpur	49	219.90	22.59	10.34	35.24	4.54	(a)	45.77	155.99	20.09	(a)
6	Rupar	19	90.30	21.04	-	33.96	3.22	(a)	-	161.40	15.30	(a)
7	Ludhiana	186	287.40	64.72	33.33	79.81	21.42	(a)	51.49	123.31	33.09	(a)
8	Ferozepur	235	540.00	43.52	9.09	52.03	5.88	55.00	20.88	119.55	13.51	126.37
9	Bhatinda	175	370.40	47.25	-	50.76	4.76	47.51	-	107.42	10.07	100.51
10	Sangrur	176	373.70	44.10	9.09	59.77	5.08	37.47	20.61	135.53	11.51	84.96
11	Patiala	117	286.20	40.88	7.69	55.72	12.88	16.12	18.81	136.27	33.95	39.43
12	Hissar	65	531.00	12.24	7.69	20.24	20.00	8.57	62.82	163.35	163.39	70.01
13	Rohtak	56	300.60	12.33	(a)	28.10	-	3.23	(a)	153.30	-	17.52
14	Gurgaon	49	262.00	18.70	-	31.75	25.00	6.11	-	169.78	133.68	32.67
15	Karnal	110	482.00	22.82	2.06	37.73	5.88	6.67	9.02	165.33	25.76	29.22
16	Ambala	26	163.00	15.96	10.86	22.08	8.57	20.00	68.08	138.43	53.73	125.39
17	Jind	16	129.00	12.40	12.50	11.29	25.00	12.73	100.80	91.04	201.61	102.66
18	Mahendragarh	4	222.00	1.80	-	33.33	(a)	(a)	-	1851.66	(a)	(a)

Source;

555.29 $\bar{x}$ = 30.85

S.D. = 16.97

C.V. = 55.01

Table 6.4

Area under High Yield Variety of four Cereals - Rice, Maize, Bajra and Wheat on Punjab and Haryana, 1973-74

(1) S. No.	(2) District	(3) Total (rice +maize + bajra + wheat) HYV area in '000 hec.	(4) Total (rice + maize + bajra + wheat) cropped area in '000 hec.	(5) % of (3) to (4)	(6) % of HYV rice to total rice	(7) % of HYV wheat to total wheat	(8) % of HYV maize to total maize	(9) % of HYV bajra to total bajra	(10) (6)/(5)x100 Crop Area Significance Rice	(11) (7)/(5)x100 Wheat	(12) (8)/(5)x100 Maize	(13) (9)/(5)x100 Bajra.
1	Gurdaspur	175	268	65.20	95.29	63.27	2.78	-	145.92	96.89	4.25	-
2	Amritsar	316	411	76.89	70.97	92.28	2.44	-	92.30	120.01	3.17	-
3	Kapurthala	102	118	86.44	100.00	95.89	18.75	-	115.68	110.93	21.69	-
4	Jullundur	224	308	72.73	100.00	96.92	3.75	-	137.49	132.71	5.15	-
5	Hoshiarpur	100	271	36.90	72.97	48.98	3.37	-	197.75	132.73	9.13	-
6	Rupar	42	108	38.89	62.50	57.14	2.70	-	160.70	146.92	6.94	-
7	Ludhiana	250	352	71.02	100.00	94.61	100.00	-	140.80	133.21	14.03	-
8	Ferozepur	265	316	83.86	93.24	80.99	-	-	111.18	96.57	-	-
9	Faridkot	236	300	78.67	100.00	83.27	8.69	-	127.11	105.84	11.04	-
10	Bhatinda	168	266	63.16	100.00	83.77	6.25	10.36	158.32	132.63	9.89	16.40
11	Sangrur	294	298	98.66	100.00	98.57	-	-	101.35	99.90	-	-
12	Patiala	263	336	78.27	68.60	81.60	-	-	87.64	104.25	-	-
13	Hissar	234	421.9	55.46	62.50	80.48	(a)	28.96	112.69	145.11	(a)	52.21
14	Bhiwani	41	302.3	13.56	(a)	79.55	-	7.26	(a)	586.65	-	53.53
15	Gurgoan	162	250.2	64.75	35.71	69.45	18.87	60.77	55.15	107.25	29.14	93.85
16	Jind	111	211.3	52.53	22.39	73.83	-	34.64	42.62	140.54	-	65.94
17	Mahendragarh	55	187.0	29.41	(a)	96.95	(a)	13.25	(a)	329.64	(a)	45.05
18	Ambala	125	193.5	64.60	42.94	99.59	12.02	21.74	66.47	154.16	18.60	33.65
19	Karnal	211	300.2	70.29	35.80	98.45	6.90	39.60	50.93	140.06	9.81	56.33
20	Kurukshetra	249	347.5	71.65	18.12	99.68	14.29	25.57	67.15	139.12	19.94	35.60
21	Rohtak	109	203.5	53.56	43.48	67.96	-	39.30	81.17	126.88	-	73.37
22	Sonepat	99	124.8	79.33	34.88	97.53	19.23	36.70	43.96	122.94	24.24	46.26

Table 6.5

Percentage of Crop-wise Irrigated area in Punjab and Haryana, 1968-69

District	% of irrigated rice to total rice area	% of irrigated maize to total maize area	% of irrigated bajra to total bajra area	% of irrigated wheat to total wheat area
Gurdaspur	77.09	36.55	11.11	45.91
Amritsar	98.90	96.33	57.58	88.88
Kapurthala	100.00	95.33	59.26	83.93
Jullundur	90.83	88.10	50.00	86.33
Hoshiarpur	72.07	17.42	(a)	39.51
Rupar	31.67	18.06	(a)	32.45
Ludhiana	73.33	94.71	28.57	93.76
Ferozepur	98.73	90.39	62.25	81.80
Bhatinda	100.00	98.57	56.11	86.50
Sangrur	94.55	98.14	44.73	91.80
Patiala	81.35	75.00	24.19	86.67
Hissar	100.00	100.00	7.14	97.55
Rohtak	81.25	66.67	4.30	64.26
Gurgaon	100.00	50.00	.76	74.60
Karnal	90.34	44.12	10.00	74.36
Ambala	23.91	5.71	(a)	31.17
Jind	100.00	50.00	23.64	88.71
Mahendragarh	-	(a)	.48	91.67

Table 6.6

Percentage of crop-wise irrigated area in Punjab and Haryana, 1973-74

S.No.	Name of the District	% of irri-gated rice to total rice	% of irri-gated maize to total maize	% of irri-gated bajra to total bajra	% of irri-gated wheat to total wheat	% of area under well irrigated to NAI
1	Gurdaspur	84.62	27.81	26.08	58.96	56.33
2	Amritsar	99.42	92.43	54.28	96.81	42.63
3	Kapurthala	100.00	100.00	(a)	86.43	96.91
4	Jullundur	99.16	94.73	66.66	95.96	92.50
5	Hoshiarpur	86.47	19.60	-	94.86	84.87
6	Rupar	78.57	23.42	(a)	95.95	93.21
7	Ludhiana	96.84	98.72	66.66	98.78	91.00
8	Ferozepur	100.00	83.63	59.82	88.93	42.40
9	Faridkot	99.35	100.00	83.52	92.64	23.16
10	Bhatinda	90.00	97.50	63.60	99.35	24.94
11	Sangrur	99.61	99.19	63.46	98.44	68.47
12	Patiala	96.58	73.87	50.00	92.51	78.77
13	Hissar	96.50	100.00	25.85	98.31	8.27
14	Bhiwani	(a)	(a)	3.62	98.48	12.36
15	Gurgaon	35.71	18.86	1.06	74.17	83.09
16	Jind	97.01	73.17	39.10	94.91	14.91
17	Mahendragarh	(a)	(a)	(a)	96.96	100.00
18	Ambala	47.03	4.80	(a)	52.84	86.51
19	Karnal	97.85	31.03	9.90	91.16	76.81
20	Kurukshetra	97.98	28.57	10.20	92.13	67.72
21	Rohtak	86.86	66.66	7.23	85.43	27.22
22	Sonepat	93.02	57.69	4.58	77.35	48.45
	X	89.08	64.58	37.38	89.10	
	J	17.06	33.63	26.57	12.36	
	C.V.	19.14	52.07	71.08	13.87	

CHAPTER VII

FINDINGS AND CONCLUSION

As has already been stated above, the main objective of our study was to see, (1) the spatial variation in the spread of high yielding variety of four crops in the States of Punjab and Haryana, and (2) the effect of environmental, technological and institutional factors on the extension of area under these crops.

Our study takes up eight sensitive factors to explain spatial HYV area variation. The variations we have found are due to interaction of these factors and it is felt that these factors are so conflicting that it requires detailed and concrete data from the primary sources which has not been accessible to us.

Our main findings are:

(1) The agro-climatic factors seem to have a significant effect on the spread of a crop, while they have a marginal effect on the yield of different crops.

(2) It is the increase in yield which has contributed most to the growth.

(3) Of the different technological factors, the spread of HYV occupies the first rank in explaining the productivity.

(4) GAI as percentage to TCA alone explains 79.2% variation of spread of area under high yielding variety.

Along with GAI as percentage to TCA, factors like percentage of agricultural labour to total agricultural worker, per hectare productivity in money terms and of course percentage of literate and educated population to total population together explain 84.4% of the variation.

(5) While studying the spread of HYV crops separately, it is found that spread of HYV of rice is higher than other crops. This may be posed by lower cost pattern of HYV of rice as compared to other HYV crops.

<u>Validity of the Hypotheses</u>

Eight simple hypotheses relating to spread of HYV with the explanatory variables have been formulated in this study. They are tested by the simple correlation method. The hypotheses are also examined from the results of multiple regression (here the step-wise regression) which gives the type of relationship between the spread of HYV area and each predictor. Table 7.1 summarises the results of tests of hypotheses by both the methods.

Table 7.1

<u>Test of Hypotheses</u>

	Variables	r	b
1	Soil rating index	.176	.260
2	% of GAI to TCA	.890**	.593**
3	Tonnage of Nitrogenous fertilizer per 100 hectare of GAI	- .133	- .865

...

Table 7.1 contd...

	Variables	r	b
4	Mechanization index	.504*	3.608
5	Productivity in money terms	.550**	.0004
6	% of agricultural labour to total agricultural worker	.472*	- .588
7	% of rural scheduled caste to total rural population	- .237	.189
8	% of literate and educated population to total population	.092	.049

The simple correlation coefficient shows that agricultural productivity is directly related with all predictors. r value with percentage of GAI to TCA with productivity are significant at 1 per cent level while that with mechanization and agricultural labour at 5 per cent level. b value is highly significant (i.e. at 1% level) with only irrigation and others not even 10 per cent level. It is really curious that relationship with tonnage of nitrogenous fertiliser per 100 hectare of GAI is negative.

The significant predictors are identified from the step-wise regression with the help of R^2 and range of residuals.

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* = significant at 5% level

** = significant at 1% level.

All the predictors put together explain 87.8% of total variation. Irrigation, agricultural labour, productivity in money terms and literate and educated population combinely explain 84 per cent out of which 79% is claimed by irrigation alone. Thus to explain the spread of HYV, irrigation from the technological side and agricultural labour, educated and literate population from institutional side and productivity in money terms emerge out as the best suitable predictors.

We have thus verified the hypotheses that the extension of HYV is very much effected by our selected variables and especially that of irrigation, agricultural labour, productivity in money terms and educated and literate population and least effected by soil rating index in Punjab and Haryana. We now necessarily face another very important question as to how is it that Punjab and Haryana had such a fantastic combination of all these factors. In our inter-State comparison of agricultural growth we found that, other States are far behind the growth rate of foodgrain of undivided Punjab. The uniqueness of Punjab and later Punjab and Haryana, as we found, definitely effected by the extension of high yielding variety. May be the combination of institutional and climatological situations of this region gave it the uniqueness and therefore, a detailed study of both institutional and climatological factors should have been done for each district as they play such an important role in determining the growth of agriculture and the extension of high yielding variety. Definitely non-availability of requisite data gave us no scope to undertake any such study in the course of the present prospect. We propose to extend our study in detail in a micro level and collect the necessary data with an appropriate methodology.

Another very important aspect omitted from our study and intended to be taken up later is the role of State and Central Governments. The contribution of the State has obviously been substantial and often played a critical role in the development of agriculture in Punjab and Haryana. This role could be direct as well as indirect.

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Appendix I

(1) Rice   HARYANA   1960-61 = 100

Year	Production ('000 tonnes)	Index	Area '000 hec.	Index	Yield	Index
1950-51	43	24.57	75	48.38	573.33	50.78
1955-56	60	24.28	78	50.32	769.23	68.13
1960-61	175	100.00	155	100.00	1129.03	100.00
1961-62	203	116.00	163	105.16	1245.39	110.30
1962-63	154	88.00	165	101.45	933.33	82.66
1963-64	220	121.71	158	101.93	1392.40	123.32
1964-65	226	129.14	185	119.35	1221.62	108.20
1965-66	204	116.57	193	124.51	1056.99	93.61
1966-67	223	127.42	192	123.87	1161.45	102.87
1967-68	287	164.00	217	140.00	1322.58	117.14
1968-69	272	155.42	229	147.74	1187.77	105.20
1969-70	372	212.57	240.8	155.38	1544.85	136.82
1970-71	460	262.85	269.2	173.67	1708.76	151.34
1971-72	536	306.28	291	187.74	1841.92	163.14
1972-73	462	260.00	2914	188.00	1585.44	140.42
1973-74	540	308.57	291.7	188.19	1851.21	163.96

Appendix I

(ii) Jowar

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg/ hec.	Index
1950-51	78	150	286	92.85	272.72	161.53
1955-56	32	61.53	278	90.25	115.10	68.53
1960-61	52	100.00	308.00	100.00	168.83	100.00
1961-62	53	102.92	304	98.70	174.34	103.26
1962-63	50	96.15	320	103.89	156.25	92.54
1963-64	48	92.30	299	97.07	160.53	95.08
1964-65	51	98.07	290	94.15	175.86	104.16
1965-66	34	65.38	248	80.51	137.09	81.20
1966-67	49	94.23	270	87.66	181.48	107.49
1967-68	58	11.57	293	95.12	197.95	117.24
1968-69	25	48.07	208	67.53	120.19	71.18
1969-70	54	103.94	231.1	75.83	233.76	138.45
1970-71	57	109.61	207.3	67.30	275.36	163.09
1971-72	45	86.53	194.0	62.98	231.95	137.38
1972-73	55	105.76	188.9	61.33	292.55	173.28
1973-74	55	105.76	186.0	60.38	295.69	175.14

Appendix I

(iii) Bajra

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg/ hec.	Index
1950-51	330	140.42	927	115.73	355.98	121.33
1955-56	345	146.80	917	114.48	376.22	128.23
1960-61	235	100.00	801	100.00	293.38	100.00
1961-62	272	114.48	773	96.50	338.93	115.52
1962-63	263	111.91	713	89.01	368.86	125.72
1963-64	250	106.38	677	84.51	369.27	125.52
1964-65	287	122.12	791	98.75	362.83	123.68
1965-66	208	88.51	780	97.37	266.66	90.89
1966-67	373	158.72	893	111.48	417.69	142.37
1967-68	459	195.31	885	110.48	518.64	176.78
1968-69	232	98.72	874	109.11	265.44	90.47
1969-70	514	218.72	930.7	116.19	552.68	188.38
1970-71	826	351.48	879.6	109.81	939.70	320.30
1971-72	624	265.53	882.0	110.11	707.48	241.14
1972-73	467	198.72	904.3	112.89	516.59	176.08
1973-74	691	294.04	955.9	111.33	723.56	246.62

Appendix I

(iv) Maize

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg/ hec	Index
1950-51	12	13.18	33	31.13	363.63	42.35
1955-56	51	56.04	51	48.11	1000.00	116.48
1960-61	91	100.00	106	100.00	858.49	100.00
1961-62	83	91.20	88	83.01	943.18	109.86
1962-63	71	78.02	111	104.71	639.63	74.50
1963-64	129	141.75	116	109.43	1112.06	129.53
1964-65	92	101.09	93	87.73	989.24	115.23
1965-66	126	116.48	88	83.01	1204.54	140.30
1966-67	86	94.50	87	82.07	988.30	115.14
1967-68	125	137.36	115	108.39	1086.95	126.61
1968-69	67	73.62	88	83.01	761.36	88.68
1969-70	137	156.54	1112	104.90	1106.11	128.84
1970-71	130	142.85	114.4	107.92	1136.35	132.36
1971-72	139	152.74	114.1	107.64	1218.22	141.90
1972-73	124	136.26	112.2	105.84	1105.16	128.73
1973-74	119	130.76	118.5	111.79	1004.21	116.97

Appendix I

(v) Wheat

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg/ hec.	Index
1950-51	294	36.11	362	57.64	812.15	62.65
1955-6	619	76.04	543	56.46	1139.96	87.94
1960-61	814	100.00	628	100.00	1296.17	100.00
1961-62	870	106.87	648	103.18	1342.59	103.58
1962-63	804	98.77	670	106.68	1200.00	92.58
1963-64	834	102.45	689	109.71	1210.44	93.38
1964-65	922	113.26	723	115.12	1275.24	98.38
1965-66	869	106.75	678	107.96	1281.71	98.88
1966-67	1059	130.09	743	118.31	1425.30	109.96
1967-68	1438	176.65	841	133.91	1709.86	131.91
1968-69	1529	187.83	898	142.91	1702.67	131.36
1969-70	2147	263.75	1017.3	161.99	2111.11	162.87
1970-71	2342	287.71	1129.3	179.82	2074.40	160.04
1971-72	2402	295.08	1177.0	187.42	2040.78	157.44
1972-73	2231	274.07	1270.6	252.32	1756.69	135.52
1973-74	1811	222.48	1176.5	187.34	1539.96	118.80

Appendix I

(vi) Gram

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg/ hec.	Index
1950-51	398	31.24	886	57.42	449.20	54.40
1955-56	1022	8021	1487	96.37	686.36	83.12
1960-61	1274	100.00	1543	100.00	825.66	100.00
1961-62	985	77.31	1395	90.40	706.09	85.51
1962-63	905	71.03	1443	93.51	627.16	75.95
1963-64	666	52.27	1418	91.89	469.67	56.88
1964-65	968	75.98	1319	85.48	733.88	88.88
1965-66	385	30.21	868	56.25	443.54	53.71
1966-67	531	41.67	1062	68.82	500.00	60.55
1967-68	1267	99.45	1160	75.17	1092.24	132.28
1968-69	421	33.04	577	37.39	729.63	88.36
1969-70	1173	92.07	1084.3	70.27	1082.10	131.05
1970-71	789	61.93	1063.2	68.90	742.23	89.89
1971-72	647	50.78	1119.1	72.52	578.19	70.02
1972-73	551	43.24	969.7	62.84	568.62	68.86
1973-74	448	35.16	993.9	64.41	451.15	54.64

Appendix I

(vii) Pulses

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg/ hec.	Index
1950-51	420	32.23	945	58.84	444.44	54.70
1955-56	1045	80.19	1565	97.44	667.73	82.30
1960-61	1303	100.00	1606	100.00	811.33	100.00
1961-62	1018	78.12	1460	90.90	697.26	85.94
1962-63	938	71.98	1512	94.14	620.37	76.46
1963-64	691	53.03	1462	91.03	472.64	58.25
1964-65	995	76.36	1380	85.92	721.01	88.86
1965-66	408	31.31	915	56.97	445.90	54.95
1966-67	563	43.20	1150	71.60	489.59	60.34
1967-68	1316	100.99	1296	80.69	1015.43	125.15
1968-69	449	34.45	655	40.78	685.49	84.48
1969-70	1215	93.24	1188.9	74.02	1022.72	126.05
1970-71	832	63.85	1158.9	72.26	718.48	88.55
1971-72	682	52.34	1206.1	75.05	565.97	69.75
1972-73	585	44.89	1056.3	65.77	553.97	68.27
1973-74	483	37.06	1082.3	67.39	446.39	55.01

Appendix I

(viii) Foodgrains

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg/hec.	Index
1950-51	1247	45.26	2752	73.95	453.12	61.20
1955-56	2264	82.17	3552	95.45	637.38	86.08
1960-61	2755	100.00	3721	100.00	740.39	100.00
1961-62	2580	93.64	3546	95.29	727.58	98.53
1962-63	2356	85.51	3593	96.54	655.71	88.54
1963-64	2233	81.05	3480	93.52	641.66	86.66
1964-65	2715	98.54	3564	95.78	761.78	102.88
1965-66	1985	72.05	3023	81.24	656.63	88.68
1966-67	2592	94.08	3520	94.59	736.36	99.45
1967-68	3970	144.10	3951	106.18	1004.48	135.66
1968-69	2754	99.96	3118	83.79	883.25	119.29
1969-70	4626	167.91	3866.6	103.91	1196.58	161.61
1970-71	4771	173.17	3867.7	103.94	1233.77	166.63
1971-72	4543	164.90	3955.4	106.35	1148.67	155.14
1972-73	4073	147.84	3967.7	106.62	1026.72	138.66
1973-74	3836	139.27	3965.9	106.57	967.46	130.66

Appendix I

(ix) Total Areas

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg./hec.	Index
1950-51	827	57.03	1807	85.44	457.66	66.75
1955-56	1219	84.07	1987	93.95	613.48	89.48
1960-61	1450	100.00	2115	100.00	685.57	100.00
1961-62	1562	107.72	2086	98.63	748.80	109.22
1962-63	1418	97.79	2081	98.39	681.40	99.39
1963-64	1542	106.34	2018	95.41	764.12	111.45
1964-65	1720	118.62	2184	103.26	787.54	114.87
1965-66	1576	108.69	2108	99.67	747.62	109.05
1966-67	2023	139.52	2370	112.06	853.58	124.50
1967-68	2654	183.03	2655	125.53	999.62	145.80
1968-69	2315	195.66	2963	116.45	939.91	137.09
1969-70	3411	235.24	2677.7	126.61	1274.18	185.85
1970-71	3939	271.66	2708.8	128.08	1454.57	212.16
1971-72	38.61	266.28	2750.3	130.04	1404.00	204.79
1972-73	3488	240.55	2911.4	137.65	1198.21	174.77
1973-74	3353	231.24	2883.6	136.34	1163.02	169.64

APPENDIX II

Production area and yield of foodgrains and their index numbers in Haryana/Punjab during 1950-51 and 1973-74

PUNJAB 1960-61 = 100

(i) Rice

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg./hec.	Index
1950-51	107	46.72	126	55.51	849.20	84.17
1955-56	107	46.72	149	65.64	718.12	71.18
1960-61	229	100.00	227	100.00	1008.81	100.00
1961-62	230	100.44	228	100.44	798.61	79.16
1962-63	261	113.97	249	109.69	1048.19	103.90
1963-64	275	120.09	257	113.22	1070.03	106.06
1964-65	351	153.28	287	126.43	1222.99	121.23
1965-66	292	127.51	292	128.63	1000.00	99.11
1966-67	338	147.60	285	125.55	1185.96	11[illegible]46
1967-68	415	181.22	314	138.33	1321.65	131.61
1968-69	470	205.24	345	151.98	1362.31	135.04
1969-70	535	233.62	359	158.15	1490.25	147.72
1970-71	688	300.44	390	171.81	1764.10	174.16
1971-72	920	401.75	450	198.24	2044.44	202.65
1972-73	955	417.03	476	209.69	2006.30	198.87
1973-74	1140	497.82	499	219.82	2284.56	226.46

Appendix II

(ii) Jowar

Year	Production in '000 tonnes	Area '000 hec.	Yield kg/hec
1950-51	2	8	250.00
1955-56	(b)	6	(b)
1960-61	1	9	-
1961-62	1	6.6	-
1962-63	1	3.8	-
1963-64	1	2.4	-
1964-65	1	5.0	200.00
1965-66	-	4.0	-
1966-67	3	5.8	517.24
1967-68	3	5.6	535.71
1968-69	2	3.5	571.42
1969-70	3	4	750.00
1970-71	3	5	600.00
1971-72	2	3	666.66
1972-73	3	7	428.57
1973-74	3	5	600.00

Appendix II

(iii) Maize

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg/hec.	Index
1950-51	83	143.10	217	176.42	382.48	81.11
1955-56	48	82.76	125	101.63	384.00	81.43
1960-61	58	100.00	123	100.00	471.54	100.00
1961-62	79	136.21	142	115.45	556.33	117.98
1962-63	65	112.07	136	110.57	477.94	101.35
1963-64	49	84.48	106	89.37	466.66	98.99
1964-65	61	105.17	160	130.08	387.25	80.85
1965-66	80	137.93	156	126.83	512.82	108.75
1966-67	150	258.62	184	149.59	815.21	172.88
1967-68	208	358.62	209	169.92	995.21	211.06
1968-69	204	351.72	193	156.91	1056.99	224.15
1969-70	238	410.34	213	173.17	1117.3	236.94
1970-71	243	418.97	207	168.29	1173.91	248.95
1971-72	171	294.83	145	117.89	1179.31	250.09
1972-73	108	186.21	129	104.88	837.20	177.54
1973-74	144	248.28	147	119.51	979.59	207.74

Appendix II

(iv) Maize

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield in kg/hec.	Index
1950-51	142	38.27	252	77.06	563.49	49.66
1955-56	192	51.75	260	79.51	738.46	65.08
1960-61	371	100.00	327	100.00	1134.55	100.00
1961-62	447	120.42	323	98.78	1383.90	121.97
1962-63	308	83.02	362	110.70	850.82	74.99
1963-64	510	137.47	354	108.26	1440.67	126.98
1964-65	491	132.35	383	117.13	1281.98	112.99
1965-66	643	173.32	389	118.96	1652.95	145.69
1966-67	614	165.50	444	135.78	1382.88	121.88
2967-68	774	208.63	476	145.57	1626.05	143.32
1968-69	706	190.30	490	149.85	1440.81	121.99
1969-70	784	211.32	534	163.30	1468.16	129.40
1970-71	861	232.08	555	169.72	1551.35	136.73
1971-72	857	229.38	548	167.58	1563.86	137.83
1972-73	906	244.20	562	171.87	1612.09	142.09
1973-74	764	205.93	567	173.39	1347.44	118.76

Appendix II

(v) Wheat

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield kg/hec.	Index
1950-51	1024	58.78	1137	81.21	900.61	72.38
1955-56	1136	65.21	1292	92.29	879.25	70.66
1960-61	1742	100.00	1400	100.00	1244.28	100.00
1961-62	1766	101.38	1433	102.36	1232.37	99.04
1962-63	1761	101.09	1516	108.29	1161.60	93.35
1963-64	1895	108.78	1510	107.86	1254.96	100.85
1964-65	2367	135.88	1563	111.64	1514.39	121.70
1965-66	1916	109.99	1550	110.71	1236.12	99.34
1966-67	2451	140.70	1608.	114.86	1524.25	122.50
1967-68	3335	191.45	1790	127.86	1863.12	149.73
1968-69	4491	257.81	2063	147.36	2176.92	174.95
1969-70	4865	279.28	2166	154.71	2246.07	180.51
1970-71	5145	295.35	2299	164.21	2237.92	179.85
1971-72	5618	322.50	2336	166.86	2404.96	193.28
1972-73	5368	308.15	2404	171.71	2232.94	179.28
1973-74	5181	297.42	2338	167.00	2215.99	178.09

Appendix II

(vi) Total Cereals

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield kg/hec.	Index
1960-61	2453	100.00	2160	100.00	1135.64	100.00
1961-62	2578	105.10	2200	102.13	1168.63	102.90
1962-63	2447	99.76	2337	108.19	1047.06	92.19
1963-64	2773	113.05	2278	105.46	1217.29	107.18
1964-65	3342	136.24	2473	114.49	1351.39	118.99
1965-66	3000	122.30	2458	113.80	1220.50	107.47
1966-67	3646	148.63	2634	121.94	1384.20	121.88
1967-68	4883	199.06	2945	136.34	1658.06	146.00
1968-69	5949	242.52	3186	147.50	1867.23	164.42
1969-70	6505	265.19	3348	155.00	1942.95	1171.08
1970-71	6997	285.24	3514	162.69	1991.17	175.33
1971-72	7623	310.76	3531	163.47	2158.87	190.10
1972-73	7399	301.63	3634	168.24	2036.04	179.28
1973-74	7327	298.70	3668	169.81	1997.54	175.87

Appendix II

(vii) Gram

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield kg./hec.	Index
1950-51	511	71.46	851	101.55	600.47	70.37
1955-56	666	93.14	1002	119.57	664.67	77.90
1960-61	715	100.00	838	100.00	853.22	100.00
1961-62	696	97.34	849	101.31	819.78	96.08
1962-63	580	81.88	817	97.49	709.91	83.20
1963-64	444	62.09	761	90.81	583.44	68.38
1964-65	666	93.14	744	88.78	895.16	104.91
1965-66	370	51.74	602	71.83	614.61	72.03
1966-67	508	71.04	634	75.65	801.26	93.91
1967-68	452	63.21	530	63.24	852.83	99.99
1968-69	233	32.98	348	41.52	669.54	78.47
1969-70	393	54.96	380	45.34	1034.21	121.21
1970-71	284	39.72	358	42.72	793.29	92.97
1971-72	282	39.44	335	39.97	841.79	98.66
1972-73	267	37.34	319	38.06	836.99	98.09
1973-74	315	44.05	352	42.00	894.88	104.88

Appendix II

(viii) Total Pulses

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield kg./hec.	Index
1950-51	566	79.83	982	108.75	576.37	73.40
1955-56	706	99.58	1113	123.26	634.32	80.78
1960-61	709	100.00	903	100.00	785.16	100.00
1961-62	726	102.40	917	101.55	791.71	100.83
1962-63	611	86.18	887	98.23	688.83	87.73
1963-64	470	66.29	823	91.14	571.08	72.73
1964-65	686	96.76	801	88.70	856.42	109.02
1965-66	389	54.87	644	71.32	604.03	76.93
1966-67	532	75.04	692	76.63	768.78	97.91
1967-68	485	68.41	527	66.11	812.39	103.36
1968-69	263	37.09	411	45.51	639.90	81.49
1969-70	419	59.10	433	47.95	967.66	123.24
1970-71	308	43.44	414	45.85	743.96	94.75
1971-72	302	42.60	384	42.52	786.45	100.16
1972-73	293	41.33	381	42.19	769.02	97.94
1973-74	352	49.65	431	47.73	816.70	104.01

Appendix II

(ix) Total Foodgrains

Year	Production in '000 tonnes	Index	Area '000 hec.	Index	Yield kg./hec.	Index
1950-51	1995	63.09	2838	92.65	702.95	70.71
1955-56	2266	71.66	3053	99.67	742.22	74.24
1960-61	3162	100.00	3063	100.00	999.67	100.00
1961-62	3304	104.49	3123	101.96	1057.95	105.82
1962-63	3058	96.71	3224	105.26	948.51	94.88
1963-64	3243	102.56	3101	101.24	1045.79	104.61
1964-65	4028	127.39	3274	106.89	1230.29	123.66
1965-66	3389	107.18	3102	101.27	1092.52	109.28
1966-67	4178	132.13	3326	108.59	1256.16	125.65
1967-68	5368	169.70	3542	115.64	1515.52	151.6
1968-69	6212	196.46	3527	117.43	1726.99	172.75
1969-70	6924	218.98	3781	123.44	1831.26	183.18
1970-71	7305	231.02	3928	128.24	1859.72	186.63
1971-72	7925	250.63	3915	127.82	2024.26	202.49
1972-73	7692	243.26	4015	131.08	1915.81	191.64
1973-74	7679	242.85	4099	133.82	1873.38	187.39

Appendix III

Average of 5 year rainfall, 1970-74 for Punjab 1968-72 for Haryana

S. No.	District	(A) July-September	(B) October-November	(C) April-June	Total	In Centimeters % of A to total	% of B to total	% of C to total
1	Gurdaspur	71.27	16.01	11.43	98.71	72.20	16.22	11.58
2	Amritsar	46.14	8.40	10.40	64.90	71.09	12.94	16.02
3	Kapurthala	31.74	10.96	12.07	54.74	57.98	20.02	22.05
4	Jullundur	41.04	10.43	16.65	68.12	60.25	15.31	24.44
5	Hoshiarpur	51.76	13.00	15.16	79.92	64.76	16.27	18.97
6	Rupar	62.44	11.91	14.83	89.18	70.02	13.36	16.63
7	Ludhiana	41.18	6.63	9.84	57.65	71.43	11.50	17.07
8	Ferozepur	21.71	3.33	5.68	30.72	70.67	10.84	18.49
9	Faridkot	26.01	3.38	10.11	39.50	65.85	8.56	25.59
10	Bhatinda	26.48	3.22	6.83	36.53	72.49	8.81	18.70
11	Sangrur	31.31	4.61	8.75	44.67	70.09	10.32	19.59
12	Patiala	41.40	8.08	9.71	59.19	69.94	13.65	16.40
13	Hissar	21.89	10.60	6.20	38.69	56.58	27.40	16.02
14	Rohtak	38.78	10.06	7.71	56.55	68.58	17.79	13.63
15	Gurgaon	38.78	16.87	7.21	62.86	61.69	26.84	11.47
16	Karnal	47.50	9.96	10.00	67.46	70.41	14.76	14.82
17	Ambala	72.94	12.50	18.56	104.00	70.13	12.02	17.85
18	Jind	38.21	11.96	8.56	58.73	65.06	20.36	14.58
19	Mahendragarh	45.30	11.93	10.68	67.71	66.90	17.62	15.77

Source: Statistical Abstract of the States.

Appendix IV

District-wise Relative Yield and Area Index of four crops in Punjab and Haryana, 1964-65

Area in '000 hec
Yield in kg/hec

S.No.	District	Area under Rice I	Area under Maize II	Area under Bajra III	Area under Wheat IV
1	Hissar	13,900	2,300	296,200	139,600
2	Rohtak	6,600	3,500	96,900	144,200
3	Gurgaon	100	2,300	122,700	99,600
4	Karnal	118,800	46,700	33,500	216,400
5	Ambala	39,000	34,700	5,000	70,600
6	Jind	4,600	1,200	44,600	43,000
7	Mahendragarh	-	-	190,400	9,100
8	Hoshiarpur	28,600	60,800	1,940	92,600
9	Jullundur	8,000	67,000	1,000	130,000
10	Ludhiana	3,000	50,000	1,000	151,000
11	Ferozepur	43,000	32,000	36,000	324,000
12	Amritsar	69,000	40,000	9,000	162,000
13	Gurdaspur	60,000	30,000	2,000	111,000
14	Kapurthala	17,000	13,000	-	56,000
15	Bhatinda	1,000	8,000	72,000	182,000
16	Patiala	41,000	34,000	4,000	142,000
17	Sangrur	10,000	32,000	33,000	191,000
18	Rupar	6,700	25,700	20	21,300

Appendix IV contd..

S.No.	District	Yield of				Area under I + II + III +IV
		Rice	Maize	Bajra	Wheat	
		V	VI	VII	VIII	IX
1	Hissar	1,295	870	436	1,254	452,000
2	Rohtak	1,515	1,429	351	1,297	251,200
3	Gurgaon	(a)	870	253	1,186	224,600
4	Karnal	1,666	942	358	1,354	415,400
5	Ambala	1,144	1,089	380	1,047	149,300
6	Jind	1,304	917	379	1,379	934,000
7	Mahendragarh	-	-	326	1,538	199,500
8	Hoshiarpur	1,129	1,693	500	961	173,940
9	Jullundur	1,375	1,507	-	1,909	206,000
10	Ludhiana	1,333	1,460	-	2,232	205,000
11	Feorzepur	1,116	1,219	361	1,299	435,000
12	Amritsar	1,391	1,250	444	1,678	280,000
13	Gurdaspur	1,150	1,067	500	1,162	203,000
14	Kapurthala	1,529	1,154	-	1,429	860,000
15	Bhatinda	1,000	750	389	1,769	263,000
16	Patiala	1,098	735	250	1,500	221,000
17	Sangrur	1,100	813	394	1,377	266,000
18	Rupar	1,149	1,342	-	1,455	537,200

Appendix IV contd.

S.No.	District	% of are under different crops to total			
		% of (I) to (IX)	% of (II) to (IX)	% of (III) to (IX)	% of (IV) to IX
		X	XI	XII	XIII
1	Hissar	3.07	65.63	.50	30.88
2	Rohtak	2.62	38.57	1.39	57.40
3	Gurgaon	.04	54.63	1.02	44.30
4	Karnal	28.59	8.06	11.24	52.09
5	Ambala	26.12	3.34	23.24	47.28
6	Jind	4.92	47.75	1.28	46.03
7	Mahendragarh	-	96.43	-	4.56
8	Hoshiarpur	16.44	1.11	29.20	53.23
9	Jullundur	3.38	.48	32.52	63.10
10	Ludhiana	1.46	.48	24.39	73.65
11	Ferozepur	9.88	8.27	7.36	74.48
12	Amritsar	24.64	3.21	14.28	57.85
13	Gurdaspur	29.55	.98	14.77	54.67
14	Kapurthala	19.76	-	15.11	65.11
15	Bhatinda	.38	27.38	3.04	69.20
16	Patiala	18.55	1.80	15.38	64.25
17	Sangrur	-	-	47.84	39.65
18	Rupar	12.47	.03	-	-

Appendix IX contd.

Relative Yield Index

S.No.	District	$\frac{V}{mean}$ x100	$\frac{VI}{X}$x100	$\frac{VII}{X}$ x 100	$\frac{VIII}{X}$ x100
		XIV	XV	XVI	XVII
1	Hissar	102.61	114.72	77.41	88.57
2	Rohtak	120.04	92.35	127.14	91.60
3	Gurgaon	(a)	66.67	77.41	83.76
4	Karnal	124.08	94.19	83.81	95.63
5	Ambala	90.64	99.98	96.89	73.95
6	Jind	103.32	99.72	81.59	97.40
7	Mahendragarh	-	85.70	-	108.63
8	Hoshiarpur	89.45	131.55	150.63	67.87
9	Jullundur	108.94	-	134.08	110.81
10	Ludhiana	105.62	-	129.90	157.64
11	Ferozepur	88.42	94.98	108.46	91.75
12	Amritsar	110.21	116.82	111.22	118.51
13	Gurdaspur	91.12	131.55	94.97	82.07
14	Kapurthala	121.15	-	102.67	100.93
15	Bhatinda	79.29	102.35	66.73	124.94
16	Patiala	87.00	65.78	65.39	105.94
17	Sangrur	87.15	103.67	72.33	97.25
18	Rupar	91.04	-	119.40	102.76

Appendix IX contd.

S.No.	District	Relative Area Index $\frac{X}{V} \times 100$ XVIII	$\frac{XI}{X} \times 100$ XIX	$\frac{XII}{X} \times 100$ XX	$\frac{XIII}{X} \times 100$ XXI
1.	Hissar	27.26	288.42	4.41	56.45
2	Rohtak	23.27	169.76	12.27	104.94
3	Gurgaon	.36	240.45	9.00	80.99
4	Karnal	253.91	35.48	99.21	96.23
5	Ambala	231.97	14.70	205.12	86.44
6	Jind	43.69	210.17	11.30	84.15
7	Mahendragarh	-	420.03	-	8.34
8	Hoshiarpur	146.00	4.89	257.72	97.31
9	Jullundur	30.02	2.11	287.03	115.36
10	Ludhiana	12.97	2.11	215.27	134.64
11	Ferozepur	87.74	36.40	64.87	136.16
12	Amritsar	218.83	14.13	126.04	105.76
13	Gurdaspur	262.43	4.31	130.36	99.95
14	Kapurthala	175.49	-	133.36	119.03
15	Bhatinda	3.37	120.51	26.83	126.51
16	Patiala	164.74	7.92	135.75	117.46
17	Sangrur	33.30	54.58	106.18	13.26
18	Rupar	110.75	.13	422.24	72.49

Appendix V

District wise Relative Yield and Area Index of Four Crops in Punjab and Haryana, 1968-9

S. No.	District	Area under Rice I	Area under Maize II	Area under Bajra III	Area under Wheat IV	Yield of Rice V	Yield of Maize VI	Yield of Bajra VII	Yield of Wheat VIII	Area under I+II+III+IV IX
1	Gurdaspur	79	29	1.8	127	1,383	1,000	500	1,953	236.8
2	Amritsar	73	49	6.6	214	1,550	1,292	625	2,342	342.6
3	Kapurthala	24	15	2.7	61	1,570	1,533	667	2,302	102.7
4	Jullundur	12	63	0.4	166	1,385	1,464	1,000	2,311	241.4
5	Hoshiarpur	29	66	2.9	122	1,145	1,080	333	1,521	219.9
6	Rupar	6	31	0.3	53	915	1,082	-	1,789	90.3
7	Ludhiana	3	70	1.4	213	1,333	2,138	1,000	2,674	287.4
8	Ferozepur	55	51	40.0	394	1,237	1,563	641	1,874	540.0
9	Bhatinda	1	21	88.4	260	1,000	1,333	1,305	2,272	370.4
10	Sangrur	11	59	42.7	261	1,000	1,508	1,100	2,144	373.7
11	Patiala	52	36	6.2	192	1,365	1,352	1,000	2,492	286.2
12	Hissar	13	5	350	163	1,590	1,341	245	1,461	531.0
13	Rohtak	16	6	93	185	1,375	746	457	1,707	300.0
14	Gurgaon	1	4	131	126	1,186	689	330	1,733	262.0
15	Karnal	145	34	30	273	1,163	617	326	2,011	482.0
16	Ambala	46	35	5	77	1,089	872	266	1,240	163.0
17	Jind	8	4	55	62	1,125	302	490	1,455	129.0
18	Mahendragarh	-	(a)	210	12	-	-	111	1,839	222.0

Appendix V contd.

S. No.	% of (I) to (IX)	% of (II) to (IX)	% of (III) to (IX)	% of (IV) to (IX)	$\frac{V}{mean}\times100$	$\frac{VI}{\bar{X}}\times100$	$\frac{VII}{\bar{X}}\times100$	$\frac{VIII}{\bar{X}}\times100$	$\frac{X}{\bar{X}}\times100$	$\frac{XI}{\bar{X}}\times100$	$\frac{XII}{\bar{X}}\times100$	$\frac{XIII}{\bar{X}}\times100$
	% of Area under dif.crops				Relative Yield Index				Relative Area Index			
	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI
1	33.36	12.25	.76	53.63	109.79	85.59	81.76	100.10	95.82	36.03	1.28	32.60
2	21.31	14.30	1.93	62.46	123.07	110.58	102.20	120.03	63.12	42.06	3.25	35.97
3	23.37	14.61	2.63	59.46	124.66	131.21	109.07	117.98	69.22	42.97	4.44	36.11
4	4.97	26.10	.17	68.77	109.97	125.30	163.52	118.45	14.72	76.76	.29	41.81
5	13.19	30.01	1.32	55.48	90.91	92.44	54.45	77.96	39.07	88.26	2.23	33.73
6	6.64	34.33	.33	58.69	72.65	88.33	-	91.69	19.67	100.97	.56	35.68
7	1.04	24.36	.49	74.11	105.84	182.99	163.52	137.05	3.08	71.65	.83	45.05
8	10.19	9.44	7.41	72.36	98.22	133.78	104.82	96.05	30.18	27.76	12.50	43.99
9	.27	5.67	23.87	70.19	79.40	114.09	213.40	116.45	.80	16.68	40.29	42.67
10	2.94	15.79	11.43	69.84	79.40	129.07	179.88	109.89	8.71	46.44	19.27	42.46
11	18.17	12.58	2.17	67.09	108.38	116.72	163.52	127.72	53.82	37.00	3.36	40.78
12	2.45	.94	65.91	30.70	126.24	114.78	40.06	74.88	7.26	2.76	110.16	18.66
13	5.33	2.00	31.00	61.67	109.17	63.85	74.73	87.49	15.79	5.88	52.28	37.49
14	.38	1.53	50.00	48.09	94.17	58.97	53.96	88.82	1.13	4.50	34.32	29.23
15	30.08	7.06	6.22	56.64	92.34	52.17	53.31	103.07	89.10	24.74	10.49	34.42
16	28.22	21.47	3.07	47.24	86.46	74.64	43.50	63.55	83.59	63.15	5.18	28.72
17	6.20	3.10	42.64	48.06	89.32	25.85	80.13	74.57	18.36	9.12	71.91	29.22
18	-	(a)	94.59	5.41	-	-	18.15	94.25	-	(a)	-	3.29

Appendix VI

District-wise Relative Yield and Area Index of Four Crops in Punjab and Haryana, 1973-74

S. No.	District	Area under				Yield of				Area under I+II+III+IV
		Rice	Maize	Bajra	Wheat	Rice	Maize	Bajra	Wheat	
		I	II	III	IV	V	VI	VII	VIII	IX
1	Gurdaspur	85	36	-	147	1,817	1,342	1,000	1,867	268
2	Amritsar	124	41	-	246	2,217	1,250	1,000	2,049	411
3	Kapurthala	29	16	-	73	2,310	1,562	-	1,917	118
4	Jullundur	27	80	-	201	2,777	1,341	-	2,348	308
5	Hoshiarpur	34	90	-	147	1,687	1,342	-	1,685	271
6	Rupar	8	37	-	63	2,125	1,459	-	1,873	108
7	Ludhiana	11	100	-	241	3,090	1,757	1,000	2,929	352
8	Ferozepur	74	-	-	242	2,770	625	1,163	2,116	316
9	Faridkot	20	23	-	257	3,176	571	1,571	2,307	300
10	Bhatinda	1	16	58	191	2,000	1,[illegible]	714	1,942	266
11	Sangrur	18	-	-	280	2,470	1,[illegible]	866	2,476	298
12	Patiala	86	-	-	250	2,197	1,260	1,000	2,196	336
13	Hissar	17.6	3.4	193.4	207.5	1,812	1,471	724	1,465	421.90
14	Bhiwani	(a)	0.4	275.5	26.4	-	-	494	1,228	302.30
15	Gurgaon	2.8	5.3	93.8	148.3	1,786	566	832	1,254	250.20
16	Jind	13.4	4.1	89.5	104.3	1,493	732	860	1,611	211.30
17	Mahendragarh	(a)	(a)	150.9	36.1	-	-	862	1,939	187.00
18	Ambala	48.9	41.6	4.6	98.4	1,513	1,034	652	1,087	193.50
19	Karnal	83.3	29.0	10.1	177.7	1,298	862	693	1,396	300.20
20	Kurukshetra	114.3	28.0	19.6	185.6	2,117	1,214	816	1,897	347.50
21	Rohtak	2.3	1.5	96.7	103.0	1,304	1,333	879	1,291	203.50
22	Sonepat	8.6	5.2	21.8	89.2	1,279	769	872	1,267	124.80

Appendix VI contd.

S. No.	% of Area under dif. crops: % of (I) to (IX)	% of (II) to (IX)	% of (III) to (IX)	% of (IV) to (IX)	V/mean x100	Relative Yield Index: VI/X x100	VII/X x100	VIII/X x100	Relative Area Index: I/X x100	XI/X x100	XII/X x100	XIII/X x100
	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI
1	1.86	13.43	-	54.85	87.00	117.03	112.58	102.17	13.50	141.97		91.98
2	30.17	9.97	-	59.85	106.15	109.00	112.58	112.13	219.90	106.39	-	100.37
3	24.57	13.55	-	61.86	110.60	136.21	-	104.91	179.08	143.23	-	103.74
4	8.76	26.97	-	65.25	132.96	116.94	-	128.50	63.85	274.52	-	109.42
5	12.54	33.21	-	54.24	80.77	117.03	-	99.21	91.40	351.06	-	90.95
6	7.40	34.25	-	58.33	101.74	127.23	-	102.50	53.94	362.05	-	97.82
7	3.12	28.40	-	68.46	147.96	153.22	112.58	160.29	22.74	300.21	-	114.81
8	3.41	-	-	76.58	132.62	54.50	129.81	115.80	170.63	-	-	128.43
9	6.66	7.66	-	85.66	152.06	49.79	176.87	125.25	48.54	80.97	-	143.65
10	.37	6.01	21.80	71.80	95.96	109.00	80.39	106.23	2.70	63.53	126.74	120.41
11	6.04	-	-	93.95	118.26	94.70	97.50	135.50	44.02	-	-	157.55
12	25.59	-	x	74.40	105.19	119.38	112.58	120.18	186.52	-	-	124.77
13	4.17	.80	45.84	49.18	87.04	128.28	81.51	80.17	30.39	8.46	266.51	82.48
14	(a)&(b)	.13	91.13	8.73	-	-	65.62	70.49	(a)	1.37	529.83	14.64
15	1.11	2.11	37.49	59.27	85.51	49.36	93.67	68.63	8.09	22.30	217.97	93.40
16	6.24	1.94	42.35	49.36	71.48	63.83	96.80	88.16	46.21	20.51	246.22	82.78
17	(a)	(a)	80.69	19.30	-	-	97.05	106.11	(a)	(a)	469.13	32.37
18	25.27	21.49	2.37	50.85	72.44	90.17	73.41	59.49	184.18	227.17	13.78	85.28
19	27.91	9.66	3.36	59.19	87.43	75.17	78.02	76.40	203.43	102.11	19.53	99.26
20	32.89	8.05	5.64	53.41	101.36	165.86	91.87	103.82	239.72	85.10	32.79	89.57
21	1.13	.73	47.51	50.61	62.43	116.24	98.96	70.65	8.24	7.72	276.22	83.87
22	6.89	4.16	17.46	71.47	61.24	67.06	98.17	69.34	50.22	43.97	101.51	119.86

Appendix VII

Area Yield and Cropping Pattern of Punjab and Haryana

		Rice	Jowar	Bajra	Maize	Wheat	Barley	Gram	Sugarcane	R & M
Punjab										
1973-74	A	499	5	147	567	2338	110	352	110	179
1964-65	A	287.3	5	159.6	382.5	1562	57	743	121.7	95.4
1973-74	Y	228.7	587	982	1348	2216	855	876	5289	763
1964-65	Y	1222	200	381	1275	1510	1274	895	3651	575
19773-74	C	.08	.00	.02	.09	.38	.02	.06	.02	.03
1964-65	C	.06	.00	.31	.07	.30	.01	.14	.02	.01
Haryana										
1973-74	A	291.7	186.0	955.9	118.5	1176.6	154.1	993.9	149.5	168.8
1964-65	A	183	287.7	989.3	90.7	722.4	92.2	88.7	143.9	166.8
1973-74	Y	1851	296	723	1004	1539	889	451	3966	314
1964-65	Y	1446	178	363	1013	1274	1105	586	4698	471
1973-74	C	.05	.03	.18	.02	.22	.03	.19	.03	.03
1964-65	C	.04	.06	.17	.02	.16	.02	.02	.03	.03

A = Area in '000 hectares
Y = Yield kg/hec.
C = Share of the total 1964 area

Appendix VIII

Area, Yield and Cropping of Different Districts of Punjab and Haryana, 1972-1973

S. No.	Name of Districts	Rice			Maize		
		Area[2] (i)	Yield[2] (ii)	Cropping pattern (iii)	(i)	(ii)	(iii)
1	Gurdaspur	82.0	1634	.30	36	1666	.13
2	Amritsar	93.0	1892	.34	36.0	1666	.09
3	Kapurthala	28.0	2607	.25	16.0	1562	.14
4	Jullundur	29.0	2241	.10	77.0	1675	.26
5	Hoshiarpur	40.0	1975	.23	81.0	1444	.26
6	Rupar	8.0	1625	.07	38.0	1078	.36
7	Ludhiana	12.0	2333	.03	94.0	2127	.26
8	Feorzepur	65	2400	.19	16.0	1000	.05
9	Faridkot	14	2857	.04	29.0	1379	.09
10	Bhatinda	1.0	2000	.00	17.0	1647	.06
11	Sangrur	16.0	1937	.04	74.0	1864	.18
12	Patiala	88.0	1975	.23	44.0	1409	.11
13	Karnal	84.10	1560	.28	26.50	1090	.09
14	Gurgaon	2.40	1594	.01	5.50	700	.02
15	Hissar	18.60	1700	.04	3.20	720	.01
16	Rohtak	3.30	1073	.02	2.40	1064	.01
17	Mahemdragarh	(a)	-	-	0.10	-	-
18	Ambala	47.40	1220	.24	42.30	1340	.21
19	Jind	13.30	1320	.06	4.20	916	.02
20	Bhiwani	0.10	-	.00	0.40	-	.00
21	Kurukshetra	112.80	1820	.33	22.30	1188	.06
22	Sonepat	9.40	1362	.07	6.30	681	.06

(1) Area in 1000 hectares (2) Yield in kg per hectare

Appendix VIII

Area, Yield & Cropping.....

S. No.	Bajra (i)	(ii)	(iii)	Wheat (i)	(ii)	(iii)	Total area K+K+B+W
1	3.0	666	.01	152.0	2013	.56	273.0
2	5.0	400	.01	248.0	2197	.65	382.0
3	-	-	-	67.0	2119	.60	111.0
4	-	-	-	194.0	2505	.66	300.0
5	-	-	-	155.0	1883	.61	276.0
6	-	-	-	61.0	1641	.57	107.0
7	1.0	1000	.00	253.0	2320	.70	360.0
8	15.0	533	.04	249.0	2136	.72	345.0
9	21.0	1142	.06	268.0	2447	.81	332.0
10	58.0	896	.20	216.0	1819	.74	292.0
11	24.0	708	.06	290.0	2400	.72	404.0
12	2.0	1000	.01	251.0	1940	.65	3850
13	9.00	115	.03	185.30	1899	.61	304.80
14	88.40	693	.34	162.40	1780	.63	258.70
15	187.80	561	.43	229.90	1653	.52	439.5
16	93.50	805	.43	119.20	1628	.55	217.4
17	144.10	399	.77	42.90	1861	.23	187.1
18	6.2	517	.03	101.40	1431	.51	197.3
19	84.00	681	.40	107.50	1717	.51	209.0
20	253.20	282	.90	26.90	1794	.10	280.6
21	15.80	586	.05	193.10	1811	.66	344.0
22	22.30	979	.16	102.00	2052	.73	140.0

Appendix VIII

Area, Field and Cropping..... 1973-74

No.	Rice (i)	Rice (ii)	Rice (iii)	& Maize (i)	Maize (ii)	Maize (iii)
1	82.00	1817	.30	35.00	1343	.13
2	124.00	2218	.30	40.00	1250	.10
3	29.00	2310	.21	16.00	1563	.12
4	27.00	2778	.09	79.00	1975	.26
5	32.00	1688	.10	73.00	1342	.24
6	8.00	2125	.07	37.00	1459	.34
7	11.00	3091	.03	99.00	1758	.28
8	74.00	2770	.22	16.00	625	.05
9	17.00	3176	.06	28.00	571	.09
10	1.00	2000	.00	16.00	1250	.06
11	17.00	2471	.45	69.00	1087	.18
12	86.00	2198	.22	46.00	1370	.12
13	83.80	1826	.28	29.00	862	.10
14	2.80	1786	.01	5.30	566	.02
15	17.60	1818	.04	3.40	1471	.01
16	2.30	1304	.01	1.50	1333	.01
17	(a)	-	-	(a)	-	(a)
18	48.90	1513	.25	41.60	1034	.21
19	13.40	1493	.06	4.10	723	.02
20	(a)	-	(a)	0.40	-	.00
21	114.30	2117	.33	28.00	1814	.08
22	8.60	1279	.07	5.20	769	.04

Appendix VIII

Area, Field and Cropping...

S. No.	Bajra (i)	Bajra (ii)	Bajra (iii)	Wheat (i)	Wheat (ii)	Wheat (iii)	Total
1	3.00	1000	.01	161.00	1868	.59	271.0
2	6.00	1000	.01	243.00	2049	.59	413.0
3	-	-	-	73.00	1918	.53	118.0
4	-	-	-	201.00	2348	.65	307.0
5	-	-	-	200.00	1685	.66	305.0
6	-	-	-	63.00	1873	.53	108.0
7	1.00	1000	.00	241.00	2929	.68	352.0
8	13.00	1154	.04	241.00	2116	.70	344.0
9	21.00	1571	.07	257.00	2307	.80	323.0
10	56.00	714	.21	191.00	1942	.72	264.0
11	30.00	867	.08	275.00	2476	.70	391.0
12	4.00	1000	.01	250.00	2196	.65	386.0
13	10.10	693	.03	177.70	1396	.59	300.6
14	93.80	832	.37	148.30	1254	.59	250.2
15	193.40	724	.46	207.5	1466	.49	421.9
16	96.70	879	.48	103.00	1291	.51	203.5
17	150.90	862	.81	36.10	1939	.19	187.0
18	4.60	652	.02	98.40	1087	.51	193.5
19	89.50	860	.42	104.30	1611	.49	211.3
20	275.50	494	.91	26.40	1288	.09	302.3
21	19.60	816	.06	185.60	1897	.53	347.5
22	21.80	872	.17	89.20	1267	.71	124.8

Appendix IX

Mechanisation Index (1971)

S. No.	District	No. of tube-wells pump-sets (A)	No. of hec-tares (B)	(A) per 1000 hec. (C)	(B) per 1000 hec. (D)	C mean (E)	D mean (F)	Index (E)+(F)
1	Gurdaspur	8253	2146	22.74	5.91	1.11	.20	1.31
2	Amritsar	11409	4611	19.47	7.87	.95	1.45	2.40
3	Kapurthala	4285	1341	27.65	8.65	1.35	1.59	2.94
4	Jullundur	14,523	5017	36.87	12.73	1.80	2.34	4.14
5	Hoshiarpur	6,640	3877	19.14	11.17	.93	2.05	2.85
6	Rupar	2,895	778	14.55	3.91	.71	.72	1.43
7	Ludhiana	14,061	5079	28.58	10.32	1.39	1.90	3.29
8	Ferozepur	10,584	9038	9.73	8.31	.47	1.53	2.00
9	Bhatinda	1,837	5143	2.12	5.93	.10	1.09	1.19
10	Sangrur	6,846	4349	10.78	6.85	.53	1.26	1.79
11	Patiala	9,540	4738	17.31	8.60	.84	1.58	2.42
12	Hissar	8,498	645	5.59	.42	.27	.08	.35
13	Rohtak	9,663	711	13.53	1.00	.66	.18	.84
14	Gurgaon	12,915	1153	29.65	1.81	1.44	.33	1.77
15	Karnal	42,193	576	40.70	.61	2.18	.11	2.29
16	Ambala	13,302	1006	37.58	2.84	1.83	.52	2.35
17	Jind	4,587	419	13.25	1.00	.65	.18	.83
18	Mahendragarh	7,230	8	16.36	.02	.80	.00	.80
Mean		-	-	20.53	5.44			

Source: Statistical Abstracts of Punjab and Haryana.

Appendix X

Correlation Matrix

	HYV	Soil	Irrigation	Fertilizer	Mechanization
HYV	1.000	0.168	0.890	-0.034	0.504
Soil		1.000	0.073	0.451	0.331
Irrigation			1.000	-0.094	0.445
Fertilizer				1.000	0.581
Mechanization					1.000

Appendix XI

Method of maximising the sum of quared projections;

This method can be explained with the help of the following example of three districts and three variables.

Let the given data matrix be

$$\begin{bmatrix} X_{11} & X_{12} & X_{13} \\ X_{21} & X_{22} & X_{23} \\ X_{31} & X_{32} & X_{33} \end{bmatrix} \qquad \ldots\ldots \qquad (1)$$

First step; Normalisation of the given data matrix is done by division of columns mean

$$\hat{X} = \begin{bmatrix} X_{11}/\bar{X}_1 & X_{21}/\bar{X}_2 & X_{21}/\bar{X}_3 \\ X_{21}/\bar{X}_1 & X_{22}/\bar{X}_2 & X_{22}/\bar{X}_3 \\ X_{31}/\bar{X}_1 & X_{32}/\bar{X}_2 & X_{33}/\bar{X}_3 \end{bmatrix} = \begin{bmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \\ x_{31} & x_{32} & x_{33} \end{bmatrix} \ldots(2)$$

Second Step; Calculate A matrix = $\frac{\hat{X}'\hat{X}}{n}$ where n = number of observations (here n = 3)

$$A = \frac{\hat{X}'\hat{X}}{n} \quad \frac{\begin{bmatrix} x_{11} & x_{21} & x_{31} \\ x_{21} & x_{22} & x_{32} \\ x_{31} & x_{32} & x_{33} \end{bmatrix} \begin{bmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \\ x_{31} & x_{32} & x_{33} \end{bmatrix}}{n}$$

$$= \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

Third Step: Calculate the eigen value with the help of equation $(A - \lambda)W = 0$ i.e. $(A - \lambda I) =$

$$\begin{bmatrix} a_{11}-\lambda & a_{12} & a_{13} \\ a_{21} & a_{22}-\lambda & a_{23} \\ a_{31} & a_{32} & a_{33}-\lambda \end{bmatrix} = 0$$

Where I = Identity matrix, λ = Eigen value, from which we can get the values of λ.

Fourth Step: Taking the highest eigen value of the matrix A which also explain the maximum total variation, wet put it in the matrix (4) and multiply it by the vector (W) which gives the weights W_1, W_2, W_3 for the three respective variables i.e.

$$\begin{bmatrix} a_{11}-\lambda & a_{12} & a_{13} \\ a_{21} & a_{22}-\lambda & a_{23} \\ a_{31} & a_{32} & a_{33}-\lambda \end{bmatrix} \begin{bmatrix} W_1 \\ W_2 \\ W_3 \end{bmatrix} = 0 \quad \ldots \quad (3)$$

where λ = highest eigen value

From the above matrix we get three equations and so the values of W_1, W_2, W_3 can be calculated.

Appendix XII

Productivity in Rupees

(Yield & Price)

S. No.	District	Rice	Wheat	Barley	Jowar	Bajra	Maize	Gram	Rape and Mustard	Toria
1	Amritsar	1074.15	1767.76	641.75	620.00	688.00	1028.85	1288.50	0.97	-
2	Bhatinda	717.60	1611.96	381.80	653.40	687.52	745.17	537.12	0.65	-
3	Ferozepur	1039.40	1663.74	695.66	431.20	587.67	758.67	470.47	0.75	-
4	Gurdaspur	988.20	1587.64	369.60	348.40	635.60	513.36	958.50	0.66	-
5	Hoshiarpur	861.30	1108.24	-	400.00	1000.00	766.65	872.85	0.64	-
6	Jullundur	925.00	1893.92	=	319.56	-	847.55	1410.00	0.87	-
7	Kapurthala	1006.49	1920.52	431.60	-	-	897.84	-	0.80	-
8	Ludhiana	936.00	2492.04	1444.00	387.10	540.00	1144.64	1128.00	1.02	-
9	Patiala	926.75	1526.84	321.75	423.15	543.30	793.14	783.75	0.63	-
10	Rupar	747.60	1480.48	594.00	216.50	-	714.45	677.25	0.43	-
11	Sangrur	696.15	1628.68	642.50	286.20	699.60	933.90	757.68	0.55	-
12	Ambala	660.76	1269.07	983.25	207.75	721.57	464.75	518.50	-	-
13	Gurgaon	1347.20	1293.60	737.88	126.00	499.00	550.00	680.10	0.03	-
14	Hissar	838.99	1622.78	401.50	212.50	482.85	904.00	571.74	-	-
15	Jind	566.00	1464.84	225.54	192.40	621.30	985.00	671.50	-	-
16	Karnal	1158.00	1892.40	410.31	161.20	444.60	789.60	755.20	0.2	-
17	Mahendragarh	-	1348.24	495.36	117.50	318.75	-	336.60	-	-
18	Rohtak	772.52	1862.35	469.20	130.50	534.24	837.00	906.75	0.7	-

Appendix XII

Productivity in Rupees (Yield and Price)

S. No.	District	Raw Sugar	Cotton (Desi)	Cotton (American)	Tobacco	Groundnut	Seasmum	Linseed	Potato	Total
1	Amritsar	3633.75	467.86	549.45	-	928.20	1.11	0.14	6474.60	18860.09
2	Bhatinda	3661.65	669.06	1102.40	-	968.00	-	-	4556.20	16292.53
3	Ferozepur	3021.75	987.50	1248.00	-	1230.25	-	-	17763.79	17763.79
4	Gurdaspur	3147.00	397.60	319.20	-	-	0.55	0.50	4128.88	13396.73
5	Hoshiarpur	3499.50	163.20	306.00	4.16	965.20	0.62	0.64	5274.64	15224.34
6	Jullundur	3632.16	464.00	900.00	9.89	1186.90	1.60	0.85	7187.29	18779.48
7	Kapurthala	2220.72	384.25	584.95	-	1133.96	-	-	5275.60	14855.73
8	Ludhiana	4200.00	592.00	749.25	-	1377.60	1.00	1.71	6213.22	21207.55
9	Patiala	3227.00	456.00	957.70	-	1456.00	1.12	0.57	5964.79	23347.28
10	Rupar	4149.00	241.50	346.72	-	909.77	0.69	0.37	6234.80	16312.49
11	Sangrur	4675.00	511.82	690.65	-	1184.40	-	-	4216.40	17023.44
12	Ambala	3573.00	320.70	-	-	1136.80	0.52	0.80	6714.40	16591.90
13	Gurgaon	2217.50	252.00	592.35	-	1335.15	-	-	3714.40	16365.21
14	Hissar	4569.50	765.00	864.92	377.00	2401.23	1.10	-	5995.00	1973.88
15	Jind	3345.65	357.00	561.60	-	-	0.66	-	5995.00	14586.49
16	Karnal	3649.80	292.60	467.50	2.58	1834.80	0.69	1.56	7913.40	19764.26
17	Mahendragarh	3372.60	-	-	-	-	-	-	-	5994.45
18	Rohtak	6400.00	357.00	414.00	3.57	2571.00	-	-	5035.80	29094.00

Table XIII

Correlation Matrix

	1 % of HYV to total cropped area	2 Soil rating index	3 % of GAI to TCA	4 Tonnage of N_2 fertilizer to GAI	5 Mechanisation index	6 Per hec. productivity in money terms	7 % of agri. lab. to total agri. worker	8 % of rural S.C. to total rural population	9 % of literate population to total population
% of HYV to total cropped area	1.00	.176	.890**	-.133	.604*	.550**	.472*	-.237	.092
Soil rating index		1.00	.078	.123	.338	-.106	-.077	-.379	.611*
% of GIA to TCA			1.00	-.039	-.445	.517*	.612**	-.338	-.045
Tonnage of N_2 fertilizer per 100 hec. GAI				1.00	.259	-.147	.148	.104	.191
Mechanisation Index					1.00	.336	.565**	-.208	.581**
Per hec. productivity in money terms						1.00	.570**	.126	.208
% of agri. lab. to total rural pop.							1.00	-.047	.213
% of rural S.C. to total rural pop.								1.00	-.039
% of lit. pop. to total population									1.00

At ** $t_{5\%}$ = 2.101 ** $t_{1\%}$ = 2.878

Appendix XIV

Results of Step-Wise Regression Analysis

Variables	Regression Coefficient	S. E.	t	R^2	Increase in R^2	$\bar{R}^2$	F
1	2	3	4	5	6	7	8
Step 1							
x_3	.566	.072	7.812****	.792	-	.890	7.466
Step 2							
x_3	.576	.071	7.958****	.792	-	.890	7.599
x_9	.276	.232	1.187	.810	.018	.893	
Step 3							
x_3	.644	.091	7.064****	.792			
x_9	.369	.239	1.541*	.810			
x_7	-.419	.330	-1.269	.829	.019	.898	7.693
Step 4							
x_3	.613	.094	6.490****	.792			
x_9	.321	.241	1.331	.810			
x_7	-.542	.344	-1.573*	.829			
x_6	.00066	.0006	1.124	.844	.015	.900	7.889

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Appendix XIV

Results of Step-wise Regression Analysis

1	2	3	4	5	6	7	8
Step 5							
x_3	.573	.102	5.603****	.792			
x_9	.117	.315	.373	.810			
x_7	-.665	.365	-1.817**	.829			
x_6	.00077	.0006	1.280	.844			
x_5	2.810	2.803	1.002	.856	.012	.901	8.185
Step 6							
x_3	.563	.104	5.406****	.792			
x_9	.127	.319	.398	.810			
x_7	-.603	.377	-1.599*	.829			
x_6	.0006	.0063	1.004	.844			
x_5	3.227	2.882	1.119	.856			
x_4	-.678	.808	-.838	.865	.009	.899	8.627
Step 7							
x_3	.611	.116	5.232****	.792			
x_9	.166	.324	.511	.810			
x_7	-.641	.382	-1.679*	.829			
x_6	.00038	.00068	.563	.844			

Appendix XIV

Results of Step-wise Regression Analysis

1	2	3	4	5	6	7	8
x_5	3.602	2.916	1.201	.856			
x_4	-.839	.832	-1.008	.865			
x_8	.167	.180	.926	.876	.011	.899	9.069
Step 8							
x_3	.593	.130	4.633****	.792			
x_9	.049	.454	.108	.810			
x_7	-.588	.422	-1.391*	.829			
x_6	.00045	.00074	0.614	.844			
x_5	3.608	3.061	1.178	.856			
x_4	-.865	.872	-.991	.865			
x_8	.189	.196	.960	.876			
x_2	.260	.675	.386	.878	.002	.890	9.944

**** = significant at 1% level
*** = significant at 5% level
* * = significant at 10% level
* = significant at 20% level.

Appendix XV

Concentration of Area under High Yielding Variety to Size Class Holdings

High yielding varieties and fertilizers are size neutral in the sense that they are perfectly divisible and can be used irrespective of the farm, but they are not resource neutral.[1] Since the large farms have a better command over resources, one should expect more adoption of HYV by large classes.

To examine this, we do not have size class data regarding the adoption of HYV. It has been just seen in chapter VI how tube well irrigated area helps in adoption of HYV more intensively than general irrigation. Therefore, an attempt has been made to examine the concentration of holdings in different size classes and area under tube well irrigation.

The following table shows the percentage of number of holdings to total in different size classes and percentage of tube-well irrigated area for the same.

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1 C.H.H. Rao, Technological Changes and Distribution of Grains in Indian Agriculture (1975), p. 44.

Size class	No. of holding	% of holding to total holding	Area under holding	Area under tube-well	% of tube-well area irrigated to total % of (E) and (D)	Proportion of (C):(F)
(a)	(B)	(c)	(D)	(E)	(F)	
Haryana						
0-4	627884	68.73	956662.55	58811.95	16.60	1 : '24
4-20	272920	29.87	2131927.70	15494.30	14.80	1 : '50
20+	12666	1.38	358866.00	39292.25	10.96	1 :7.93
Punjab						
0-4	1058754	76.97	1392494.36	433988.04	34.52	1 : '40
4-20	306253	22.26	2284730.13	760717.03	60.52	1 :1.50
20+	10385	7.55	296866.27	62261.24	4.96	1 :2.78

In case of Haryana, it is found that size classes of more than 20 hectares holds only 1.38% of holdings to the total and this claims 7.65% of tube well irrigated area to total tube-well irrigated area, while 68.73 % of holdings to total which is under 0.4 hectare claims only 30.92% of tube well irrigated area.

The above picture is same in case of Punjab. It is 20 and above size again, where concentration of tube well irrigated area is highest.

Therefore, we can conclude that adoption of high yielding variety is more in case of large size class farms.

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Appendix XVI

A Brief Description of Some Important High Yielding Varieties of Different Crops Recommended for Punjab and Haryana*

Rice:

IR-8: Ability to stand up to heavy fertilization and lack of sensitivity to season. Plants are 80 to 85 cm tall, have good hillering ability and flower in 105 to 115 days. Resistant to some extent to blast disease but susceptible to blight and affected by low temperature at hillering time. It has a good response to nigrogen and a good degree of resistance to lodging.

Padma: Stiff and upright leaves having greater capacity to utilize solar energy for increased rate of photosynthesis, stiff straw and dwarf plant height having capacity to resist lodging, good tillering capacity with synthroneus tillering habit, photosensitivity, response to high levels of nitrogen. Susceptible to low temperature of tillering stage, moderate resistant to blast disease and bactorial leaf blight.

Java: Seedling vigour fair, dwarf plant, height, upright leaves exposing greater leaf area to sun for better

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* Source: (i) S.K.C. Verma, "Green Revolution in Indian Agriculture" 1972.

(ii) ICAR, "Hand Book of Agriculture

(iii) Fertilizer Association of India (a) Agronomy of wheat; (b) Agronomy of Rice.

utilization of solar energy, responsive to high nitrogen fertilization. Moderate susceptible to stem borer, less susceptible to bacterial leaft blight, susceptible to low temperature at tillering stages, resistant to lodging.

Other high yielding varieties used in Punjab and Haryana are Jamuna, Pusa-2-21, Palmau-579, ADT-27 etc.

Wheat

Lerma Rojo: It is a late maturity with high degree of resistance to rusts. It performs well when sown in time and is to be prepared to 'Sonora 64' in areas where yellow rust epidemics occur. Grains are white, semi-hard, bold, susceptible to weevil attack. More susceptible to lodging than other dwarf wheats.

Sonora 64: It is shorter than 'Lerma Rojo' and highly resistant to lodging. Being an early variety, it is capable of giving as good yields when sown in the first week of December as when sown in mid-November or later October. It is susceptible to stripe (yellow) rust and hence unsuitable for areas where this disease is important. It is suitable particularly for cultivation under late sown conditions in the country.

Sharbati Sonara: It resembles Sonora 64 but differs in having amber-coloured, bold seeds. It is particularly suitable for areas where yellow rust is not a problem.

Kalyan Sona: It is an amber, hard and medium highly resistant to loose smut, and tolerant to powdery mildew. The variety was resistant to rusts at the time of its release in 1967 but now it has become susceptible. It is recommended for cultivation all over India including hilly areas where winter season is longer.

Sonalika: Good chapati making quality, tendency to shatter grain if over-ripe.

PV-18:   It is grown mostly in Punjab and some areas in the northern hills. The plants assume reddish colour on maturity. Grain medium to small, red. High degree of resistance to yellow, brown and black rusts and loose smut.

Other important varieties are Chhoti Lerma, Safed Lerma, Mukta (HI385), WG377, WG357, HD1981, HD2122 etc.

Maize

Ganga 101: Plants have broad dark green leaves. Stems are thick. They are resistant to lodging. It takes 100 to 110 days to mature. It is late in maturity and hence, suitable for normal cropping. It is highly resistant to downy mildew, leaf blight and rust and medium tolerant to top shoot borer.

Ganga 5: It has been evolved to replace Ganga hybrid-3 which is susceptible to stem borer and downy mildew. It is resistant to stem borer and downy mildew.

Vijay: It is a composites variety of early maturity maize. This variety is resistant to leaft blight rust and lodging.

Other hybrids and composites are Ganga hybrid 1, Ganga Safed 2, Sona, Vikram, Kisan, Jawahar etc.

Bajra

Hybrid PHB 10: Developed at the Punjab Agricultural University, Ludhiana, High resistance to downy mildew, high degree of tolerance to moisture stress.

Other hybrid bajra are HB-1, HB-3, HB-4, BJ-104.

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