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Maize in India

a review of literatures

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CHAPTER I

MAIZE CULTIVATION IN INDIA

A. **Environmental conditions***:

Maize can be grown in almost all over India but it is popular in the northern and south western part. In the northern part, it is grown only in rainy season (*Kharif*), but in the south western part it can be grown in winter (*Rabi*), summer (*Zaid*) and rainy (*Kharif*) seasons. To carry out research work on maize in India, the differences in climate, soil type and other agro-climatic factors are taken into consideration. The whole country, therefore, is divided into four different zones on the basis of agro-climatic and edaphic factors. A main research centre, is established for each zone and within each zone different substations have been formed. The four zones are as follows:

Zone 1 - includes the hilly areas of the Himalayas
Main centre: Srinagar
Substations: Bajaura, Solan, Almora, Sikkim and Kalimpong

Zone 2 - includes the western Indo-gangetic plains with moderate to low rainfall
Main Centre: Delhi
Substations: Ajmer, Ludhiana

Zone 3 - includes the eastern Indo-gangetic plains
Main Centre: Pantnagar
Substation:: Dholi

Zone 4 - includes the southern and peninsular India
Main centre: Hyderabad
Substations: Godhra (Gujarat), Arbhavi (Mysore), Chhindwara (M.P.)

Fig.1 represents the map of India with the different main centres and substations.

Geographic and climatic data of these centres are presented in Table 1 and Fig. 2.

The latitude of breeding centres ranges from 16°N to 34°N. The range in altitude is from 49 meters at Dholi to 1,520 meters of Solan. The maximum temperature during June often exceeds 40°C at some of the locations while minimum temperature during winter are favourable for maize at most of the locations except Zones 1 and 2. Lack of adequate irrigation facilities limit the area under maize experiment during winter (*Rabi*) season at Godhra, Arbhavi and Zone 1.

Annual rainfall varies from 513 mm. at Arbhavi to about 2200 mm. at Almora and Kalimpong. Most of the rainfall is received between April and October at a majority of the locations. Winter rainfall is high only at Bajaura where the temperatures are unfavourable for maize during the *Rabi* season. Lack of adequate irrigation facilities limit the area under maize experiment during winter (*Rabi*) season at Godhra, Arbhavi and Zone 1. (Appendix I)

The crop is successfully raised on a wide variety of soil types ranging from the alluvia of the Indo-Gangetic plains to the black soil of the Deccan. Table 2 gives the characteristic of soils in the experimental fields of some of the research centres which represent most of the different soil types in the country. A brief description of soils in each of the centres is given herein**.

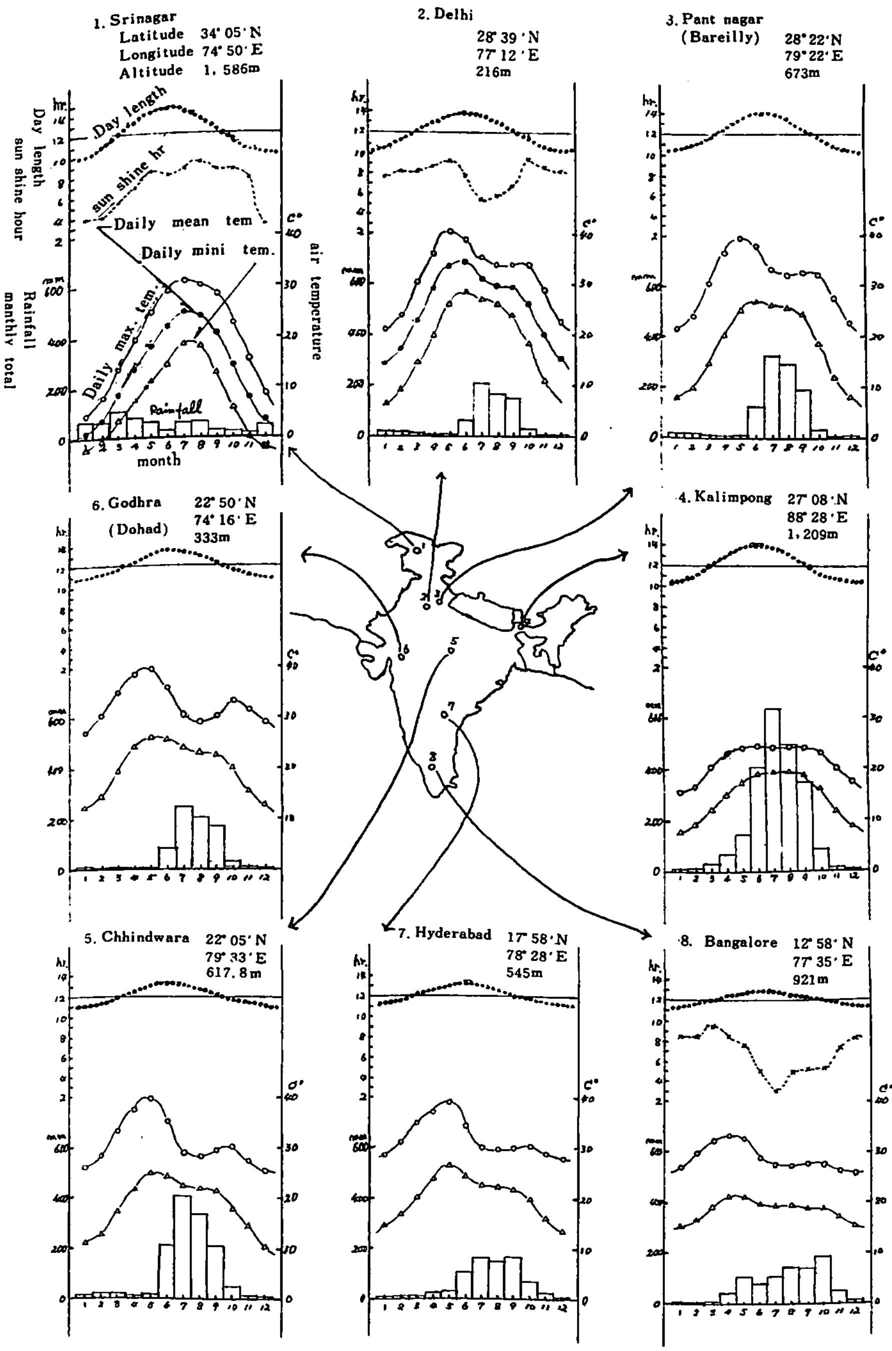
* According to the Progress Report of Coordinated Maize Breeding Scheme 1962, ICAR, INDIA.

** According to the technical Report, Maize Agronomy, 1964-1968, ICAR, INDIA.

Figure 1. Location of Maize Breeding Centers in INDIA *

* Figure in the Progress Report of Coordinated Maize Breeding Scheme. 1963, ICAR, was cited with a slight modification.

Figure 2. Climatological Data of Maize Breeding Center *



* Compiled from Climatological Tables of Observatories in India (1931-1960), Indian Meteological Department, Government of India.

Table 1 **Geographic and climatic data of maize breeding centre and subcentre****

Station	Altitude (meters)	Latitude (° ′)	Mean daily temperature (°C) June Max.	June Min	December Max.	December Min.	Average annual temp. (°C) Max.	Min.	Average annual rainfall (mm.)	Soil texture
Zone 1										
*Srinagar	1,580	34 05	29.7	14.1	9.0	-2.6	19.5	7.2	660	Loam
Bajaura	1,040	31 50	-	-	-	-	-	-	950	Clay loam
Solan	1,520	30 00	23.9	15.6	10.3	4.1	-	-	1,270	Sandy loam
Almora	1,280	29 35	37.8	13.6	-	-	17.5	10.1	2,210	Sandy loam - loam
Gangtok	1,370	27 15	23.3	16.4	15.6	6.4	20.1	7.7	3,800	Sandy loam
Kalimpong	1,070	27 04	24.0	19.1	16.8	9.0	21.2	14.6	2,185	Sandy loam
Zone 2										
*Delhi	228	28 35	39.1	28.1	23.2	7.2	31.5	18.1	665	Alluvial-silty
Ludhiana	247	30 56	39.8	27.2	21.6	6.8	-	-	690	Sandy loam-sandy
Ajmer	486	26 27	38.0	27.7	24.1	8.1	31.2	18.4	530	Sandy loam
Zone 3										
*Pantnagar	240	29 22	37.9	26.9	22.8	8.1	30.9	18.3	1,083	Loam - clay loam
Dholi	49	25 05	35.7	26.6	23.7	11.3	30.5	19.5	1,260	Sandy loam-loam
Zone 4										
*Hyderabad	537	17 26	34.8	24.0	28.6	13.6	32.4	20.2	745	Sandy loam - clay loam
Godhra	307	22 45	36.5	26.6	30.7	10.7	32.8	19.5	713	Sandy loam - clay loam
Chhindwara	682	22 00	35.0	24.7	26.3	9.8	31.3	17.6	1,460	Sandy loam - clay loam
Arbhavi	584	16 00	27.6	20.2	27.8	14.7	32.6	20.0	513	Sandy - Sandy loam

* Main centre

** Compiled from Climatological Tables of Observatories in India (1931-1960).

Table 2 Characteristics of soils in Experimental fields**

Location	Year	Range of soil reaction (pH)	Range of E.C. millimhos/cm.	Range of organic matter C %	Range of available nutrients 'P' lbs/acre	'K' lbs/acre
Pantnagar	1964	6.4 - 7.6	0.3 - 0.6	1.01 - 1.15	3 - 17	90 - 246
	1965	6.8 - 7.0	0.15- 0.30	1.16 - 1.20	8 - 23	152 - 244
Godhra	1964	6.0 - 6.7	0.5 - 2.6	0.46 - 0.50	23 - 54	264 - 420
	1965	5.9 - 7.3	0.2 - 0.6	0.36 - 0.63	7 - 62	52 - 520
	1966	6.5 - 7.2	0.25- 0.80*	0.38 - 0.50	6 - 60	136 - 460
Ajmer	1964	8.5	0.3	0.54	22	296
	1965	8.2	1.3	0.38	12	200
Delhi	1965	7.8	1.2	0.40	4	-
	1966	7.7 - 8.1	0.70 - 1.40*	0.32 - 0.42	4 - 43	112 - 252
Hyderabad	1964	7.6	0.3	0.65	60	800
Bajaura	1964	6.1	0.2	0.80	9	360
Chhindwara	1964	5.8 - 6.0	0.15-0.25	0.63 - 0.84	80 - 85	346 - 560
Ludhiana	1964	8.2 - 813	0.15-0.20	0.42 - 0.46	10	176 - 228
Kalimpong	1964	5.0	1.1	1.36	69	328

*Soluble salts (E.C.: electric conductivity) m.m.hos/cm.

Classification of different soil constituents:

Soil Reaction (pH)	Salinity
Acidic - below 6.0	Normal - below 1
Normal - 6.0 - 8.7	Injurious - above 1

	Low	Medium	High
Org.C	Below 0.5	0.5 - 0.75	above 0.75
'P'	" 9	9 - 22	" 22
'K'	" 100	100 -250	" 250

** According to Final Technical Report, Maize Agronomy (1964-1968), ICAR, INDIA.

Bajaura: The soil at Bajaura in the Kulu Valley is a slightly acidicsilt loam of alluvial soil. There is no problem with salinity and it is relatively high in organic matter (0.8% C). The phosphorus status is very low but the exchangeable potassium is high. This soil is well drained and is capable of very good yields.

Kalimpong: The Kalimpong farm is a terraced farm that was an irrigated paddy farm some years previously. The soils are fairly fine-textured, and waterlogging is a problem. These are the most acid of all experimental soils (about pH 5.0), the organic matter content is relatively high. Contents of phosphorus potassium are both high. In spite of the drainage problems this farm has given the highest yield recorded in the maize scheme.

Delhi: The experimental field at I.A.R.I. (Main Block #8) is a low-lying, poorly-drained silt loam to silty clay loam. Salinity is a very real problem with water tables usually standing at 1 to 3 meters. Surface drainage is exceedingly poor. PH is about 8.0, organic matter is low, phosphorus is very low, and potassium is fairly high. In some areas of this field soluble sodium is prominent. On the whole, this is a poor agricultural soil. At present, attempts are being made to tile drain this field so that the water-table can be lowered and the excess salts leached out.

Ludhiana: The soil at Ludhiana is a deep sandy soil subject to drought because of its low water-holding capacity. The soil is calcareous with little organic matter, low phosphorus, and fairly high potassium levels. Salinity is not a problem here although many of the soils in this area are "salting out" due to rising water-tables.

Ajmer: The soils of the Ajmer farms are sandy, and salty. Moreover, the irrigation water is also high in salt (2800-4750 millimhos/cm.). Only the coarse textured soils and the fairly concentrated monsoon rains (little as they are) prevent this area from accumulating large quantities of salt. The soil pH is about 8.5, organic matter is low as is "available" phosphorus. "Available" potassium is in the medium range.

Pantnagar: This experimental soil is in the "Tarai" region, a zone of natural grassland which was only recently put into cultivation. The organic matter content is relatively high (slightly less than 2% organic matter) and salinity is no problem. "Available" P is generally very low, and K is medium to high. These soils are young alluvial silty clay loam soils with very little profile differentiation. There is usually present a layer of coarse gravel at 1 to 3 meters below the surface. These are productive soils.

Hyderabad: The Hyderabad soils are fine - textured "black cotton soils". They are slightly alkaline, relatively low in organic matter, low in P except where fertilizer has been used for some time, and very high in potassium. Salts are a problem in a few spots. Although this soil does not appear to be especially good for high yields, year in and year out Hyderabad reports excellent yields.

Chhindwara: The research farm at Chhindwara encompasses two kinds of soils, red sandy soils and black clay soils. This soil is slightly acid, low in organic matter and high in both P and K. This soil has given very good Yields in the past.

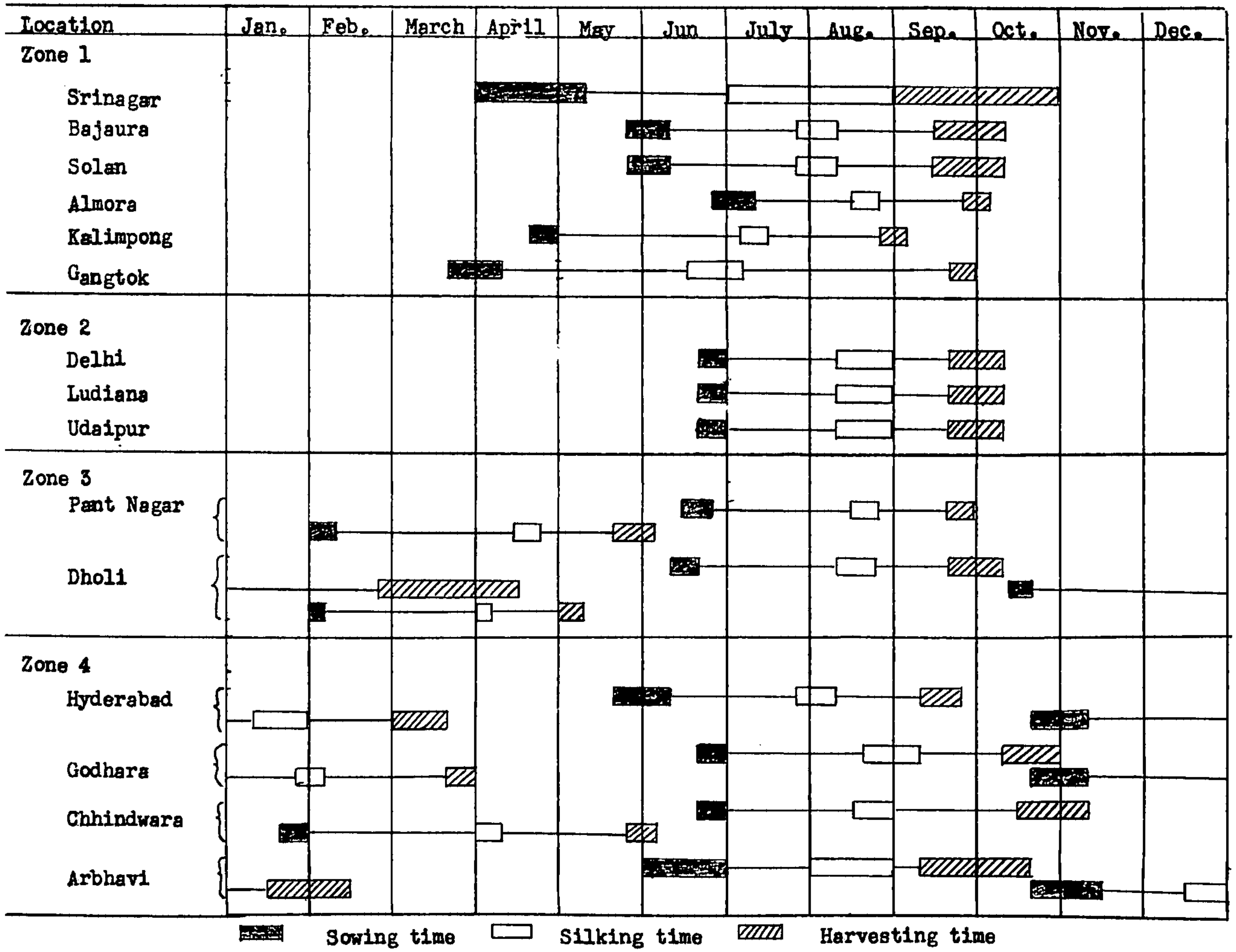
Godhra: The Godhra soils are slightly acid to neutral, low in organic matter, generally low in P, and high in K. Salts are a problem in some spots. These sandy loam soils do not generally yield well.

Arbhavi: The soils at Arbhavi are sandy loam soils.

B. Cropping seasons:

In the states of West Bengal, Bihar, Utter Pradesh, Punjab, Jammu and Kashmir, Rajasthan, Gujarat and Madhya Pradesh, maize is grown as a *kharif* crop. It is planted at the onset of the monsoon rains at the end of June and beginning of October. However, very early maturing varieties are grown during the summer months in river valleys. Such varieties are planted in April and are harvested

Figure 3. Croping season of maize growing areas*



* Complied from the data of Breeding Centre respectivery.

in about 70 days, before the monsoon starts.

The varieties in the hilly regions are planted from March to May. The crop matures in 110 to 130 days and is harvested from August to September.

In the states of Andhra Pradesh and Maharashtra, there are two cop seasons. *Kharif* planting starts about the middle of June, varieties mature in about 110 to 120 days and harvesting is done in September. A considerable area of maize is also grown in the *Rabi* season; it is planted in November and harvested from March to April. Most of the *Kharif* maize is rainfed; the *Rabi* crop is, however, grown under irrigation.

Fig. 3 represents the time of sowing, silking of the crop and harvesting of the crop at the different stations in each zone.

C. Cropping area:

It is interesting to note that though India is such a big country, yet only 4.6% of its total area is cropped. Out of all the states, only Punjab has the largest cropping area, as high as 20.1%. Rest of States fall far back in utilization of land for agricultural production. Madhya Pradesh has the largest area but only 4.3% of it is under cultivation. Rajasthan has only 4.5% under crops. Uttar Pradesh and W. Bengal have 7.3% under crops. A comparison of total land area and total cropped area is presented in Table 3.

Table 3 Land area and cropped land in India*

State	Area in sq.km.	Total cropped area ('64-'65)	%
1. Andhra Pradesh	275,281	12,756	5.0
2. Assam	203,380	2,717	1.2
3. Bihar	134,038	10,832	6.2
4. Gujarat	187,115	10,044	5.4
5. Haryana	43,869	-	-
6. Jammu & Kashmir	222,800	843	0.4
7. Kerala	38,855	2,489	6.4
8. Madhya Pradesh	443,452	18,903	4.3
9. Madras	130,357	7,177	5.5
10. Maharashtra	307,477	19,214	6.2
11. Mysore	192,204	10,801	5.6
12. Nagaland	16.488	49	0.3
13. Orissa	155,825	7,446	4.8
14. Punjab	50,236	10,121	20.1
15. Rajasthan	342,274	15,501	4.5
16. Uttar Pradesh	294,364	21,517	7.3
17. W. Bengal	87,617	6,391	7.3
18. Andaman & Nicobar	8,327	10	0.1
19. Chandigarh	114	-	-
20. Dadra & Nagar Haveli	489	-	-
21. Delhi	1,484	102	6.9
22. Goa, Daman & Diu	3,693	139	3.8
23. Himachal Pradesh	56,019	175	0.3
24. Laccadive, Minicoy & Amindive Islands	28	3	10.7
25. Manipura	22,347	-	-
26. Pondicherry	479	47	9.8
27. Tripura	10,453	322	3.1
Total	3,269,075	151,103	4.6

* According to Area, Production and Yield of Principal Crops in India, 1949-1950 to 1967-1968. Summary Table.

Maize growing area:

Maize is grown in almost all the states of India, but the acreage under this crop varies according to the food habits of the people in each state. Maximum acreage under maize is in Himachal Pradesh (68.5%) followed by Jammu and Kashmir (29.7%). Kerala does produce very little or no maize. Madras, Mysore, Maharashtra, Orissa and W. Bengal have less than 1% area under maize. The percentage of acreage under maize for each state can be seen from Fig.4.

Considering total area under maize in different states (Fig.5) it can be seen that Uttar Pradesh has the maximum acreage (over 1,000,000 hectare), Rajasthan and Bihar has over 700,000 hectares, Punjab and Madhya Pradesh have over 400,000 hectares under maize. Gujarat, Jammu and Kashmir and Himachal Pradesh have over 100,000 ha. The rest of the states grow only less than 100,000 ha. under maize.

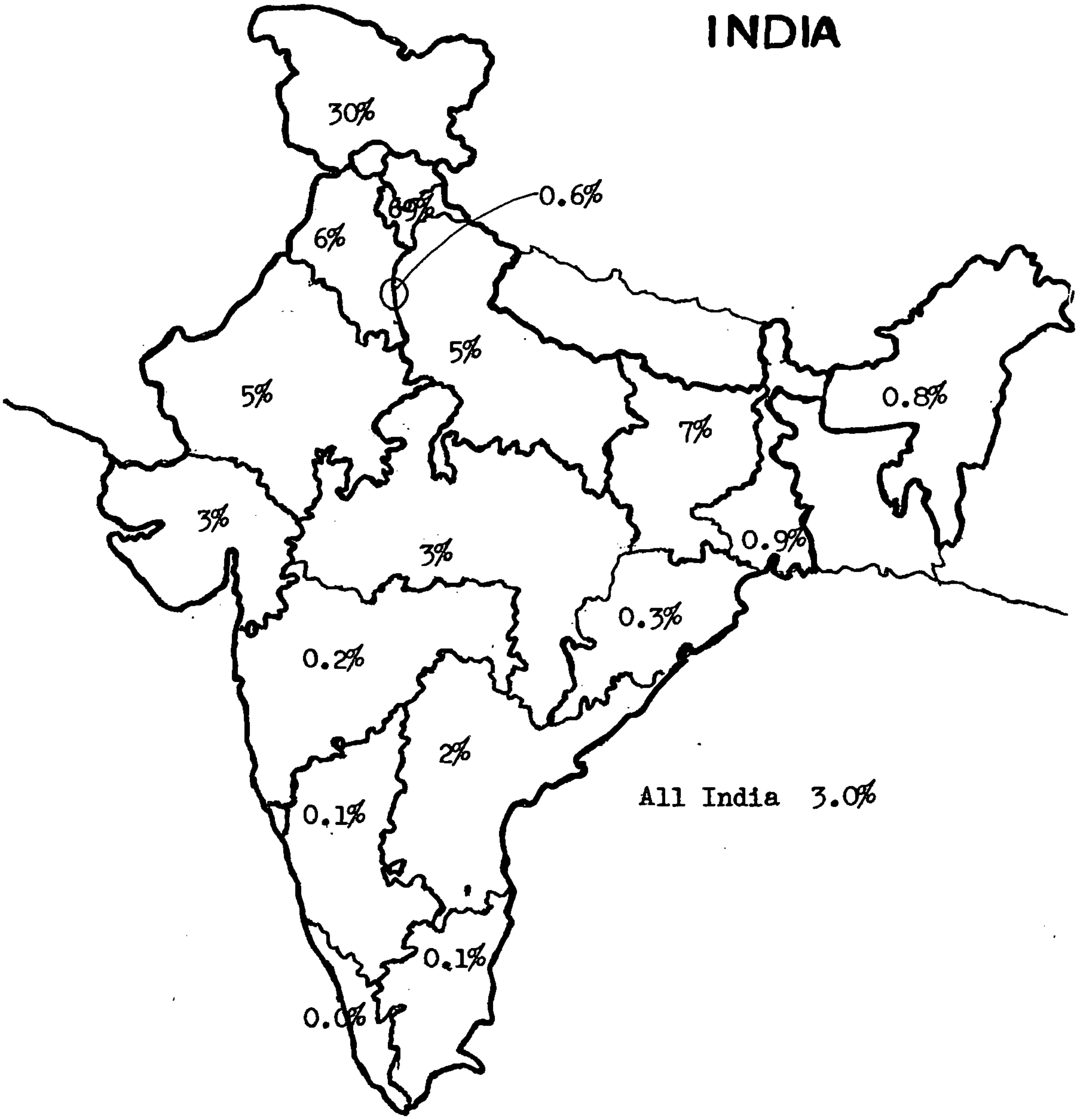
Table 4 gives the actual acreage under maize in different states. If we compare the maize acreage in each state with the total maize acreage of the country, the same pattern as shown in Fig.4 emerges. Uttar Pradesh leads all the states in having 26.4% of the country's total maize area followed by Bihar having 17.7%. Delhi's contribution of maize area to the country is minimum.

Table 4 State-wise acreage under maize*

	State	Area (thousand hectares) 1967-68 (final estimate)	%
1.	Andhra Pradesh	252.8	4.5
2.	Assam	24.4	0.4
3.	Bihar	989.1	17.7
4.	Gujarat	239.7	4.3
5.	Haryana	117.3	2.1
6.	Jammu and Kashmir	251.0	4.5
7.	Madhya Pradesh	589.2	10.7
8.	Madras	2.9	0.1
9.	Maharashtra	38.9	0.7
10.	Mysore	15.4	0.3
11.	Orissa	55.2	1.0
12.	Punjab	469.2	8.4
13.	Rajasthan	745.5	13.4
14.	Utter Pradesh	1472.1	26.4
15.	West Bengal	51.5	0.9
16.	Delhi	1.6	0.02
17.	Himachal Pradesh	285.8	4.6
18.	Manipur	5.1	0.1
	Total	5576.7	100.0

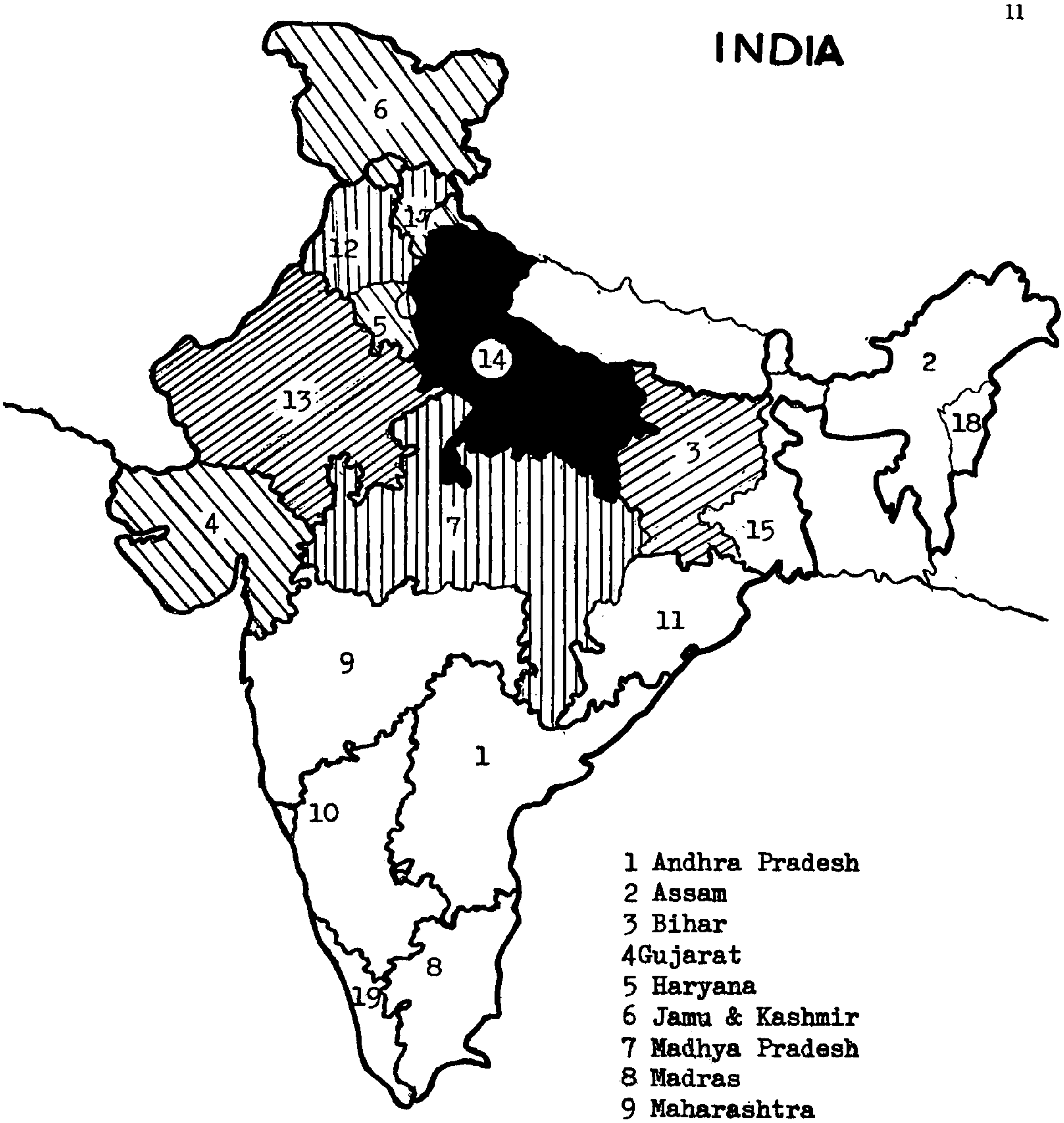
* According to Area, Production and Yield of Principal crops in India, 1945-50 to 1967-68, Summary Table.

Figure 4. Percentage of Maize area to total cropped area in state wise*



* Culculated from the data of Area, Production and Yield of Principal Crops in India, 1949-50 to 1967-68, Summary table.

Figure 5. Maize Area State-wise*



1 Andhra Pradesh
2 Assam
3 Bihar
4 Gujarat
5 Haryana
6 Jamu & Kashmir
7 Madhya Pradesh
8 Madras
9 Maharashtra
10 Mysore
11 Orissa
12 Punjab
13 Rajasthan
14 Uttar Pradesh
15 West Bengal
16 Delhi
17 Himachal Pradesh
18 Manipur
19 Kerala

Over 1,000,000ha.
Over 700,000ha.
Over 400,000ha.
Over 100,000ha.
Less than 100,000ha.

* Compiled from the data of Area, Production and Yield of Principal Crops in India, 1949-50 to 1967-68, Summary Table.

Appendix II gives the area under maize in hectares for the different states from 1952 to 1967.

D. Maize diseases, their control and pattern of infection in India: *

Maize is affected by about 25 diseases in India; three caused by bacteria, one by a virus and the rest by fungi.

The diseases can be broadly categorized into those that attack seedlings, foliage, stalks and cobs or ears. They can be combated by use of disease-resistant varieties and hybrids, seed treatment with fungicides. Limited control can also be achieved by adjustment of soil fertility, planting date, and soil moisture and by spraying plants with fungicides.

The establishment of vigorous seedling is very important to the development of productive plants. Seed rot in the soil and seedling diseases can be largely prevented by planting sound, healthy seed that has been treated with a fungicide (thiram or captan) at the rate of 2.5 gm. per kg. Seed treatment is obligatory for certification by the National Seed Corporation and agricultural universities. When uncertified seed is used, farmers should avoid chaffy, light or moudly kernels, those which show blemishes, streaking, silk cut, or cracks induced by sieving or other physical operations and such seed should then be treated with a fungicide.

Several diseases that affect the foliage are highly debilitating, but can be kept in check by growing resistant released hybrids (Ganga 101, Deccan, Ranjit) or composites (Jawahar, Kisan). Leaf blights *Helminthosporium turcicum* and *H. maydis*) and brown stripe downy mildew (*Sclerophthora rayssiae* var. zeae) are the major diseases and are favoured by extended wetting periods and moderate temperatures. Where the economic value of the crop is high, e. g. in case of sweet or pop corn or seed production, leaf blight can be controlled by the application of 2 lb. per 100 gallons of water (1-1½ tablesponfuls of fungicide per gallon) of zineb (zinc ethylenebisdithiocarbamate) sprayed on the plants, beginning when first infection is fund and continued at about 7 day intervals until grain formation. The number of applications may be reduced if weather appears unfavourable for disease development.

Stalk rots are widespread in India and six are known to occur. Bacterial and pythium stalk rots often occur suddenly at the time of flowering and their incidence can be reduced by planting in well-drained soil to avoid water-logging, and by providing well-balanced fertilization (use of potash is specially recommended). Hybrid Deccan, Ranjit and Ganga 101 show moderate resistance to the black bundle or Cephalosporium stalk rot. Charcoal rot can be minimized by avoiding drought conditions, particularly after flowering.

Ear rots pose a serious threat in areas where the atmospheric humidity is high and where the ears are injured by birds, insects of other agencies. A long, tight husk cover proves helpful in reducing ear rot incidence. Adjustment of planting time so that kernel formation occurs during dry conditions can also be practised.

In the following table, the important diseases are listed together with their causal organisms, symptoms and control practices.

Maize diseases*

Disease	Symptoms	Causal organism	Control Measures
Seed rots and seedling blights	Brown water-soaked depressed lesions on mesocotyl, patchy stands, poor emergence, damping off.	*Cpehalosporium acremonium* *Fusarium moniliforme*. *Pythium aphanidermatum*	Treat the seed with Thiram or Captan (1:400)

* According to Combating Maize Disease by Dr.M.M.Payak and Dr. B.L.Renfro, 1967.

Disease	symptoms	Causal organism	Control measures
Turcium leaf blight	Long elliptic greyish green or brown spots, more severe on lower leaves; heavily infected plants present a burnt appearance.	*Trichometasphaeria turcica* (*Helminthosporium turcicum*)	Grow resistant hybrids, Ranjit, Deccan and Ganga 101. Spray Dithane Z-78 (zineb) from first symptom to cob formation stage at 5-7 day intervals.
Maydis leaf blight	Greyish tan parallel or straight-sided lesions with slight zonation ranging from one-half to one and one-half inch in length.	*Cochliobolus heterostrophus* (*Helminthosporium maydis*)	Same as above.
Downy mildew	Leaf streaking and chlorosis, stunting in severe cases; whitish coarse downy growth on affected parts (see Plate 2).	*Sclerospora philippinensis*	Use of Bordeaux mixture has been suggested but it may prove injurious to foliage.
Brown stripe Downy mildew	Well demarcated chlorotic stripes turning straw or tan coloured and delimited by leaf veins; fine downy growth in early mornings; cob formation docs not occur in severe cases. (See Plate 1)*	*Sclerophthora rayssiae*	Grow resistant hybrids-Ganga 101, Ranjit and Deccan; composites- Kisan and Jawahar. Regulate planting time in Tarai area; early seeding in June may help in reduction of incidence.
Rust	Saffron or rust coloured pustules develop on leaves which release powdery spores; later these turn dark and produce the telial stage. (see Plate 3).	*Puccinia sorghi*	Grow resistant hybrids: Deccan Ranjit, Ganga 101 and Him. 123
Mosaic	Affected plants pale green in appearance, slightly stunted, show mosaic mottling.	*Virus*	Grow resistant hybrids: Deccan Ranjit and Ganga 101.-Composites: Jawahar and Kisan.
Bacterial Stalk rot	Softening of basal internodes: plants may wilt and emit farmenting odour; ears may become blighted and rot.	*Erwinia carotovora* var *zeae*.	Plant in well-drained soil to avoid water logging; provide well-balanced fertilization.

* Plate No. 1 to Plate No. 6: By Courtesy of Dr. B.K.Mukherjee.

Disease	Symptoms	Causal organism	Control measures
Phthium stalk rot	Part of any one of the lower internodes becomes soft and gets twisted; plants lodge though they remain green for sometime.	*Pythium aphanidermatum*	Same as above.
Black bundle	Affected plants show blackening of vascular bundles in the stalk; in severe cases plants wilt; also causes ear rot and streaking on kernels (see Plates 4A and 4B).	*Cephalosporium* and *acremonium* and *C. acremonium* var. *cereum*	Grow resistant hybrids: Deccan, Ranjit and Ganga 101.
Charcoal rot	Shredding of the pith in stalk; back dot like sclerotia on the rind and inside stalk; lodging of crop in severe cases(see Plate 5)	*Macrophomina phascoli*	Avoid water stress to the crop after flowering.
Common smut	Conspicuous galls first covered by host membrane develop on any above ground part of plant (floral or vegetative); these rupture and release black spore masses (see Plate 6).	*Ustilago maydis*	Balanced soil fertility and clean cultivation.

None of the zones were free from diseases, but zone 4 shows relatively less prevalence of diseases and compared to the other zones. Seed rot and seedling blight was scarce in all the zones. Turcium leaf blight is most severe in zone 1 and zone 4. Maydis blight does not appear in zone 4 and very little in zone 1. Zone 2, however, is very much affected by maydis blight. Downy mildew (*Sclerospora philippinensis*) is found in zone 2 and zone 3 only while brown stripe mildew (*Sclerophthora rayssia* var. *zeae*) occurs in all zones. Occurrence of rust is very mild in zones 2 and 3 but occurs moderately in zones 1 and 4. Bacterial stalk rot is noticed in all the zones varying from light to heavy, specially in zones 2 and 3. Smuts are prevalent by in zone 1.

The range of infection for the different stations is given in Table 5.

E. Maize pests, their control and pattern of infestation in India *

India is now on the threshold of farm revolution. With the advent of a large number of new high yielding varieties and hybrids, the outlook on agriculture seems to be bright.

Farmers would be soon going for maize crop. They would be investing large resources, financial and otherwise in anticipation of a bumper crop.

* According to Insect Enemies of Maize by Shri Y.S.Rathore. 1968.

Proper protection of plants from ravages of the insect pests is one of the important pre-requisites for higher yield. Sixty seven species of insect pests have been reported to infest maize and millets. These insects start their activities right from the seedling stage up to the harvest. It would, therefore, be paying to know of the nature and extent of damage and methods of control in respect of few of the important insect pests of maize.

Table 5 Disease pattern in India*

Station	Seed rots and seed-ling bli-ght	Tur-cicum leaf bli-ght	Maydis leaf bli-ght	Downy mildew	Brown stripe downy mildew	Rust	Mosaic	Bacter-ial stalk rot	Phy-thium stalk rot	Stalk rot	Charcoal rot	Physo-derma	Common smut	Head smut
Zone 1														
Srinagar	-	2	-	-	-	1	-	-	-	-	3	1	3	2
Bajaura	-	3	1	-	2	3	-	2	-	1	-	2	2	2
Solan	-	3	2	-	3	2	-	2	-	-	-	1	2	2
Almora	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalimpong	-	4	1	-	3	3	2	4	-	2	-	3	4	1
Gangtok	-	4	1	-	-	3	2	4	-	-	-	3	2	1
Zone 2														
Delhi	-	-	2	3	2	-	2	3	3	-	-	-	-	-
Ludhiana	-	2	1	2	2	1	-	3	3	-	-	-	-	-
Udaipur	-		3	-	2	1	-	2	1	-	-	3	-	-
Zone 3														
Pantnagar	-	-	3	3	4	1	-	4	4	3	-	1	-	-
Dholi	-	4	-	-	2	3	-	3	3	-	-	-	-	-
Zone 4														
Hyderabad	-	3	-	-	1	3	2	2	2	3	3(*Rabi*)	-	-	-
Godhra	-	3	-	-	2	2	-	2	2	3	3	-	-	-
Chhindwara	-	3	-	-	1	2	2	2	-	-	-	-	-	-
Dharwar	-	3	-	-	-	3	-	-	-	-	2	-	-	-

1 - Very light 2 - Light 3 - Moderate 4 - Heavy 5 - Severe

Compiled from the auther's observation.

1. Stem borer:

The adults of this borer are straw colour, while caterpillars are brownish with four longitudinal violet stripes on the upper surface of the body. Full grown larvae measure about one inch in length.

The larvae are responsible for maximum damage. They feed first on leaves by making small irregular pin holes. Much of the injury is done within the leaf whorl and finally the larvae bore into the stem where they make extensive tunnels. All parts of the plants are attacked (see Plates 7A, 7B and 7C)*. In the early stage of the crop the "dead hearts" are produced i.e. the growing points dry up and often results in the death of affected plants. In later stages, the crop suffers in vigour and bears weak earheads (cobs). If adequate control measures are not taken well in time, the larvae feed on cobs and grains as well. The larvae of this insect feed heavily on jowar, and is, as such, also known jowar stem borer. The pest is active from first week of March to middle of October. The cultural and chemical control measures are as under:

Control measures:

Cultural measures: - (a) Remove all the grasses, particularly the wild sorghum from the vicinity of the maize as it serves the alternative host for the borers when maize crop is not available to them.

(b) Uproot and burn the maize stubbles in the field itself so as to kill hiding caterpillars.

Chemical control: - Spray endrin 20 EC. 0.03% solution (1.5 CC in one litre of water) or 0.2% sevin 50 w.p., or 0.2% BHC 50 wp 4 gm. in one litre of water) 15 days after sowing at the rate of 225 litres per acre. Apply 2% endrin or 1% lindane granules in the whorls twice, 25 and 35 days after sowing at the 6 kg. and 8 kg. per acre respectively.

In case borer attack is noticed at cob stage, it would be advisable to spray 0.2% sevin or 0.2% BHC at the rate of 315 litres per acre.

2. Pink borer:

The larvae of this borer are pink in colour hence the name pink borer. This insect is widely distributed, however, in the Southern regions, it is present in menacing proportions, Like stem borer, this also causes "dead hearts" in the early stages of plant growth. In later stages of crop, these feed on tassels; cobs and make deep tunnels in the stem. Basides maize, the larvae of this borer has been known to do no less damage to jowar, sugarcane, ragi, paddy, wheat and Guinea grass. This pest is more active during winter season.

Control measures: - The cultural and chemical methods recommended for stem borer are applicable for the control of this pest also.

3. Shoot fly:

It occurs throughout India and is a serious pest of jowar, wheat, maize, broom-corn and smaller millets and grasses. However, in case of maize, it is a more serious menace in spring crop, particularly at Tarai area of U.P.

The maximum damage is done by the maggots of this fly. These are whitish in colour and are legless. These maggots bore into the central shoot of young plants where they damage the growing point, which dries and results in "dead heart". Due to death of the growing point the plant produces side tillers. In case of severe infestation, the tillers are again infested. The pest is serious in young plants.

* Plate No. 7 to Plate No. 8: By courtesy of the Rockfeller Foundation in New Delhi.

Control measures:

Cultural measures: - Rotten material could be an ideal breeding place for the fly, as such it is advisable to all, to cover properly manure pits and other rubbish.

(b) Poor drainage in the field accelerates the rate of breeding, adequate drainage facilities should be provided.

Chemical measues:- The chemical control measures are as under:

(a) Apply 10% phorate (Thimet) granules in the furrows before sowing at the rate of 7 kg/acre. Cover the insecticide with little of the soil and then place the seeds.

(b) Spray 0.025% metasystox after germination (1 cc. metasystox in one litres per acre after about six day) and repeat twice at the interval of 10-12 days.

4. Leaf roller:

Its caterpillars are green in colour and are responsible for damage. Though it is regarded only as a minor pest but at times assumes serious proportion. Its incidence on jowar is serious and that is why it is known as jowar leaf roller. Besides maize and jowar, it has also been recorded on bajra and other millets and sugarcane. The larvae of this pest roll the leaves and feed inside by scratching the epidermis and thereby cause longitudinal patches on leaves.

Control measures:- Spray 0.03% endrin at the rate of 225 litres per acre, or dust the crop with 5% BHC at the rate of 10 kg. per acre.

5. Aphids:

These are tiny, dark green coloured soft bodied insects. Many of which are found feeding at one place. Both adults and young ones (nymphs) suck the sap from leaves and tassels. In case of severe infestation, the plants show sickly appearance. Tassels dry before attaining maturity. These aphids secrete a sticky substance, known as honeydew. Dust particles adhere to this substance and hinder in the photosynthetic activities of the plants.

Besides maize, this polyphagous insect has been recorded on a number of crops including wheat, jowar, bajra, oat, barley and other millets.

Control measures:- Spray 0.025% metalystox at the rate of 225 litres per acre, or 0.05% malathion (1 cc. in litre of water) at the rate of 225 litres per acre. Repeat once at the interval of 15 days in case of severe infestation.

6. Grasshoppers:

This is a very destructive pest and is commonly called as 'Phadka'. The adults as well as the young hoppers feed on the leaves. In case of severe infestation only the midribs of the leaves are left. Jowar, bajra, paddy, sugarcane and other millets are its other favourite holts (see Plate 8).

Control measures:-

(a) Common breeding places of this insect, such as irrigation and field bunds and other raised areas should be dusted with 2.5% BHC so as to kill the emerging hoppers. It may be desirable even to treat the waste lands where eggs may have been laid, in the breeding season.

(b) Spray the crop with 0.1 to 0.2% BHC 50 W.P. at the rate of 225 litres per acre, or (c) dust with 10% BHC or 5% Aldrin at the rate of 10 kg. per acre.

7. Jassids:

This is a small greyish brown bug; the adults and nymphs of which feed inside the leaf sheath, whole and sometimes on cobs. They suck the plant sap thereby causing gradual fading and consequently drying up of the affected shoots. These plants generally bear weak cobs. Besides maize, this insect also feeds on jowar.

Control measures: Dust the crop with 5% DDT at the rate of 10 kg. per acre.

8. Army worms:
This is very destructive and sporadic pest and is found throughout the country. It can be observed feeding on maize, wheat, paddy and sugarcane crops. During the day, it generally remains hidden in the leaf whorl, leaf sheath, or under the trash and under clods in the field. In case of maize, it feeds, inside the whorl during early stage of the crop and on the silk in the later stages.

Control measures: Spray 0.03 and 20 EC at the rate of 270 litres per acre, or dust the crop with 5 to 10% BHC at the rate of 10 kg. per acre.

9. Hairy caterpillar
These caterpillars can be recognized at the first sight, since they have long hairs on the body. On maize, they feed on silk and hence hinder in pollination. All this ultimately affects in setting of grains in the plants.

Control measures: Spray 0.03% endrin 20 EC at the rate of 225 litres per acre, or 0.2% BHC 50 W.P. at the rate of 225 litres per acre.

Insect patten in India:
The most common insect pest attacking maize is stem borer (*Chilo zonellus*). Stem borer occurs in all the zones and is a major problem for maize cultivation. Zones 2,3 and 4 are the ones which show severity of attack while zone 1 shows relatively moderate infestation. The range of infestation is given in Table 6.

Table 6 Insect patten in India*

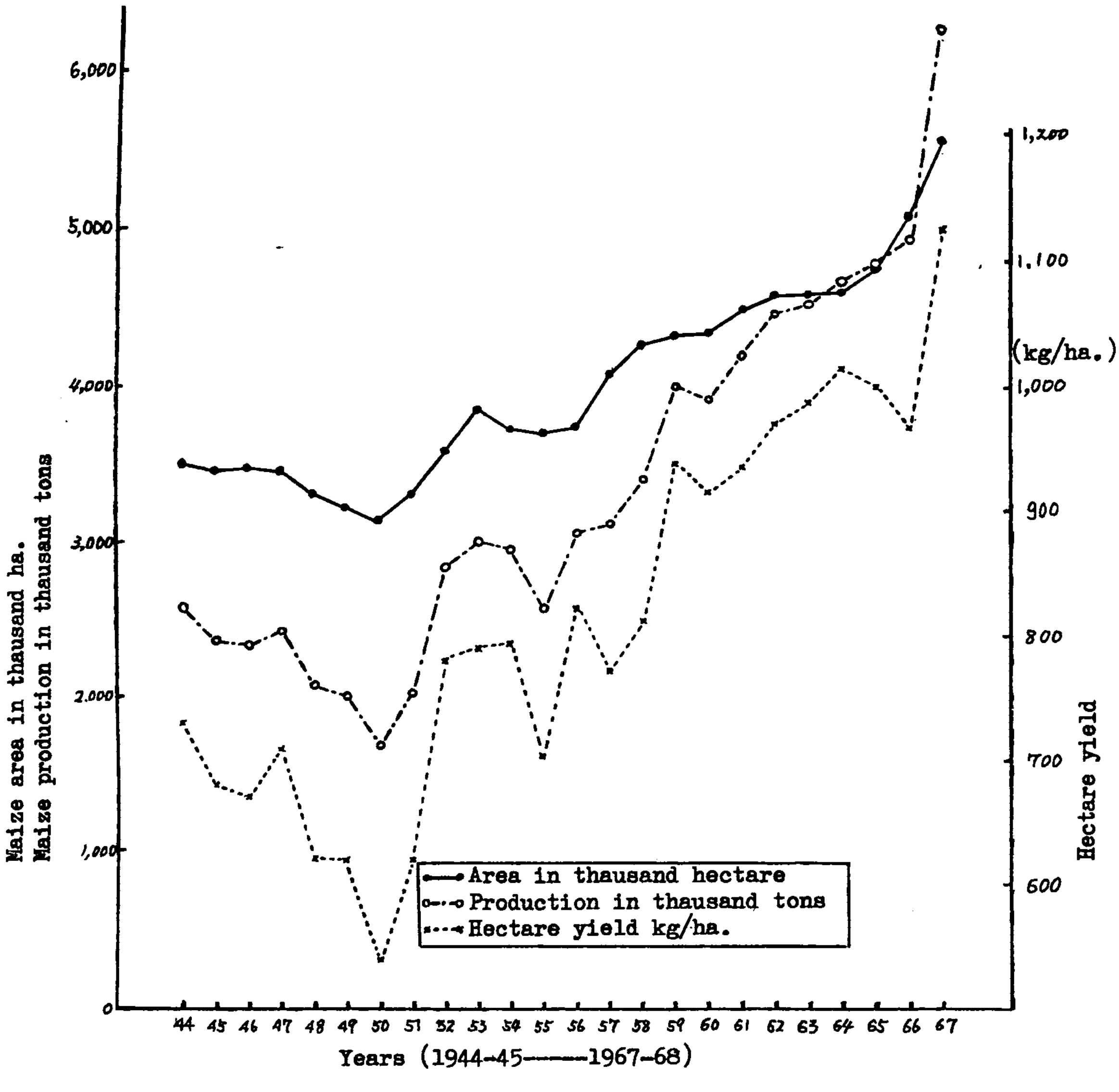
	Stem borer	Pink borer	Shoot fly	Leaf roller	Aphids
Zone 1	1-3	-	-	-	-
Zone 2	3-4	1	-	1	1
Zone 3	2-3	1	2	1	1
Zone 4	2-4	4	-	-	1

* Compiled from the author's observation.

Note: 1 - Very light
2 - Light
3 - Moderate
4 - Heavy
5 - Severe

F. Production and hectare yield:
The Fig. 6 summarises the area under maize in thousand hectares production in thousand tons and yield per hectare from (1944-45) to (1967-68). It can be seen that there is a remarkably similar trend in area under maize, yield per hectare and total production. Total production follows the same pattern on yield per hectare. There has been quite a fit of fluctuation in hectare yield over the different years. The depression in hectare yield is due to low therefore erratic rainfall resulted into drought at a time when water requirement of the crop was maximum.

Figure 6. Production and Hectare Yield of Maize in INDIA*
for the years 1944-45 through 1967-68



* compiled from the Area, Production and Yield of Principal crops in India. 1949-50 to 1967-68. Summary Table.

However, the production and area under maize showed a steep increase from 1964 onwards. This was due to the popularisation and cultivation of high yielding hybrid maize using improved technique by the farmers.

The total maize production and hectare yield by the different states for the year 1967-68 have been given in Table 7. The maximum production was obtained from Uttar Pradesh followed by Bihar and Rajasthan. Taking the hectare yield in consideration, it is interesting to note that though Uttar Pradesh gave maximum production, the hectare yield was very low. Himachal Pradesh and Punjab, on the other hand, gave the top two hectare yield, respectively, even though their total production was quite low. This is due to the fact that in Uttar Pradesh, most of the maize growing areas are rainfed and also most of the farmers have not taken up hybrid maize production and the latest improved techniques. On the contrary, the farmers of Punjab are more enthusiastic about the latest findings in cultural practices and new high yielding seeds. Moreover, the irrigation facilities in this region are better developed (Table 8). The hectare yield obtained in each state when considered in comparison with total irrigated area, a good positive correlation exists.

Table 7 Total maize production and hectare yield in state-wise for the year 1967-68*

S. NO.	State	Production (thousand tons) 1967-68 (Final estimate)	Yield kg/ha
1.	Andhra Pradesh	307.0	1,352.4
2.	Assam	13.1	536.8
3.	Bihar	1129.8	1,316.9
4.	Gujarat	280.5	1,170.2
5.	Haryana	127.7	1,088.6
6.	Jammu and Kashmir	190.8	760.1
7.	Madhya Pradesh	657.9	1,176.5
8.	Madras	3.1	1,068.9
9.	Maharashtra	52.7	1,354.9
10.	Mysore	9.0	584.4
11.	Orissa	50.4	913.8
12.	Punjab	773.3	1,648.1
13.	Rajasthan	1024.7	1,374.5
14.	Uttar Pradesh	1167.2	925.0
15.	West Bengal	45.0	889.3
16.	Delhi	0.6	375.0
17.	Himachal Pradesh	436.5	1,706.4
18.	Manipur	5.0	657.8
	Total	6275.1	1,125.2

* Compiled from the data of Area, Production and Yield of Principal Crops in India, 1949-50 to 1967-68, Summary Table.

Table 8 Area under irrigation state-wise*

S.NO.	State	Gross irrigated area in thousand hectares
1.	Andhra Pradesh	3850
2.	Assam	668
3.	Bihar	2208
4.	Gujarat	828
5.	Jammu and Kashmir	294
6.	Kerala	494
7.	Madhya Pradesh	1098
8.	Madras	3263
9.	Maharashtra	1345
10.	Mysore	1069
11.	Orissa	1778
12.	Punjab	4495
13.	Rajasthan	2080
14.	Uttar Pradesh	6018
15.	W. Bengal	1454
16.	Himachal Pradesh	67
17.	Delhi	25
18.	Manipur	68
19.	Tripura	17
20.	Nagland	12
21.	Pondicherry	39
22.	Goa, Daman and Diu	19
	Total	31,189

* Compiled from the data of Area, Production and Yield of Principal Crops in India. 1949-50 to 1967-68. Summary Table.

Areas where good irrigation facilities are available and farmers are using improved seeds and practices, the hectare yield of such areas are very high. Appendices III and IV give maize production and yield per hectare respectively, for the different states from 1952 to 1967.

G. National demonstrations in maize production:*

Out of 2000 double or triple crop National Demonstrations planned for 1967-68, maize was included in 262 demonstrations. The results of 116 demonstrations reported so far are summarised in this report.

In the last two years i.e. 1965-66 and 1966-67, the results of 75 and 47 demonstrations on maize, respectively, were reported. Statewise number of the demonstrations for which the results have been reported, mentioned in Table 9.

Highest yield:- A highest yield of 8375. kg/ha. was obtained at the farm of Shri Somappa Melligeri, Village Bagalkot, Bijapur District (Mysore). The variety used was Deccan with 15 kg. seed rate per hectare. The fertiliser application was as follows:

N 125, P 80, K 34 kg. per hectare and 60 C. L. of F.Y.M./ha. The crop was sown on 15.7.1967 and harvested on 3.11.1967. In all 14 irrigations were given and one insecticidal spray.

The highest yield obtained in 1966-67 was 74.20 q/ha.

* According to the Report on the National Demonstration conducted on maize during 1967-68. (compiled by ICAR).

The second highest yield obtained was 80.63 at the village Bheemanahath, Distt. Bangalore, Mysore State at the farm of Shri B. S. L. N. Iyenar, using variety Deccan with 15.85 kg/ha. seed rate. The fertilization application was N 196, P 130, K 56 kg/ha and 12 C. L. of FYM. The crop was sown on 26.6.1967 and harvested on 13.10.1967. Irrigation was made at 10 days interval.

Table 9 Number of demonstrations conducted on maize in different states (1967-68)*

S.NO.	States	Variety	Results reported so far
1.	Andha Pradesh	Deccan	4
2.	Madhya Pradesh	Deccan, Ranjit, Ganga 101, Hy. 450	15
3.	Delhi - I.A.R.I.	Ganga 3	3
4.	Mysore	Deccan	9
5.	Haryana	Ganga 101, Ganga 3	11
6.	Punjab	Ganga 101	29
7.	Himachal Pradesh	Ganga 101, Him. 123	4
8.	Jammu and Kashmir	G SM2, Him 123	10
9.	Uttar Pradesh	G3, G 102, Hy 73	4
10.	Maharashtra	Deccan	1
11.	Gujarat	Ganga Safed	1
12.	Rajasthan	Ganga 3	25
	Total		116

* According to the Report on the National Demonstration conducted on maize during 1967 - 1968 (compiled by ICAR).

The third highest yield was 7003. kg/ha. at Village Bari, Kulu Distt. H. P. at the farm of Shri Mahant Kailas, using variety Him. 123 with seed rate 20 kg/ha. The fertilizer dose was N 60, P 24. The crop was sown on 6.6.1967 and harvested on 14.10.1967.

The lowest yield of 938. kg/ha was obtained at the BISR Agri. Farm, Village Rogulguda, Distt. Hyderabad. It was due to less inputs used in this demonstration. The second lowest yield obtained was in Madhya Pradesh village Khajuri, Distt. Sehore at the farm of Aman Singh, using Ranjit variety. This is also due to the low inputs used in the demonstration. The yield obtained was 1038. kg/ha.

Range of yield and average yild

The average yield of 116 demonstrations was 4123. kg/ha. This is about 3.15% more than the national average. The average yield in 1965-66 (75 demonstrations) and 1966-67 (47 demonstrations) was 4077. and 4325. kg/ha. respectively.

The highest average yield of 6677. kg/ha. was obtained in Mysore state (9 demonstrations) followed by 5742. kg/ha. in Himachal Pradesh (4 demonstration), as mentioned in Table 10.

Frequency of distridution

Out of 116 demonstrations the yield of 4 demonstrations was lower than 2000 kg/ha. In 12 demonstrations the yield obtained was above 6000 kg/ha. The highest frequency was between 4100 to 5000 kg/ha. The frequency distribution of the yield is given in Table 11.

Table 10 Results of National Demonstrations under different fertilizer doses*

S.NO.	States	No. of national demonstrations conducted	Fertilizer kg/ha N	P	K	FYM	Average yield kg/ha.
1.	Andhra Pradesh	4	90	40	22	8 C.L.÷ 3,200	3188.
2.	Madhya Pradesh	15	110	57	30	5 C.L.÷ 2,000	3800.
3.	Delhi - IARI	3	150	62	45	20 C.L.÷ 8,000	4220.
4.	Mysore	9	139	97	44	19 C.L.÷ 7,600	6677.
5.	Haryana	11	82	40	10	10 C.L.÷ 4,000	4310.
6.	Punjab	29	118	60	47	25 C.L.÷10,000	4488.
7.	Himachal Pradesh	4	77	52	11	10 C.L.÷ 4,000	5742.
8.	Jammu and Kashmir	10	68	75	30	15 C.L.÷ 6,000	4023.
9.	Uttar Pradesh	4	122	46	59	300 Mds.÷11,250	3695.
10.	Maharashtra	1	50	-	-	5 C.L.÷ 2,000	1250.
11.	Gujarat	1	150	-	-	30 C.L.÷12,000	3800.
12.	Rajasthan	25	68	38	25	43 C.L.÷17,200	4282.

* According to the Report on the National Demonstration conducted on maize 1967-68 (compiled by ICAR, India).

Note: (i) CL: Cart Loads
(ii) Mds: Maunds÷37,5kg
(iii) q: Quintal=100kg
(iv) FYM: Farm Yard Manure
(v) N: Nitrogen
(vi) P: Phosphorous
(vii) K: Pottasium

Table 11 Frequency of distribution of National Demonstrations State-Wise*

S.NO.	Yield kg/ha.	No. of demonstrations	States and numbers
1.	Below 2000	4	A.P.1, M.P.2, Maharashtra 1, M.P.3, Punjab 1, J & K 1, U.P. 1
2.	2100 - 3000	10	Rajasthan 4
3.	3100 - 4000	30	A.P.2, M.P.4, Delhi 1, Haryana 3, Punjab 7, J&K 5, U.P.1, Gujarat 1, Rajasthan 6.
4.	4100 - 5000	41	M.P.4, Delhi 1, Mysore 1, Haryana 7, Punjab 15, J & K, 2, U.P.2, Rajasthan 8, Gujarat 1.
5.	5100 - 6000	18	A.P.1, M.P.1, Delhi 1, Mysore 1, Haryana 1, Punjab 6, J&K 1, Rajasthan 6.
6.	Above 6000	12	M.P.1, Mysore 7, J&K 1, Rajasthan 1, H.P. 2.

Note: (1) A.P. Andhra Pradesh
(2) M.P. Madhya Pradesh
(3) U.P. Uttar Pradesh
(4) J & K Jammu and Kashmir
(5) H.P. Himachal Pradesh

Comparison of the state average yield and the yield obtained in National Demonstrations is given in Table 12.

The average of 116 National Demonstrations conducted in 12 important maize growing states was 4123. kg/ha. or 315% higher than all India average yield.

Table 12 Comparison of state average yield and the yield obtained in National Demonstrations *

S.No.	States	State average yield kg/ha	Average yield kg/ha	% increase over state average
1.	Andhra Pradesh	901	3183	253
2.	Madhya Pradesh	1098	3800	245
3.	Delhi	-	4220	-
4.	Mysore	775	6677	761
5.	Punjab	1207	4487	271
6.	Himachal Pradesh	1454	5742	294
7.	Jammu and Kashmir	878	4028	358
8.	Uttar Pradesh	808	3695	357
9.	Maharashtra	723	1250	72
10.	Gujarat	1101	3800	219
11.	Rajasthan	1036	4282	313
12.	Haryana		4310	-
	Average	9.98	41.23	315

* According to the Report on the National Demonstration conducted on the maize during 1967-1968 (compiled by ICAR, India).

H Rotation practices:**

The most common rotation in the Indo-Gangetic plain consists of maize, jowar, cotton or bajra in the *Kharif* season, followed by wheat, barley, brassicas, linseed or potatoes, in the *Rabi* season. Other type of rotation are:

2- Year rotations
maize - berseem (*Trifolium alexandrium*) - jowar - pea
maize - gram - marua - pea
maize - potato - cotton - pea

3-year rotations are:
green manure - sugarcane - maize - kalai
maize - potato - sugarcane - wheat

** According to information given by Dr. N.L.Dhawan.

I. Recommended cultural practices*

The recommended practices are the following:

1. Prepare a good seed bed - This requires adequate ploughing to a depth of at least 5-6 inches and in such a way as to turn under organic matter - either crop refuse, green manure or compost. This can best be accomplished with a moldboard turning plough correctly used. One such ploughing is all that is required. This should be followed by enough harrowing to break up clods and partially smooth the soil. A good planking will usually finish the job and this should leave the soil free of any weeds and in a good condition to receive the seed.

2. Select good seed - of known genetic origin, purity and high germinating ability. In this particular case, this means a hybrid, bred for the part of the country in which it is to be grown. The bag containing the seed should bear a certified seed tag giving essential information i.e. name of variety, lot number, percentage of inert matter and germination percentage. The bag should also be sealed to prevent contamination.

3. Follow an adequate fertility programme - This means first incorporating into the soil adequate quantities of organic material either from crop refuse, green manure or compost. This is very important in order to maintain the soil in good condition and to increase its water holding capacity. Crop refuse or compost are best for this purpose. The organic materials should be ploughed into the soil during seedbed preparation. The second requirement is the use of adequate amounts of commercial fertilizer, N, P and K. The amounts to be used will vary according to local deficiency conditions and according to the crop being grown. The best method is to have the soil tested by one of the soil testing laboratories to determine nutrient requirements, but where this cannot be done the Demonstration Committee for the improvement of maize recommended that 100 lb. of N, 60 lb. of P_2O_5 and 30 lb. of K_2O per acre be applied to the hybrid maize demonstrations. This represents what should be considered a minimum application, even on fertile land, to produce a reasonably good hybrid maize crop. The first application includes all of the P and K and 30 lb. of N. These are mixed, or obtained as a mixed grade, and applied in a band two or three inches to one side and one to two inches deeper than the seed. The remaining 70 lb. of N should be applied by scattering it between the rows when the maize plants are between one and two feet high. Care should be taken not to get this fertiliser on the plants nor closer to the stalks than about 10 inches. This fertiliser should be worked into the top or inch and a half of soil immediately, using a cultivator or other implement. This will prevent loss from washing in case of a heavy rain.

4. Follow proper methods of sowing - For maize this means sowing in lines. The lines may be 24, 30 or 36 inches apart depending on equipment and local conditions. Where lines are 24 inches apart seed should be spaced one foot apart in the lines. With 30 inch lines seed should be 8 to 10 inches apart and with 36 inch lines seed should be 7 to 8 inches apart. More than 20,000 seeds per acre will be sown at these rates. An effort should be made to have approximately 20,000 plants per acre at maturity. Under some conditions it may be necessary to sow at a somewhat heavier rate and than thin to the desired stand when the plants are about 8 inches high. Seed should be sown between one and two inches deep but not deeper than two inches in soil sufficiently moist to bring about immediage germination.

5. Keep all weeds out of the field - Weeds if uncontrolled, may reduce yields 50% or more. Weeds may be controlled with a cultivator, hoe, by pulling or

* According to information given by Dr. N.L.Dhawan.

by chemical means. At present hoeing is the commonest methods. Inter-cultivate is to be made to raise the soil level around the plants higher than in between the rows.

6. Control insects and other pests - There is little point in going to the expense of sowing and fertilizing a crop and then allowing insects, birds or other pests to destroy, a part or all of it. Borers and other insects should be controlled with appropriate insecticides.

Endrin 20% granules (15-20 lb/acre)	Endrin 20 E.C.(10 cc/gallon)
BHC 60% wettable powder (25 gm/gal)	Dipterex spray 80% soluble powder (15-20 gm/gal)

Borers often seriously reduce stands by attacking, when the plants are quite small. It is recommended that spraying or dusting with DDT or Endrex be done when the plants are about 4 inches high and before any sign of borer is to be seen. This should be repeated at an interval of 10 days or two weeks till the crop attains tasseling and silking stage. Other insects should be controlled as necessary. Steps also are required to protect the crop at maturity from birds, monkeys, jackals, cattle and other animals.

7. The seventh practice required for good crop production is correct water management. In this respect equal importance should be given to both drainage and irrigation. Maize will not grow under conditions of water-logging, so adequate drainage is absolutely necessary to satisfactory production. Adequate field drainage must be provided and if there are bunds around the field, these should be cut in several places to allow quick surface drainage after heavy rainfall. In addition to surface drainage sufficient sub-surface drainage should be provided to ensure that the water-table will be 3 feet or more below the surface. If these requirements cannot be met, then do not plant maize.

It is also very important that irrigation be provided when it is needed. Maize is a heavy user of water and the plants never be allowed to wilt for want of moisture. When soil conditions indicate that irrigation should be provided this should be done before the plants show by wilting that they are suffering for want of water.

8. In the event that the crop is hybrid maize or any other crop of similar origin, it is necessary that new seed be obtained each year and that seed never be taken from the growing crop. This is required because the hybrid originates by crossing two or more low producing inbred lines, and while the hybrid is high yielding, the succeeding generations will tend to be like the parents and performance will rapidly deteriorate.

J. Economics of cultivation:*

Cost and returns from maize crop depend mainly on the technique of cultivation, intensity of input use and the yield obtained. Table 13 lists the various direct (variable) and indirect (fixed) costs and returns associated with one hectare of maize crop grown by local and improved methods. The total cost of growing a hectare of maize by local and improved methods, works out to about Rs.814 and Rs.1,554, respectively.

The profit from maize would depend on the yield obtained, price of the product and the cost incurred. Table 13 shows an average yield of 11.32 quintals per hectare under local method and 47 quintals under improved method. The price of maize produced by local and improved methods remains almost the same. So, if maize sells, say at Rs. 60 per quintal, it can expect to have a gross income of Rs.679.20 and Rs.2,820 per hectare, under local and improved methods, respectively.

The net income per hectare would depend on whether one considers both fixed and variable costs or variable cost alone. If both are considered a net income of Rs.1,265.75 per hectare under improved method and a loss of Rs.134.80 per hec-

* According to Economics of Maize Cultivation by Sarvshri Katar Singh and V.K.Shama.

tare under local method is obtained. However, if only variable costs are taken into account then a net income of Rs.154.20 under local method and Rs.1554.75 under improved method is obtained. However, such a calculation will not be sound economics. With a view to stabilize the net income and spread over the expenses evenly over a number of years, one must take into account both fixed and variable costs.

Table 13 Average production costs and returns from maize* (Rs./ha.)

Item	Local method	Improved method
Variable cost		
1. Human labour	300.00	480.00
2. Implements and machinery	38.00	205.00
3. Seed	10.00	22.75
4. Farmyard manure	135.00	-
5. Fertilizers	20.00	462.50
6. Irrigation	-	50.00
7. Interest on current investment	22.00	45.00
Total variable cost	525.00	1265.25
Total fixed cost	289.00	289.00
TOTAL COST	814.00	1554.25
Average yield (q./ha.)	11.32	47.00
Gross income @ Rs.60/q.	679.20	2820.00
Net income over variable cost	154.20	1554.75
Net income over total cost	-134.80	1265.75

* According to Economics of Maize Cultivation by Sarvshri Katar Singh and V.K. Sharma.

Explanation of various costs

It would be of interest to know the constituents of both the costs variable as well as fixed. This would help in working out the economics of maize cultivation.

Variable cost:

Human labour:- The cost of human labour has been calculated at an average rate of Rs. 3.00 per day, irrespective of the consideration whether labour was actually hired from outside or supplied by the farmer himself. The actual cash expenses on this account would be reduced to the extent, the labour is provided by the farmer and his family members. The actual number of man-days required to produce a hectare of maize will vary according to the frequency of various cultural operations done and the type of power used.

Implements and machinery: Under this head, are included hire charges for tractor and other machines and implements. The cost has been calculated with the assumption that machines and implements were hired from outside and paid for at the rates then prevailing. The actual cash expenses will be lowered to the extent when the farmer uses his own tractor and other machines and implements. For those farmers who use their own bullocks and implements, no costs would be incurred under this head.

Seed:- Cost on this account would vary depending on whether local or hybrid seed is used.

Manures and fertilizers:- It is the usual practice to apply farmyard manure in maize, particularly under local method where no, or very small quantities of chemical fertilizers are used. However, under improved method, use of chemical fertilizers is a must. The typical fertilizer recommendation for maize under improved method generally includes 125 kg. of N, 75 kg. of P_2O_5 and 75 kg. of K_2O each per hectare.

Irrigations:- Irrigation cost depends on the source of irrigation. For instance in Tarai, farmers use both canal and tubewell water. Farmers who have the facilities of tubewell irrigation, generally grow maize by improved method. Canal water, where it is available, is cheaper than the tubewell water but its supply can not be assured at the desired time.

Plant protection:- No expenses are generally incurred on this head in Tarai both under local and improved methods. Obviously, because there has been, so far, no serious insect pest or disease problem.

Fixed cost:- It includes maintenance cost of bullocks, interest and depreciation cost of farm buildings, machinery and equipments. The actual cost on this account will vary from farm to farm, depending on the type and number of fixed assets. Here average fixed cost has been obtained by on the basis of a survey of 100 farmers in Rudarpur block of Tarai region of Uttar Pradesh.

CHAPTER II

COORDINATED MAIZE IMPROVEMENT PROJECT - Its Inception and Aim*

Maize was introduced to India from America at about the beginning of the 17th century. It is now next only to rice, wheat and jowar, as a food crop. Though consumed all over the country, it is the staple food of people in the hilly and sub-mountaneous tracts of Northern India. It is also grown as fodder, which is sweet, succulent and fit for feeding green or ensiling. The starch extracted from the grain is used for industrial purposes as well.

During the period 1951-62 the area under maize increased from 3.7 million to 5.2 million hectares, while production rose from 2 million to 4.5 million metric tons of grain. Production is increased from 4.5 million metric tons to 5.0 million metric tons with the extensive adoption of hybrids and improved practices, including higher levels of fertilizer application. The total area sown to commercial hybrids in 1966-67 is about 50,000 hectares. In India, maize is essentially a rich land crop. It grows best on fertile, well drained loamy soils that are neither too heavy nor too light.

In 1953, two maize specialists Dr. U.J. Grant and Dr. E. J. Wellhausen visited the country and explored the possibility of establishing a breeding programme on the country wide scale in consultation with the Government of India. They submitted a plan to start a coordinated maize breeding scheme for the improvement of maize.

Based on their recommendations and with the collaboration of Rockefeller Foundation, supplying financial and technical support, Coordinated Maize Breeding Scheme was initiated in 1957.

Before the inception of Coordinated Maize Improvement Scheme, very limited investigations were carried out at different research stations in India. Research in maize breeding and genetics was limited to the states only. There were several factors limiting the progress of breeding programme. Lock of technical personnel, equipments, land, germplasm, etc. were some of the main factors. The most important fact was that the varieties present in the Indian collection were highly uniform. These varieties appeared to have originated from a few introductions. This indicated that there was lock of divergent materials (genetically). There was no coordination among the different research station in the country. Some inbred lines were developed but no early testing was done. Though about 30 advanced generations lines (F4 or more) were available, nothing was known about their combining ability. Collections of exotic germplasm was limited and the inbreds obtained from U.S.A. were found to be unadaptable. Three hybrids, namely, Punjab Hybrid No.1, No.2 and No.3 were developed by the Punjab stations but none of these hybrids were very high yielding (2500-.4000 lb/acre). Some inbred lines were developed from the local materials, namely, KT41-70, KT41-267, Jathia, D-74, Jalna(y)-4-2, Piarka-1-# etc. Nothing was, however, known about their combining ability.

Dr. U.J. Grant and Dr. N.L. Dhawan made extensive survey of the country and they suggested a coordinated approach for maize improvement work in India. Based on their suggestions, the following aspects were carried out.

a) On the agro-climatic basis, the whole country has been divided into four zones**- as follows:

Zone 1 - North eastern and western Himalayas
Zone 2 - Northern plains
Zone 3 - Indo-Gangetic plains
Zone 4 - Peninsular India.

* According to Dr. N.L.Dhawan, Dr. B.K.Mukerjee and Mr. N.N.Singh.
** Refer to chapter 1 on the detail.

b) Within each zone, there has been established a main centre, and a number of sub-centres whose main responsibility is to carry out regional testing. However, this pattern is not rigid, but has flexibility since certain substations may have qualified and experienced staff and excellent facilities for actively participating in the work of the main centre in addition to their regional responsibility. Consequently, the programme of work relating to development of experimental materials and their testing are implemented jointly by the main centres and sub-centres within the zone.

c) Inter-disciplinary approach is a very important aspect of the organization set up. In the past, there has been a tendency on the part of the plant breeders and geneticists to claim that any crop improvement has to be collaborated effort between scientists of different disciplines who work as a team and as equal partners.

d) The Coordinating unit forms the corner stones in the overall structure. The normal tendency in the past has been for individual stations to function independently of each other and thereby become insular. History has repeatedly demonstrated that long periods of isolation of any plant or human community has led to loss of productivity. The Coordinating Units plays a key role in perpetually keeping the participating stations creatively functioning. Over the years, through trial and error and through experience, there has been established a working relationship between the coordinating office and other stations. The essential points are -

1. The Project Coordinator is not a man with authority to punish or to reward. He has no such functions. He is one of the members of the team.
2. The Coordinator actively participates in the research programme of each station, and takes the responsibility for the implementation of the project at a station, where technical staff has not yet been recruited or temporarily displaced.
3. He serves as a common link between the various stations, and his office is the agency responsible to bring about a rapid and frequent exchange of ideas, experimental materials, information and data.
4. He encourages research staff to visit the other stations from one station and study the projects being implemented there.
5. He works as a friend and guide and if need be, as a supervisor.
6. He makes periodical visits to various stations and keep them informed of what is happening at other centres.
7. It is his responsibility to arrange for periodic zonal meetings and annual conferences where the progress of research are discussed and research programmes for the next year are planned.
8. It is the responsibility of the Coordinator to prepare the annual progress report of All India Maize Scheme, and keep the participating organizations informed on the progress of the project at each station and the lacunae, if any, that need to be filled and bottlenecks removed.
9. The Coordinator in order to function effectively, should not only have high level of scientific and technical competence, but also the ability to win the confidence and respect of the research staff.
10. He should create the development leadership at different levels of operation. To attain the objective there has to be a free play of scientific ideas and freedom to implement them at the station and zonal levels.

The sources where implementation is planned are the zonal and annual meetings. Scientists of all disciplines meet to review the results of last year and plan for the future. The annual workshop meeting is the nucleus that controls the organism.

The programme of the annual workshop conference first calls for the discipline-wise meetings and then point discussions where each discipline presents to the whole group the results and the plans for the next year. The joint meetings are open for discussion and everyone participates. At these meetings different research problems are presented and discussed, procedures are standardized, priorities are fixed and training programmes are initiated. Such aspects as standardization of procedures is essential since every participating scientist must talk in a common language with regard to the scientific data. to facilitate the work uniform formats for taking data, its analysis and submission are prepared. Decisions are also taken on uniform multi-location testing and uniform experimental procedures.

Different stations were located in each zone and worked as a single unit. Uniform procedures, technique, and nomenclature were formulated which were followed by all stations. A Coordinator was appointed to coordinate the research project being carried out by the different stations. The main projects are listed below:

1. Collection and evaluation of Indian and exotic varieties and races of maize.
2. Derivation of inbred lines from promising germplasms, their testing and production of double crosses.
3. Evaluation of combining ability of maize germplasm collections by intervarietal crosses and test crosses.
4. Development of composite varieties by combining elite varieties and races of maize.
5. Breeding for disease and insect resistance.
6. Breeding for prolific ear character, compact plant type and high quality protein maize.
7. Development of superior sweet corn and pop corn composite, varieties and hybrids.

A brief review of the work done on these aspects are discussed herein.

A. Breeding section*

(i) Derivation of inbred lines and making of double cross hybrids:

After the inception of the Coordinated Maize Improvement Scheme, a large number of inbred lines and hybrids were introduced from USA and the Caribbean region. More than 800 inbred lines were put into top cross trial in 1958 with several single crosses as testers. The introduced double cross hybrids and the Punjab Hybrids were put into trials. 28 promising inbred lines on the basis of their top cross test in 1958 were picked up for further study. Several of the hybrids from Southern USA performed well, particularly deserving mention are NC 27, Texas 26 and Dixie 18. These hybrids though performed wall, had dent grains and, therefore, were not very popular with Indian farmers who preferred flint grains (see Plate 9).**
Moreover, the inbred lines of these hybrids were difficult to maintain. A breeding project using indigenous maize materials and other exotic germplasm was undertaken. Emphasis was laid on yellow flint grain type and high yield. More attention was placed in the selection of elite inbred lines having high general comvining ability, desirable agronomic characters and resistance to diseases and pests. A large number of inbred lines numbering more than 4,000 were developed from Indian and adapted exotic germplasm. Out of these 52 outstanding inbred lines belonging to several groups like AdeCuba, Funks, G715 Dixie, Jalna (y), K.T.41, Eto, Peru 330, Desc. 2, Venezuela 1, Nar 330, Wf. 9, Kys, Tenn 29, GT 122 etc. were picked up. A large number of experimental single crosses were made and double cross performance was predicted from the single

* According to the Progress Reports of the Coordinated Maize Breeding Scheme 1959 to 1968, ICAR, India.
** Plate No.21: By courtesy of the Rockfeller Foundation in New Delhi.

cross data. All the inbred lines that were developed were screened for diseases and pest resistance. The lines of Ade-Cuba, Cuba 1, G 715 and G 733 were found to be fairly resistant to *Helminthosporium,* downy mildew, bacterial diseases. The materials from Caribbean, Central American and Columbian region were found to be very promising since such lines like NC 7 and NC 13 showed poor adaptation and considerable susceptibility to diseases such as *Sclerospora philippinensis* and the pest *Chilo zonellus.* . These were, however, certain exceptions such as inbred lines derived from the Hybrid G 715. The inbred lines were screened for their agronomic performance and disease and pest resistance at the different stations in the different zones. The initial screening of large number of inbred lines was done by top cross testing. The tester used for the evaluation of the inbred lines was usually the best adapted local variety. A list of outstanding inbred lines is given in Appendix V. On the basis of the top cross test data, the good combiners were selected and single crosses were produced. All the single crosses were then put into yield trials conducted at several locations over several years. Since a large number of double crosses are possible from such a large number of elite inbred lines, it was not possible to make all the double crosses and study their performance. Predictions of the performance of double crosses were, therefore, made using Jenkin's Method B, before actually making the double crosses. Only these double crosses were made whose predicted performances were the maximum. These double crosses were then put into large number of trials at different locations. In general, the lines that gave outstanding double crosses were G 7(B), CI 21E, Cuba 342, PH 3, Eto 81, AdeC 257 etc. The different stations in the different zones produced their own experimental double cross hybrids and put them into uniform trials as coordinated trials. A list of promising experimental hybrids, studied for more than two years and their performance in the different zones, is given in Appendix VI. Appendix VII gives the coded pedigree of the experimental double crosses listed in Appendix V.

The hybrids which perform very well in these trials are recommended for the commercial release by the maize breeders to the Central Varietal Release Committee. The hybrids are not released unless they are resistant to diseases and pests.

By 1961, four double cross hybrids, namely, Ganga 1, Ganga 101, Ranjit and Deccan were selected and recommended for release in the plains and peninsular India. In 1962, a new hybrid (VL 54) was developed by the Vivekananda Laboratories and was released in Almora area. In 1963, the white double top cross hybrids Ganga Safed 2 and Hi Starch were released. In 1964, two double cross hybrids Ganga 3 and Him. 123 were released. All these succeeding hybrids were progressively better than the preceding ones. Recently in 1967, a new double cross hybrid Ganga 5 which is resistant to new downy mildew disease has been released. All these inbred lines which had gone into released hybrids were given code number starting with letters CM. A complete list of the released inbred lines and varieties is given in Appendix VIII. Plates (10-21) represent some of these inbred lines and varieties. The parental constitution of the released hybrids and their year of release has been given in Appendix IX. Plate 22** represents some of the released Indian Maize Hybrids.

The direction of crossing in the development of single crosses and the double crosses in case of the released hybrids have been represented in Appendix X. Plates (23 to 26)*** represent some of the male parents of the released hybrids. A short description of each of the hybrids, their area of adaptation, maturity period and yield level is given below:*

Ganga Hybrid Makka 1

Pedigree: (P4A(Y)-1-3y-#-#)x(P5PB5-3-f)x(P'4-1(B)-#-#-#-#)x(G 715-A36-

* According to information given by Dr. N.L.Dhawan.

** Plate No. 22 to Plate No. 24: By courtesy of Dr. N.L.Dawan.

*** Plate No. 25 and Plate No.26: By courtesy of the Rockfeller Foundation in New Delhi.

#-#-#-#)
Area of adaptation: Indo-gangetic plains, foot-hills of Himachal Pradesh and parts of Gujarat, Maharashtra and Mysore.
Maturity period: 80 to 90 days.
Description: Plants resistant to lodging; tendency to develop two well-filled ears per plant; ears have tight husk cover providing protection against bird damage; attraction small, round, hard and yellow grains. Resistant to downy mildew, medium tolerant to the maize top shoot borer.
Grain yield: The hybrid was yielded from 17% to 70% more than local varieties, when grown under recommended agronomic practices.
Fodder:- The hybrid has given from 32% to 200% more fodder than local varieties.

Ganga Hybrid Makka 101

Pedigree: - (Col.1x38-11(Lot No.etc.) 327mez) x (A Theo-21-f-#-3-#-#) x (G 715-A1-2-2-#) x (Peru 330-#-#-29C-1-f-#)
Area of adaptation: Indo-gangetic plains
Maturity period: 95 to 105 days
Description: - Plants highly resistant to lodging ears have very tight husk cover, extending beyond the tip of the ear tendency to develop two big grain-filled ears per plant very attractive, bold, round, hard, orange-yellow grains highly resistant to downy mildew, leaf blights and rust medium tolerant to the maize top shoot borer.
Grain yield:- The hybrid has yielded from 22% to 152% more than local varieties, when grown under recommended agronomic practices.
Fodder:- The plants are still somewhat green at harvest and make better quality fodder than local varieties. The hybrid has given from 65% to 400% more fodder yields than local varieties.

Ranjit Hybrid Makka

Pedigree: (Col.1x38-11(Lot No. etc.) 327mez) x (A Theo-21-f-#-3-f-#-#) x CI21E(Derivative of U.S.released inbred line) x (Nar 330-#-23B-1-f-f)
Area of adaptation: South Rajasthan, Gujarat and Maharashtra
Maturity period:- 100 to 110 days.
Description:- Plants highly resistant to lodging; have a thick stem with a reddish base ears have tight husk cover a strong tendency to develop two big grain-filled ears per plant attractive bold, round, hard, orange-yellow grains highly resistant to downy mildew, leaf blights and rust medium tolerant to the maize top shoot borer.
Grain yield:- The hybrid has yielded from 22% to 150% more than local varieties under recommended agronomic practices.
Fodder:- The plants are still somewhat green at harvest and make better quality fodder than local varieties. It has given from 43% to 428% more fodder than local varieties.

Deccan Hybrid Makka

Pedigree:- (A Theo-21-f-#-3-f-#-#) x (Peru 330-#-#-29C-1-f-#) x (G 715-A1-2-2-#) x C121E(Derivative of U.S.released inbred line)
Area of adaptation:- Peninsular India
Maturity period: 100 to 110 days
Description: Plants have broad, dark green leaves, and thick stem resistant to lodging very tight husk cover giving protection against bird damage tendency to develop two big grain-filled ears per plant; bold, hard and bright yellow grain, highly resistant to downy mildew, leaf blights, and rust disease tolerant to top shoot borer.
Grain yield:- The hybrid has yielded from 23% to 145% more than local varieties under recommended agronomic practices.
Fodder:- The plants are still somewhat green at harvest and make better quality fodder than local varieties. It has given from 58% to 383% more

fodder than local varieties.

Ganga Safed Hybrid Makka 2

Pedigree: (Eto PL-13-1-#-2-1-#(U.P.) x Tenn 29) x Rudrapur Local (Pantnagar)
Area of adaptation: Indo-gangetic plains or Zones 2 and 3, and also in the areas of Zone 4 where farmers prefer white grain.
Maturity period: 92 - 95 days.
Description: Plants resistant to lodging, moderately susceptible to *Helminthosporium* and rust; appears to be tolerant to top shoot borer; good husk over; tendency to develop two well filled ears per plant; and round, medium sized, white coloured grain.
Grain yield: Ten percent higher than Ganga Hybrid Makka 101 in Zones 2 and 3 for the years 1961 and 1962 and four per cent less than Deccan Hybrid Makka in Zone 4.

Hi-Starch Hybrid Makka

Pedigree: (Eto PL-13-1-#-#-1-#(U.P.) x Tenn 29)x Jellicorse
Area of adaptation: Throughout India and recommended wherever market demand exists for this type grain. Performs particularly well in the Himalayas.
Maturity period: Approximately 95 days in plains and peninsular India.
Description: Plants very broad-leafed and resistant to lodging tendency to develop two ears, good husk vover, moderately susceptible to *Helminthosporium* and rust; tolerant to top shoot borer and bold, dent to semi-dent, white kernels.
Grain yield: Approximately equal to Ganga 101 in Zones 2 and 3 on an average of 1961 and 1962 data, less than Deccan in Zone 4 and approximately equal to VL 54 in Zone 1.

VL 54:

A double cross hybrid developed at the Almora Station and which has been known by the station code name VL 54, was released for the foot-hills of the Himalayas by the Release Committee at their meeting in New Delhi, on February 10, 1962. The hybrid has been tested extensively at a number of stations of the Coordinated Maize Breeding Scheme over a three year period and has given good performance. It has a tendency to produce two well developed ears with a tight husk cover. Two of the parental inbred lines were selected from NC 7 and NC 13, released inbred lines from U.S.A. while the other two lines were selected from GCL 31 and GCL 33, released lines from Colombia, South America.
A brief description as provided by the Almora Station is presented below:
Pedigree: (GCL 31 x GCL 33) x (NC7(10 derivative of U.S. released inbred lines) x NC 13)
Area of adaptation: Himalayan hills and foot-hills and Indo-Gangetic plains.
Maturity period: 100 - 110 days.
Description: Good vigour, plant aspect and husk vover:
resistant to lodging moderately resistant to *Helminthosporium* blights, and an excellent pollen producer. Yellow, flinitish grain colour and type with medium to high ear placement. Tendency to develop two well filled ears per plant. Medium to long ear length with small ear diameter.
Grain yield: Has given the highest yield at Almora for three successive years significantly higher than Ganga 101 and Deccan. It is also one of the highest yielding hybrids at other stations in Zones 1, 2 and 3.

Himalayan Hybrid Makka 123

Past six years data on the performance of hybrids and other materials, has indicated that the Himalayan Region should be treated as two subzones, namely, the more arid western Himalayas (represented by the stations: Srinagar, Bajaura, Solan and Almora) and the more humid eastern Himalayas (represented by the stations Kalimpong and Gangtok). While the released hybrid VL 54 has shown superior performance in the eastern region, there was a lacuna for a good hybrid for the western Himalayas. Consequently, the Hybrid Maize Release Committee, on the basis of three years' data, recommended the release of Himalayan Hybrid Makka 123 for this region.

Pedigree: CI21E (Derivative of U.S. released inbred line) x Kys (U. S. inbred line) x
(Desc 2-229-1-1-f-#-#-#) x (Eto-190C-4-2-f-f-#)

Area of adaptation: The eastern part of Zone 1 represented by the hilly areas of Jammu and Kashmir, Punjab, Himachal Pradesh and Eastern Uttar Pradesh.

Maturity Period:- 105 to 110 days.

Description: Vigorously growing plants, resistant to lodging, *Helminthosporium* and rust. Well developed ears, possessing a tight husk cover, tendency to develop two ears per plant, tolerant to top-shoot borer, yellow semi-flint grains.

Grain yield: In its area of recommendation, the hybrid has given from 60% to 112% more yield than local variety and has proved a superior performer than VL 54.

Ganga Hybrid Makka 3

It is an early maturing yellow flint grained hybrid, which has about the same maturity as the local varieties under cultivation and Ganga Hybrid Makka 1, and about 7 days earlier flowering than Ganga Hybrid Makka 101 and Ranjit.

Pedigree: (CI21E x Kys) x (Desc 2-229-1-1-f-f-#-#-#) x (Eto 190c-4-2-f-f-#)

Area of adaptation: Indo-gangetic plains comprising Zones 2 and 3; also in Peninsular areas where early maturity hybrids are required.

Maturity period:- 90 to 95 days

Description: Plants resistant to lodging and moderately resistant to *Helminthosporium turcicum, H. maydis,* and rust, tolerant to the top-shoot borer; good husk cover, well developed ears, possessing bright, orange flint grains.

Grain yield:- Over a three year period, it has given from 28 to 47 per cent more yield than local varieties and is slightly superior in yield to Ganga 101 and Ranjit. It has given as good yields as Deccan in Peninsular India.

High yielding maize hybrid Ganga 5

In recent years, the new downy mildew disease (*Sclerophthora rayssiae* var. *zeae*) has increased to alarming proportions in the Northern plains, such that in 1967, its severity was to such an extent as to limit the cultivation of the susceptible maize hybrid Ganga 3. Moreover, the parental inbred lines of Ganga 3, namely, CM 109 and CM 110 were found to be highly susceptible and it was not possible to increase the seed particularly of CM 110.

In this period, a number of new experimental hybrids have been under test and it was found that the Experimental Hybrid 2385 showed a high degree of resistance to the new downy mildew disease. In yield trials, over the past 2 to 3 years this has also given the same level of yield as Ganga 3, in the northern plains. The maturity of the Experimental Hybrid 2385 was comparable to the hybrids already released for the different zones.

An additional feature of the Experimental Hybrid 2385 is the fact that of all maize germplasm in the breeding programme, whether released or under experimental test, this hybrid has shown the highest degree of resistance to the top shoot borer of maize.

The female parent, single cross of this Experimental Hybrid is CM 202 x CM 111 which has been one of the most productive single crosses in the breeding programme. Consequently, hybrid seed production becomes more economical and profitable.

Considering the points raised above, this hybrid was recommended for release not only for Northern plains but particularly in regions where the new disease is limiting production.

Pedigree: (CI21E)x(Cuba 342-2-2y-#-#) x Antigua Gr. 1

Area of adaptation: Northern plains and parts of Peninsular India where the brown stripe downy mildew disease is becoming severe.
Maturity period:- 90 to 95 days
Description: Plants relatively compact, with sturdy stalk and broad dark green leaves, single eared type, ears conical with bold semi flint to flint yellow grains, resistant to the leaf blights *Helminthosporium turcicum* and *H. maydis* and to the brown stripe downy mildrew (*Sclerophthora rayssiae*) resistant to the stem borer (*Chilo zonellus*)
Grain yield: Same yield potential as Ganga 3.

(ii) **Collection and evaluation of Indian and Exotic germplasm***

All these years, though emphasis was laid on the development of inbred lines and production of double cross hybrids, yet a project was underway to collect and evaluate a large number of Indian and Exotic germplasms. A wide collection of maize germplasm obtained from Mexico and other Latin American countries is being maintained at I.A.R.I. Delhi centre of the Coordinated Maize Breeding Scheme. This material is being used for the development of improved hybrids and composites. The collection includes a large number of varieties of exotic origin.

Under the Maize and Millet collection Project, jointly sponsored by the I.C.A.R. and the Rockefeller Foundation, collection of local varieties were made from the states in India during the period 1959-62. Collection made under this project was handed over to main station, Delhi, for evaluation. Table 14 records the number of collections that were made from different states from the country. It may be noted that out of the total of 1591 collections, the states of Bihar (259), Madhya Pradesh (247), Jammu and Kashmir (221), Uttar Pradesh (186), Punjab (170), W Bengal (94), Assam, Nanipur, Tripur and NEFA (96) made the major contribution. While from other states, relatively smaller number of collections were made.

Table 14 Indian maize collections*

State	No.of maize collections made and evaluated	No.of collections used in the complexes	No. of complexes available
Andhara Pradesh	27	27	3
Assam,Manipur,Tripura &NEFA	96	71	10
Bihar	259	154	10
Bombay	-	16	4
Gujarat	26	23	6
Himachal Pradesh	77	56	10
Jammu and Kashmir	221	134	12
Kerala	7	5	2
Madhya Pradesh	247	160	15
Madras	4	4	1
Maharashtra	29	-	-
Mysore	9	7	2
Orissa	57	31	3
Punjab	170	195	13
Rajasthan	82	5	2
Uttar Pradesh	186	135	11
West Bengal	94	51	9
Total	1594	1074	113

* According to information given by Dr. N.L.Dhawan.

These collections were grown in observation trials and were evaluated for maturity, plant and ear characters, husk cover, lodging and grain type. Subsequently, these materials were grouped, state-wise on the basis of maturity seed color and grain type. These complexes have been grown from two to three seasons subsequent to composition. Appendix XI records the number of collections that have been used in making these complexes in each state while the total number of complexes made in each state are also recorded in the last column of the same table.

Considerable variability with regard to maturity, plant type, grain colour and disease reaction were observed. Some of the collections from Punjab, Gujarat and Madhya Pradesh flowered as early as 32-35 days, and on the other extreme some of the collections from Tripura and Assam did not flower until 85 days.

It may also be worth mentioning that collections made from the states of Jammu and Kashmir, Himachal Pradesh in particular were outstanding. Collection particularly from parts of Assam, Tripura and Agartala showed some of the very impressive plant type, even though some of them were quite late.

IARI Delhi centre also maintains all the inbred lines which have gone in the released hybrids. The breeders seed is supplied by the Coordinator to the National Seeds Corporation which is responsible for the multiplication and supply of seed to the farmer.

(iii) Composite breeding approach and results obtained: *

The varietal collection being so large, it is practically impossible to make all possible crosses and determine their combining ability. Before any material is used in breeding programme, it is important that its combining ability is known. Therefore, the combining ability is being tested by crossing these materials to testers which are locally adapted materials and released composites. This serves the purpose of initial screening when the number of good combining lines becomes limited, intervarietal crosses in diallel or partial diallel are made. This material serves two purposes - (a) It gives the general combining ability and specific combining ability of the materials under test. (b) It has been experienced that some of the inter-varietal crosses are giving very high heterotic responses and their yield levels are comparable to best double cross hybrids released to date (see Plates 27A and 27B).** Based on these observations the higher yielding F_1's of the intervarietal crosses can be advanced to F_2 and F_3. The cases where there is no or very little decline in advance generations, could be used as commercial variety by farmers. It has got an additional advantage over the hybrids that its seed could be used further without undergoing the performance.

It is realised by most of the maize workers that initial performance of the lines have got an important bearing upon the yield performance of the hybrids. Therefore, if one starts with a population which is already very high yielding, the hybrids developed from these materials will yield still higher. Further in our conventional breeding programme, because of inbreeding there is rapid fixation of genotypes and there is no further chance of improvement by developing inbred lines from these hybrids. Therefore, it is felt that if a base populations could be developed with yield, higher than that of the released hybrids, they can serve as such as a reservoir for tapping better performing inbred lines. It is well known, yield is governed by polygenes and the work done by several workers

* According to information given by Dr. N.L.Dhawan.
** Plate No. 27 to Plate No. 29: By courtesy of Dr. N.L.Dhawan.

have established that hybrid vigour could result from dominance or over-dominance or additive type of gene action. Hybrid vigour resulting from dominance or over dominance is not stable, but very large in magnitude. This type of gene action is utilized in the double cross hybrid production programme. The hybrid vigour resulting from the additive genetic type of gene action is very stable though a little less in magnitude than that resulting from the former. However, it is possible to elevate the yield level of the population progressively by exploiting the additive component more and more. Investigations, carried out by Robinson, Comstock, Lonquist and Gardner and others in U.S.A. show that considerable additive genetic varaiance exists in the germplasm from north and south America and the Caribbean region. It was felt by Dr. N.L. Dhawan that these exotic germplasms and also the indigenous germplasm should be studied genetically and the components of the genetic variance be estimated so that such germplasm could profitably be used. Investigations carried out by several of Dr. Dhawan's students have revealed that germplasms introduced from central and south America and Caribbean region has a much wider range and a higher level of performance. The first step in the breeding programme was, therefore, to use a good local variety or a varietal complex as a top cross tester in a wide spectrum of introduced materials. The F_1 top crossed was tested and a large number of them gave yields equal to or better than the best double cross hybrids. Heterotic response range as high as 20-30% or more than the better parent. Trials with F_2 generation showed that certain of them gave little decline in F_2 or further generation. Such F_1 varietal crosses or their advanced generation can, therefore, be released for commercial cultivation. A few examples of such varietal crosses and the advanced generation are given in Tables 15 and 16. In certain cases there was improvement in yield which could be due to the breakage of certain undesirable repulsion phase linkages. Based on these concepts a large number of composite populations were developed and studied over various locations. It was also found that the composites possessed a wider adaptability and more buffering capacity for untoward environment.

The early generations of such composites can be further improved by certain breeding procedures. Better F_2 populations are subjected to different recurrent procedures to obtain maximum gains.

Dr. N.L. Dhawan has suggested certain modifications - recurrent selection procedures and also a methodology for developing progressively higher yielding populations and hybrids. These procedures are, herein, described in detail.*

Table 15 Maize composites (4 generations) - Grain yield kg/ha at 15 % moisture (Northern plains)

Entry	F_1	F_2	F_3	F_4
Composites				
B_1 x Antigua Gr.1	4870	4145 (85.0)	4493 (92.3)	3687 (75.7)
(Kisan)				
J_1 x Coastal Trop. Flints	4376	4206 (96.1)	3808 (87.0)	3936 (90.0)
(Jawahar)				
A_1 X Antigua Gr.1	4408	4155 (94.3)	4077 (92.5)	4207 (95.4)
Hybrid				
Ganga 3	4694			

According to Progress Report of the Coordinated Maize Breeding Scheme, 1966, ICAR, India.

Values in bracket percentage of F_1

*According to the Breeding methodology for Yield and Other characters in Maize, by Dr. N.L.Dhawan. 1965.

Table 16 Maize composites (3 generations) Grain yield kg/ha at 15% moisture (Northern plains)

Entry	F_1	F_2	F_3	% of F_1 F_2	% of F_1 F_3
Composites					
(B_1 x Cuba 11J)	4217	3433	3043	81.4	72.1
(J_1xCuba11J)(Sona)	3447	3290	3827	95.4	111.0
(Puerto Rico Gr.1 x Cost.Trop.Flints)	3577	3907	4330	109.2	121.0
Hybrids					
Ganga 5	3577				
Ganga 101	3613				

Accrding to Progress Report of the coordinated maize breeding scheme, 1966, ICAR, India.

Modified mass selection: (Fig. 7A)

The population developed in the manner tested above should be grown in a half acre plot in isolation. The plot should be divided into equal sectors, and plants should be selected in each sector in order to minimsie the effects of soil heterogeneity and fertility gradient. Equal number of plants should be selected in each sector keeping in view the norms for the characters. Undesirable plants should be detasselled. Ears are harvested from the selected female plants and are screened for undesirable attributes. Equal quantities of seeds are taken from each ear and bulked. The reconstituted population is tested against the base parental population. The shift in the population will be in the direction selection pressure has been exercised. Selection cycle can be repeated so long as the population shows a shift in the direction selection is being done.

Reciprocal recurrent selection: (Fig. 7B)

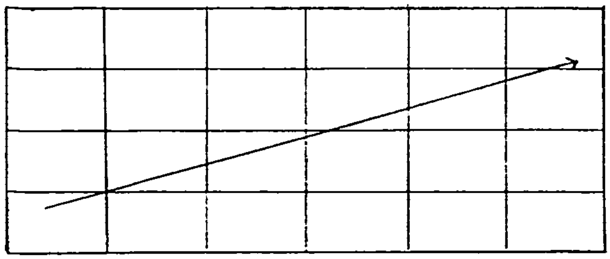
Parental populations A and B which have given excellent F_1 and F_2 performance in hybrid combinations, are suitable for a recurrent selection programme. The inbred lines developed from A are top-crossed to the base population B and vice versa. From top cross test data, the elite inbred lines are selected and selection pressure is exercised in the desired direction. The elite inbred lines from each population are then chain crossed and equal quantities of crossed seed from each line are then bulked to reconstitute the population. If tests reveal that significant improvement has been achieved, the cycle of selection can be repeated.

Bi-parental progency selection:

One of the main objective in improving a heterozygous population is to prevent the fixation of genotypes and increase the frequency of favourable genes governing the quantitative traits concerned. The production and evaluation of biparents, and reconstitution of the population from the superior biparentals is one such procedure. It can readily be visualised that by selecting elite biparents, in repeated cycles, it should be possible to concentrate favourable genes and eliminate the undesirable ones. A population can thus be developed, which in a panmictic state not only gives a high level of performance for the quantitative traits under selection, but also possesses a low level of plant to plant variability. Such a breeding methodology would be suited to a quantitative trait whose genetic architecture consists predominantly of additive gene effects and complimentary epistasis.

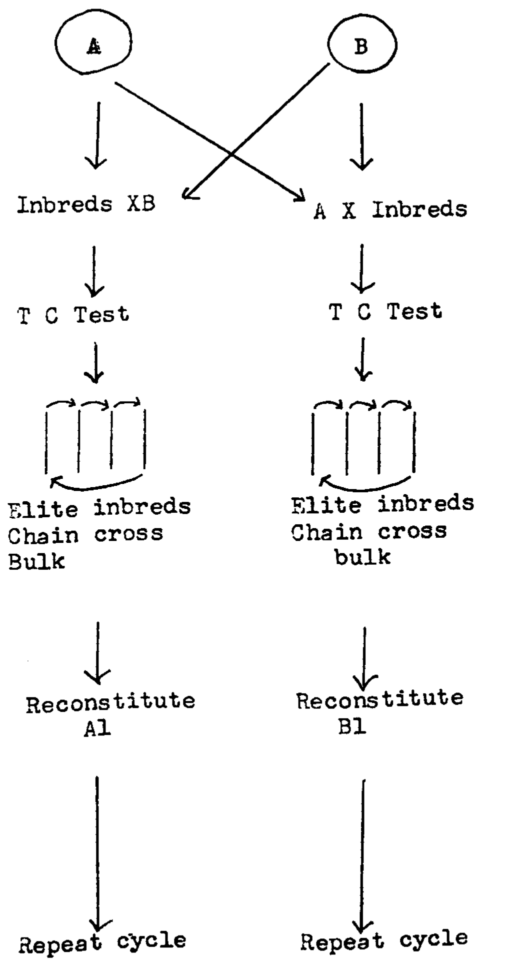
Figure 7. RECURRENT SELECTION PROCEDURES *

7A Modified Mass Selection

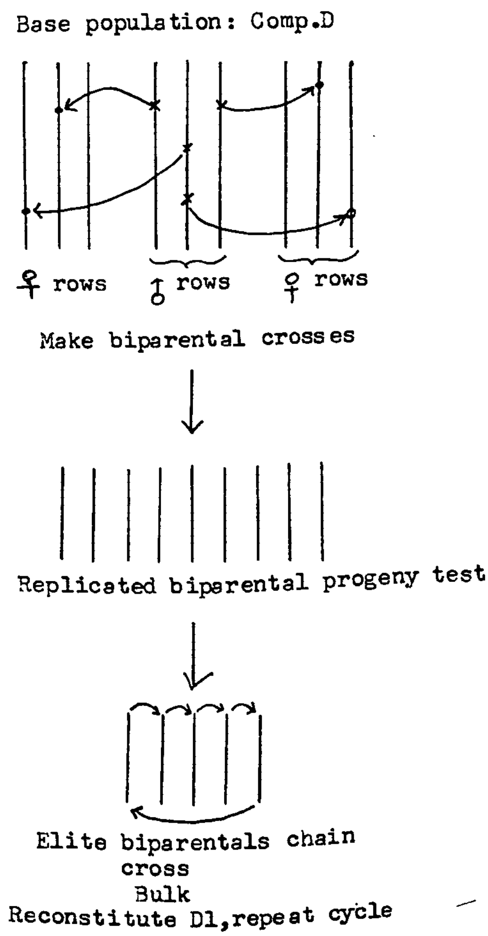


1. Select equal number of plants in each sector
2. Detassel undesirable plants
3. Bulk seeds of female plants

7B Reciprocal Recurrent Selection



7C - Biparental Selection



* According to Breeding Methodology for Yield and Other characters in Maize by Dr. N.L.Dhawan, 1965.

Figure 7C illustrates the recurrent biparental progeny selection procedure. Briefly stated, in this method, male plants are selected, possessing the desirable characters and each male plant is crossed to a selected female plant. Biparental progency test will indicate whether selection pressure has been effective. On the basis of the biparental progeny data, remnant seed of the elite biparentals are planted and chain-crossed. Equal quantities of seed from each cross are then bulked. The cycle is repeated as long as tests indicate that the population is not reaching a stage of diminishing returns.

Table 17 presents data on the yield performance of biparental progenies developed from a F_2 population of (Dorado de Tequisate x Eto Amarillo). The yields of the biparentals range from 132 to 83 per cent of the F_1 cross. in all 280 progenies were tested and 24% significantly outyielded the F_1 combination (see Plate 28).

Table 17 Performance of bi-parental porgenies base population*
(Dorado de Tequisate x Eto Amerillo)F_2

Pedigree	Yield kg/ha	% of F_1
F1	5174	100
F_2	4563	90
BP_1	6835	132
BP_2	6632	128
BP_3	6443	125
BP_4	6079	118
BP_5	5484	106
BP_6	5038	94
BP_7	4282	83

Total biparentals tested 280
24% significantly outyielded F1

Table 18 Biparental progeny selection *

Entry	Yield kg/ha	% of Ganga 101
Basi x Eto F_1	3184	110
(Basi x Eto)-# F_2	2539	88
Ganga 101	2897	100
Reconstituted:		
(Basi x Eto)-#	4863	114
Ganga 101	4210	100

* According to the Breeding Methodology for Yield and Other characters in Maize by Dr. N.L.Dhawan, 1965.

Table 18 shows the performance of a reconstituted population, advanced another generation after recombining elite biparentals. The base population was developed by crossing to outstanding varieties, Basi (India) and Eto Amarillo (Colombia). The F1 gave ten per cent more yield than the double cross hybrid Ganga 101, while the F_2 yielded 12 per cent less. After a biparental progeny test the population was reconstituted and advanced another generation by sib mating. It will be seen that it yielded 14 per cent more than Ganga 101.

A designate scheme for the development and improvement of composites is shown in Fig. 8

The various steps for the development of a composite are -

Step 1
The first step in the composite breeding programme is the screening of wide spectrum of base varieties for adaptation, by multilocation tests, and identification of sources possessing resistance to the prevailing diseases and pests, and possessing other desirable attributes.

Step 2
Consists of either making diallel and partial diallel crosses between the elite base varieties, keeping in view the fact of genetic diversity, or using one or more varieties (preferably a varietal complex of the best indigenous varieties in agro-climatic zone), and top-crossing it to the screened base varieties.

Step 3
Constitutes a multi-location test with the F_1 and F_2 generations of the varietal crosses. Only these combinations that give high yield (as compared to the best check entry), high heterotic response and the least decline in the F_2, and also conform to the norms for the other characters, are further utilized in breeding. According to the genetic theory overdominance and epistatic effects will to a considerable extent be dissipated in the F_2, and F_2 performance will largely be the result of additive gene effects.

Step 4
Certain of the elite F_2 populations then serve as composite varieties, which are futher tested in advance generations before release.

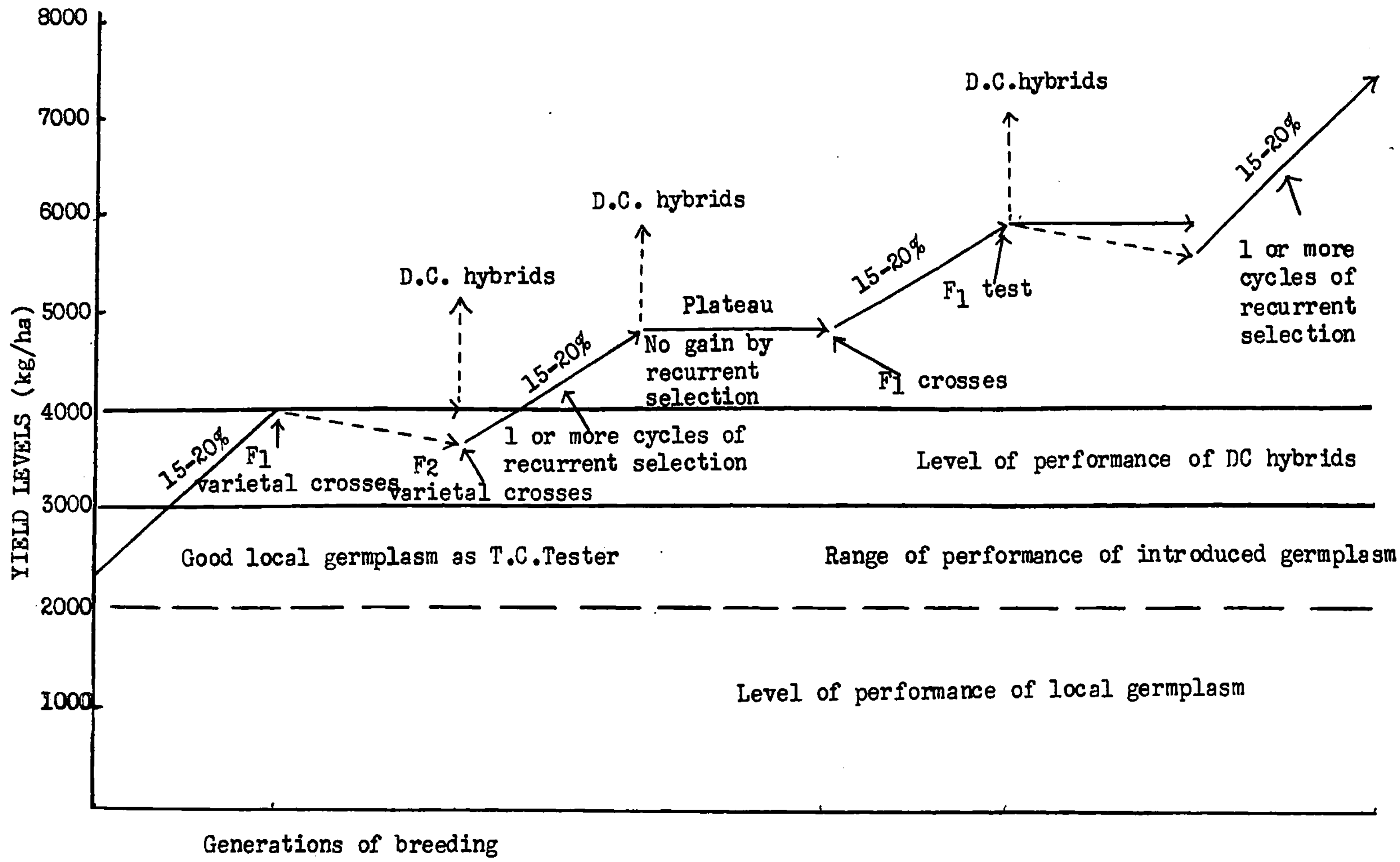
Alternatively, the diallel or top cross data is used for compositing varieties with high general combining ability into combinations of two or four or multiple combinations of selected varieties, followed by advance generation testing. For compositing, the elite varieties are selected from different geographic areas.

Step 5
The outstanding composite populations are subjected to recurrent selection. Response to selection depends upon the magnitude of the additive genetic variance. Recurrent selection can be repeated so long as significant gains are realised in each cycle of selection. Data in literature indicates that mass selection on an average gives gains of 5% and 15% gains from full-sib family selection have been reported. A stage will be reached when the composite plateaus off, thereby indicating that the additive genetic variance has been exhausted.

Step 6
This population is now used for crossing with new germplasms that are being constantly funnelled into the programme. It is anticipated that by the introgression of new germplasms, the composite performance will be again pushed up, and a new spectrum of genetic variability will again become available for mobilization.

Step 7
In the methodology outlined above, the epistatic component of variance has been ignored. This portion of the genetic variance can be used over and above the gains made by exploiting the additive genetic variance by developing and releasing double cross hybrids. Consequently, as the composite yields rise, the double cross yields will also increase by using composites at higher and higher rungs of ladder.

Figure 8. Scheme for the development and improvement of composite varieties*



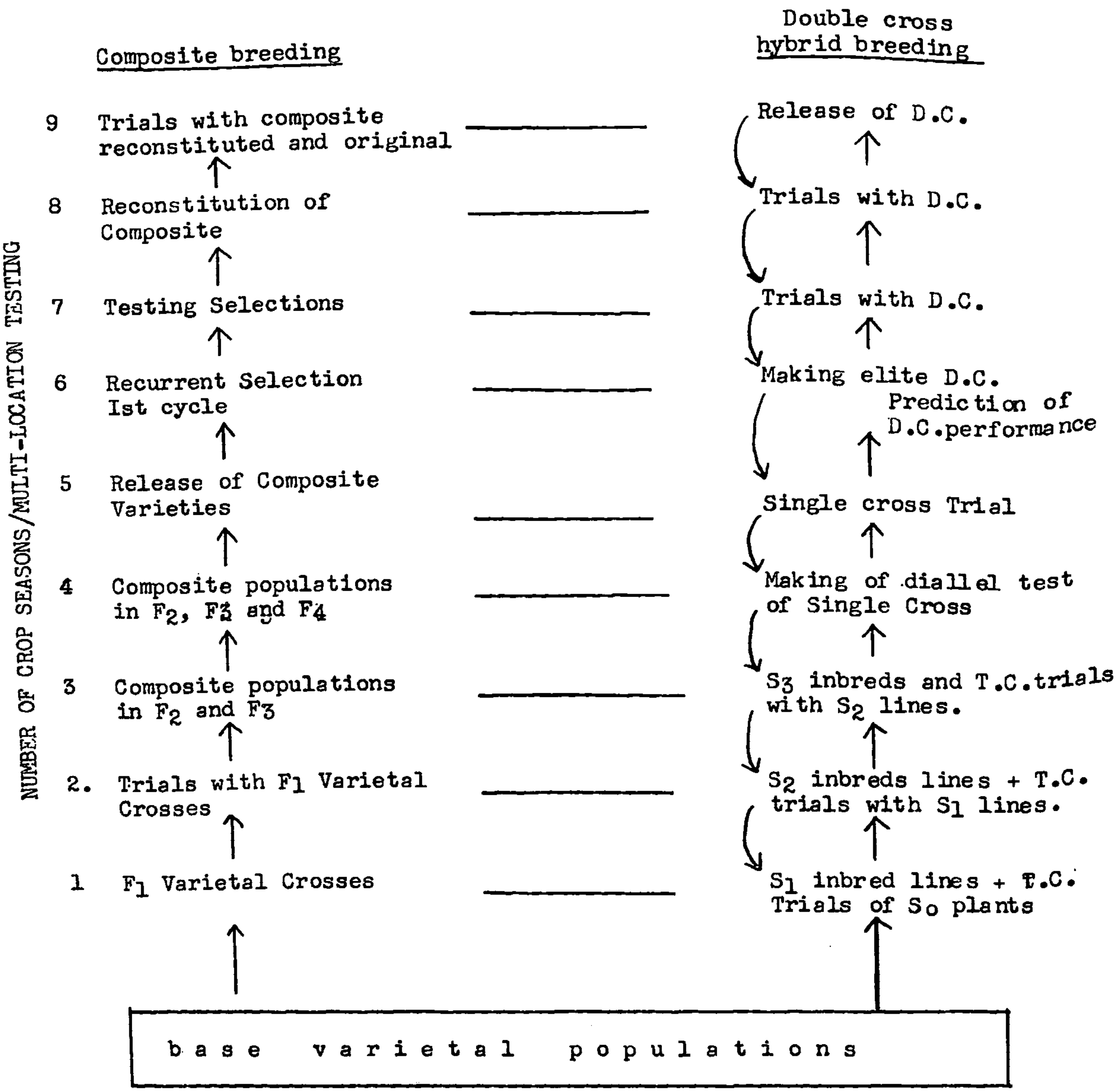
*According to the Breeding Methodology for Yield and Other characters in Maize by Dr. N.L. Dhawan.

The question arises that in terms of time, which breeding methodology can give more rapid gains. Fig. 9 graphically presents the number of crop seasons needed for the release of composite varieties and double cross hybrids. It will be seen that breeding composites is three crop season faster, and far less complicated. Perhaps, in the ultimate analysis composite breeding will have to supplement the production of double cross hybrids.

Table 19 shows the performance of reconstituted population using different selection procedures in the Coordinated Maize Breeding Scheme against the base population. Several selection procedures have been tried and were tested here. Data indicate that the reciprocal recurrent selection and mass selection and biparental selection are quite effective for the improvement of the populations whereas unit selection, visual rating selection and _per se_ selection are not much effective.

In 1967, six high yielding composites, namely, Amber, Vijay, Jawahar, Kisan, Sona and Vikram were released for commercial cultivation. One advantage with these composites is that the farmers can keep their own seeds to two to three generations. Plates 29A, 29B and 29C show some of the released composites. A short description of each composite is given below:

Figure 9. The time factor in composite vs. double cross hybrid breeding*



* According to the Breeding Methodology for Yield and Other characters in Maize by Dr. N.L.Dhawan, 1965.

Table 19 Performance of reconstituted composite populations using different selection procedures against the respective base population*(Kharif,1968)

	Delhi		Ludhiana		Pantnagar		Dholi		Hyderabad		Arbhavi		Chhindwara	
	Yld	R	Yld	R	Yld	R	Yld	R	Yld	R	Yld	R	Yld	R
J1	4677	4	3224	26	4973	13	3681	3	5233	25	3756	28	4631	4
J_1(original)	4406	11	3384	19	5743	4	3114	26	5568	9	4194	15	4711	2
J_1(Arr)-#	4947	2	4761	1	6452	2	3337	18	6078	4	3847	26	4389	8
J_1(Arr)-#-#	4675	5	3692	8	5685	5	3026	31	5527	11	4057	20	4527	5
J_1(Jrr)-#	4236	18	2944	39	5539	6	3654	5	5478	14	3647	29	3994	17
J_1(Aps)Path-#-#	3910	31	3000	34	4987	11	3168	23	4918	34	3391	38	3812	24
JML1	4519	9	3709	7	4705	18	3492	11	5669	7	3492	34	4245	9
JML1(Jms)	4332	16	3628	13	5237	9	3229	21	5836	5	3957	22	4113	13
J_1(Arr)-#	4788	3	4142	2	4718	17	3445	14	6349	1	3565	31	4178	12
Cuba 11J	3272	39	2984	36	3846	34	2405	49	4231	46	3938	24	2981	46
Cuba 11J (B-original)	-		-		3031	47	2884	40	-		-		-	
Cuba 11J(Arr)-#	3532	36	2997	35	3489	41	3060	30	4780	38	4166	16	3348	39
Cuba 11J(Arr)-#-#	3202	41	3339	21	3317	44	2972	35	5318	21	3957	22	3560	34
Cuba 11J(Brr)-#	2926	44	2141	48	3513	40	3148	24	4405	42	3856	25	3398	37
Cuba 11J(Brr)-#-#	2726	46	2739	44	3366	42	3519	9	4872	36	4276	13	3198	44
Cuba 11J(Bms1)	2288	48	2349	47	2848	49	2472	48	4232	45	4112	17	3381	38
Cuba 11J(Bms2)	2759	45	2402	46	2907	48	2763	44	4565	41	4504	10	3512	35
Cuba 11J(Bpbl)-#	3797	34	2749	43	3032	46	2756	45	4898	35	3546	32	2771	48
Cuba 11J(ArrJ)-#	-		-		4342	26	3459	13	-		-		-	
Sona	4048	26	3064	31	3689	38	2959	37	4991	31	3227	41	3761	27
(J1 x Cuba 11J)F_1	4578	7	3207	29	4645	19	3661	4	5520	12	4285	12	3989	18
Sona (JMS)	4557	8	3420	18	4773	16	3222	22	5495	13	4568	9	4192	11
(J_1(Arr)-#-#)x(Cuba11J(Arr)-#-# F1	4650	6	3839	5	4644	20	4053	1	6244	2	4969	3	4475	6
Sona (AU)-#	3925	30	2916	41	4442	23	2857	41	4812	37	4075	18	3786	26

* Compiled from the data of Progress Report of the Coordinated Maize Breeding Scheme,1968,ICAR, India.

Table 19 (Cont'd)

	Delhi		Ludhiana		Pantnagar		Dholi		Hyderabad		Arbhavi		Chhindwara	
	Yld	R	Yld	R	Yld	R	Yld	R	Yld	R	Yld	R	Yld	R
Sona (App)-#	3430	37	3650	11	4389	25	3357	11	4937	33	3127	44	3923	21
Sona (Ar-TC)-#	4112	22	3613	14	3981	31	3924	2	5111	29	3847	26	3997	16
Sona Ar-#	3854	32	3521	16	4150	27	3506	10	4751	40	3036	45	2909	47
Puerto Rico Gr.I(Original)D	3203	40	2585	45	4500	22	2743	46	3881	48	2489	49	3249	42
Puerto Rico Gr.I(Lms)	4387	12	3210	27	5138	10	3638	6	5824	6	4303	11	4084	14
Puerto Rico Gr. I (Lp.s)	3404	38	2979	37	4921	14	2418	34	3844	49	2753	46	3588	32
B_1(B original)	3977	29	3344	20	3856	33	2803	42	4777	39	3327	39	3317	40
B_1(Brr)-#	4114	21	3656	10	3944	32	2972	35	5262	23	4668	7	4071	15
B_1(Brr)-#-#	4110	23	3433	17	3321	43	2945	39	5410	18	4704	6	3986	19
B_1(Hrr)-#	3740	35	3226	25	-		-		5047	30	4203	14	3715	29
BII(B original)	3153	42	3027	32	3982	30	2493	47	4361	43	3200	42	3934	20
BII(Brr)-#	4447	10	4006	3	4042	29	3006	36	5161	27	5160	2	3499	36
BII(Brr)-#-#	4219	19	3678	9	4433	24	3141	25	5585	8	5317	1	4222	10
BII(Hrr)-#	4099	24	3023	33	-		-		5314	22	4732	5	3665	31
Antigua 2D	3036	43	2902	42	5051	11	2790	43	4298	44	2698	48	3279	41
Antigua 2D (Mbp)-#	2520	49	2936	40	4909	15	3330	19	3913	47	3282	40	3228	43
A2(B) original	4362	13	3316	23	3297	45	3114	26	5136	28	3446	37	3120	45
A2(Bbpl)-#	4357	14	3330	22	3762	36	3492	11	5473	15	3546	32	3752	28
A2(Bmsl)	4162	20	2954	38	3800	35	2959	37	5213	26	3647	29	3669	30
A2(Bms2)	3980	28	3208	28	3719	37	3013	32	5394	20	3136	43	3883	23
(JlxAntigua Gr.1)(B original)	4079	25	3883	4	6165	3	3377	16	5255	24	3482	35	3804	25
(JlxAntigua Gr.1)(Bbp)-#	2802	33	3632	12	5530	7	3567	8	5537	10	4075	18	3568	33
Checks														
Local	4025	27	2077	49	3516	39	3567	8	5537	10	2753	46	4400	7
Ganga 3	4264	17	3602	15	4114	28	3107	28	5399	19	3485	36	3887	22

Table 19 (Cont'd)

	Delhi		Ludhiana		Pantnagar		Dholi		Hyderabad		Arbhavi		Chhindwara	
	Yld	R	Yld	R	Yld	R	Yld	R	Yld	R	Yld	R	Yld	R
Ganga 5	5308	1	3755	6	6518	1	3323	20	6130	3	4595	8	4678	3
Ganga 101	1930	49	3288	24	-		-		-		-		-	
Ganga Safed 2	-		-		5438	8	3607	7	-		-		-	
Deccan	-		-		-		-		5423	17	4878	4	4726	1
Jawahar	-		-		-		-		4944	32	4011	21	4400	7
Kisan	4266	16	3183	30	4377	21	3431	15	-		-		-	
C.D. at 5%	779		832		971		708		680		1010		938	
C.V.%	13.2		16.3		13.1		15.8		9.0		18.6		15.2	

Amber composite makka

Pedigree: B1(Y) was developed by bulking the seeds of 11 varietal crosses which involved five flint varieties (Narino 330, Diacol VI, Venezuela 1, Cornelli 54, Eto Amarillo) and six dent varieties (Jarvis, Ferguson Yellow Dent, Cocker 811 Gr/N 1000/1452, Mexican June, Bolita Amarillo). The crosses were made in 1959 and the population was allowed to random cross pollinate in subsequent generations.

Breeding procedures: Equal quantity of seed of varietal crosses was mixed. The mixed seed was sown in 1959 in three plots at one week's interval. The ears in plot 1 were pollinated with the bulk pollen of plot 2 and the ears of plot 2 were pollinated with the bulk pollen of plot 3. Ears with orange flint grains were harvested from selected plants and seed bulked. This procedure was repeated in 1960. The composite was then maintained by open pollination in isolation. From 1961 onwards, it is being maintained either by open or sib-pollination.

Area of adaptation: Himalayan hills upto an altitude of 1700 meters, and Peninsular India.

Grain yield potential (kg/ha): 6500 to 7800

Salient characters: Recommended for Peninsular India and Himalayan hills upto an altitude of 5000 ft. Maturity period 110 to 115 days; plants tall vigorous growing, bearing broad dark green leaves; partial resistance/ tolerance to downy mildew, leaf blights and rust; one big ear per plant; ears long and tapering with uniform kernel rows; grain flat and bold, pale yellow and semi flint.

Vijay Composite Makka

Pedigree: Genetic base is selected open pollinated ears from No. 14 yield trials grown in 1961 kharif. Seeds from selected ears were bulked and the population allowed to random cross pollinate in subsequent generations.

Breeding procedure: After the initial composition in 1961, the composite has been planted in two dates of planting and bulk sib-bed between the 2 dates of planting in 1962 and 1963. Subsequently, it has been maintained in isolation in 1964 and 1965.

Area of adaptation: Indo-gangetic plains

Grain yield potential (kg/ha): 5500 to 6300

Salient characters:- Recommended for the northern plains; plants tall growing, with long narrow comparatively lighter green leaves; resistant/ tolerant to leaf blights and rust; strong tendency to bear 2 ears per plant; the ears are long and tapering with bold flint to semi-flint yellow grains.

Sona Composite Makka

Pedigree: Cross between J_1 and the Cuban orange yellow flint variety Cuba 11J. Cross was made in 1963 and the population allowed to random cross pollinate in subsequent generations.

Breeding procedure: After the initial cross, the F_2 was developed by mass sibbing (1964), between rows. Subsequently, it has been maintained in isolation.

Area of adaptation: Indo-gangetic plains

Grain yield potential (kg/ha): 5000 to 6000

Salient characters: Recommended for northern plains; maturity 90 to 100 days; tall vigorous plants, with broad light green leaves; tendency for 2 ears per plant; ears small and conical; grains small, bright orange hard flint.

Jawahar Composite Makka

Pedigree: A1 composite was developed by bulking seeds of 15 varietal crosses, which involved the following varieties: Amarillo-de-Cuba, Basi, Arbhavi Local, HM 1, Eto Amarillo, Pusa Culture LPL 2, Jullundur Local,

Yellow Tuxpan, Cuba Yellow Dent, Peru 330, Cateto, Theobromina, KT 41, Indian Chief, Ferguson, Yellow Dent, 2E Syn and L Syn.
Antigua Gr. 1, a composite developed by the Mexican Programme, from tropical flint varieties, from the island of Antigua. The cross Al x Antigua Gr. I was made in 1963 and the population allowed to random cross pollinate in subsequent generations.
Breeding procedure: After the initial cross, the F_2 was developed by mass sibbing between rows (1964). Subsequently, it has been maintained in isolation.
Area of adaption: Indo-gangetic plains and Peninsular India.
Grain yield potential (kg/ha): 5600 to 6600
Salient characters: Recommended for northern plains and Peninsular India; maturity 100 to 110 days; resistant/tolerant to downy mildew, leaf blights and rust possesses considerable measure of resistance to the top shoot borer (*Chilo Zonellus*) one ear per plant; ears long and cylinderical with tight husk cover; grains orange yellow bold; round and semi-flint.

Kisan Composite Makka

Pedigree: The Coastal Tropical Flint is a composite developed by the Mexican Programme, from flint varieties originating in San Vicente, Barbados and Antigua.
The cross between J_1 and Coastal Tropical Flint, was made in 1963 and allowed to random cross pollinate in subsequent generation.
Breeding procedure: After the initial cross, the F_2 was developed by mass sibbing between rows (1964). Subsequently, it has been maintained in isolation.
Area of adaptation: Indo-gangetic plains
Grain yield potential (kg/ha): 5600 to 6500
Salient characters: Recommended for the Northern plains; maturity 105 to 110 days; plants compact with thick stem and long, broad dark green leaves; considerable resistance/tolerance to the top shoot borer, downy mildew leaf blights and rust; tendency for 2 ears per plant, ears with tight husk cover; ears cylindrical and short; grains medium in size, yellow, hard flint.

Vikram Composite Makka

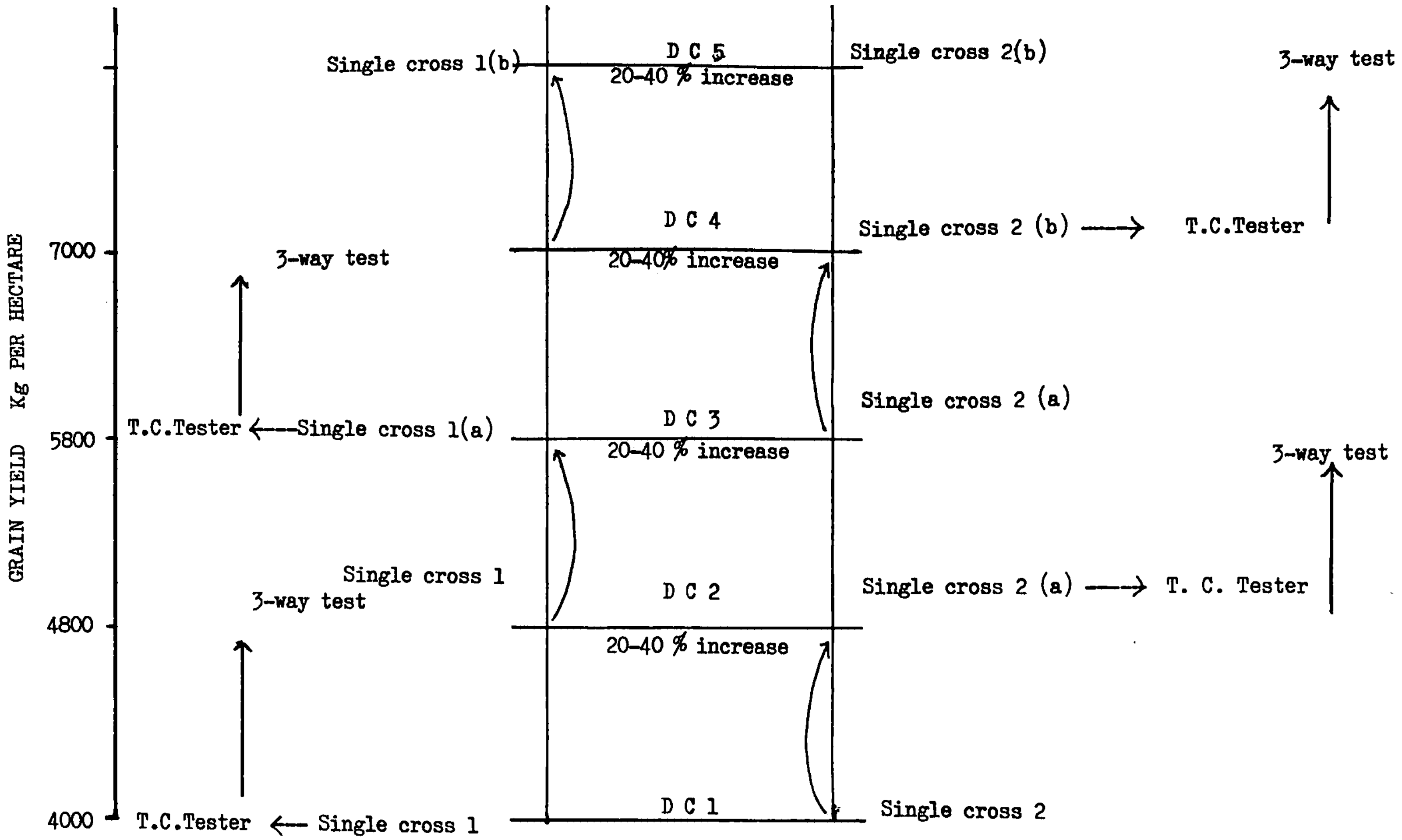
Pedigree: Basi is an orange flint variety from Rajasthan. Eto Amarillo is a variety of unknown origin from Colombia.
The cross Basi x Eto Amarillo was made in 1963 and allowed to random cross pollinate in subsequent generations.
Breeding procedure: After initial cross, the F_2 was developed by mass sibbing between rows (1964). Subsequently, it has been maintained in isolation.
Area of adaptation: Indo-gangetic plains, particularly the low rainfall areas in Gujarat, Rajasthan and Punjab.
Grain yield potential (kg/ha): 5000 to 6000
Salient characters: Maturity 90 to 100 days; plants vigorous; considerable resistance in drought and partial resistance to downy mildew leaf blights and rust; tendency to bear 2 ears per plant, ears long and tapering, with bold, hard orange-yellow shining flint grains.

It can be seen from the Fig. 8 that at after every cycle of recurrent selection, better inbred lines can be developed from the improved populations and higher yielding double crosses can be produced.

The existing double cross hybrids can also be improved by a method called Step Ladder Breeding as suggested by Dr. N. L. Dhawan.

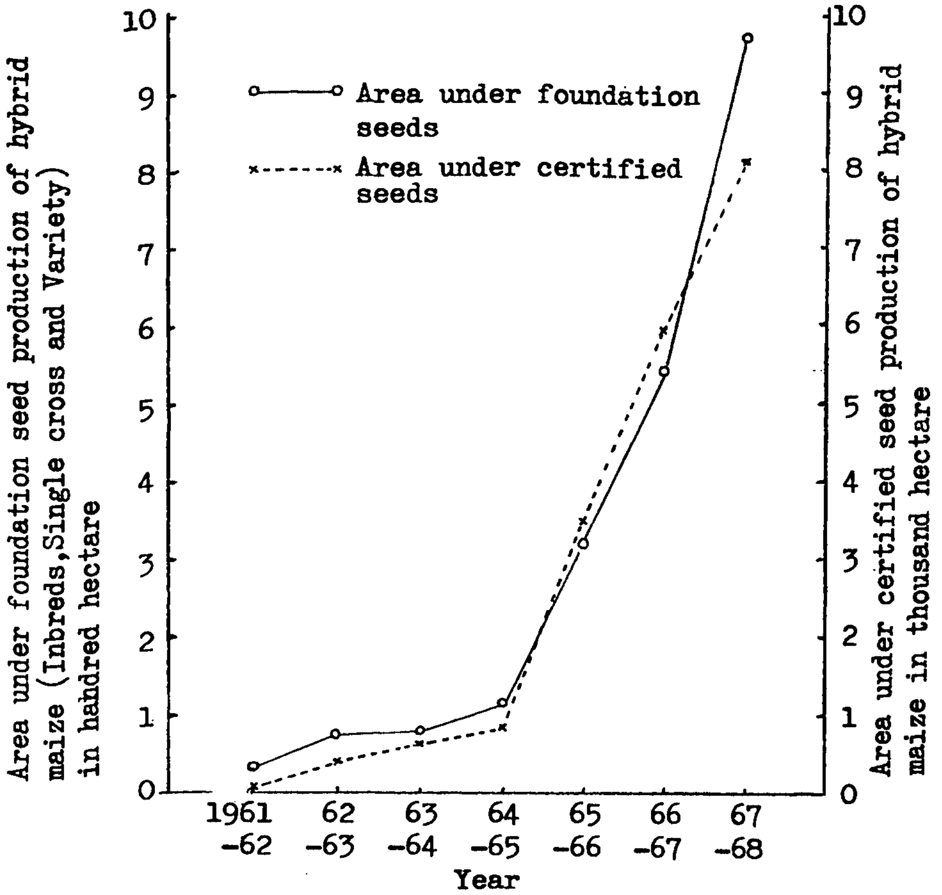
The breeding procedure outlined here is designed to suit a project which has developed and released for cultivation double cross hybrids.

Figure 10. Step ladder breeding for hybrid maize*



* According to the Breeding Methodology for Yield and Other characters in Maize by Dr. N.L.Dhawan, 1965.

Figure 11. Seed production of hybrid maize*



* Compiled from the data of NSC, Plans and Progress by the National Seeds Corporation, 1968, New Delhi.

Figure 10 illustrates what has been designated as step ladder breeding for hybrid maize. Starting at a yield level given by a double cross hybrid, the better parental single cross (SC 1) should be used as a top-cross tester on new lines emerging in the programme. From the three-way cross test, the superior combining lines are identified. A new double cross can be predicted where the tester SC 1 forms one parent and a new single cross (SC 2A) developed from two superior lines (as indicated by the three-way cross test) froms the other parent. Thus the inferior SC 2 is replaced and the new double cross hybrid not only gives increased yield but also better agronomic performance. In the second cycle, SC 2A is now used as tester and SC 1 is replaced. The cycles of breeding can be repeated, and yield and other characters can be raised step-wise to higher and higher levels of performance.

Table 20 presents data to illustrate the points mentioned above.

Table 20 3-way cross test *

Pedigree	Yield (kg/ha)
AdeC-A406 x SC Tester	5268
G101-A37 x SC Tester	4660
Predicted DC (CM 202 x CM 111) x (AdeC-A406xG101- A37)	4964 (20 per cent increase)
Ganga 3 (CM202xCM111)x(CM109xCM110)	4120
SC Tester (CM202xCM111)	4323

* According to the Breeding Methodology for the Yield and Other Characters in Maize by Dr. N.L.Dhawan, 1965.

The single cross parent CM 202 x CM 111 of the double cross hybrid Ganga 3 was used as a top cross tester on new lines. The performance of the double cross (CM 202 x CM 111) x (AdeC-A416 x Ganga 101-A37) was predicted to give 20 per cent more yield than Ganga 3. This double cross is being produced and will be tested against Ganga 3. The other parental single cross of this hybrid, (CM 109 x CM 11)) was giving trouble because of its susceptibility to the disease complex prevalent in India.

Further improvement of released composites:

The yield level of the released composites can be further raised by intrograssing new germplasm into them. By crossing unrelated varieties with these composites, F_1 complexes have been obtained which 10-15% more yield than the parental released composites. Plates 30A, 30B and 30C*** represent some of such F_1 combinations.

(iv) Breeding for prolific eared character, compact plant type and protein content in maize: **

The yield component analysis in maize have revealed that probably the number of ears per plant can make maximum contribution towards the total yield per plant. Keeping these facts in view, the four prolific sources, namely SP_2, G.C.E. Fla H94 and T 224 were used to develop an ideal maize population which can serve the base population source for incorporating this character since the original sources do not have the desired agronomic

** According to information given by Dr. B.K.Mukherjee and Mr. N.N.Singh.
*** Plate No. 30: By courtesy of Mr. N.N.Singh.

base (see Plates 31A and 31B*). A composite has been developed from above four populations by practising mass selection for 3 generations. From this population, the bi-parents were made between prolific types at three plant population levels viz. 10,000, 20,000 and 40,000 plant per acre at Delhi and Chhindware, simultaneously. These biparents were put into yield trial to determine their yielding ability and the extent of prolificacy both at Delhi and Chhindware. Based on these performance 15-20 biparents have been selected in each population level and used for the reconstitution of prolific population. The number of ears per plant in biparents ranged from 2 to 3 (see Plate 32). The population was also reconstituted based on the visual observation on number of ears per plant. The two populations thus obtained will be tested next year for their yield performance.

With the rapid advance in the yield levels by changing the plant type in wheat and rice the maize breeders have also tried to reduce the plant hight. In many parts of the country, because of prevalence of high velocity winds there is an appreciable loss in yield due to lodging. Therefore, the dwarf plant type should help to reduce lodging. Unfortunately, the dwarfing genes are accompanied by many undesirable genes that reduce the yield and therefore many scientists argue about the possibility of dwarf hybrids. But it is now being felt that we should be able to break this linkage by growing large populations. Secondly, we can look for compact plants which are intermediate in height. Br_2 source has been used in maize scheme to incorporate dwarfing gene in composite Kisan, Jawahar, Antigua 2D and all the inbred line which have gone in commercial hybrids. The selection for desired agronomic characters is being done in composites while in inbred lines three back crosses have been made and the inbreds are now uniform. The hybrids have been reconstituted by crossing the parental inbred lines and these dwarf hybrids have been tested on the main stations of each zone.

Most of the present hybrids and composites in cultivation are low in lysine and methionine, amino acids and therefore, these are supposed to be poor in nutrition. Two genes, opaque 2 and floury 2 which have been recently discovered as source of high lysine and methionine are being incorporated in high yielding composites as well as inbred lines of the promising hybrids. Third back cross generation of composites with opaque gene have been produced and it is hoped that a composite with high lysine and methionine content would be released for cultivation fairly soon (see Plate 33**).

Investigations are also being carried out in sweet maize. The sweet maize varieties available are very low yielding. Using Hawaiian Sugar sweet corn as source, and applying composite breeding approach a sweet corn composite has been developed which is fairly high yielding. This composite is being put under yield trials (see Plate 34).

(v) Summary of breeding work being carried out at different stations***

Zone I (Himalayan region)

1. Yield trials: Eight trials comprising of top crosses of composites with D1 as tester (F_2); elite composites from 1967 data; top crosses of composites with B1(Y) and J_1 as tester and N_1(W) and AdeC as testers: a diallel set of crosses of 10 inbred lines; top crosses of *Helminthosporium turc: cum* resistant lines; dwarf hybrids and composites; released hybrids and composites.

2. Advance trials: It was decided that the following materials will be tested in advance trials: Him. 123, Ganga 5, Exptl. Hybrid 450, Composite C_1, C_2, JML 236, Jawahar, Kisan and Local variety.

3. Recurrent selection: Reciprocal recurrent selection in composite B1(Y)

* Plate No. 31 and Plate No. 32: By courtesy of the Rockfeller Foundation in New Delhi.

** Plate No. 33 to Plate No. 37: By courtesy of Dr. B.K.Mukherjee.

*** According to the Progress Report of Coordinated Maize Breeding Scheme, 1968, ICAR, India.

and Puerto Rico Gr. 1. Mass selection in advance generation of the cross Bl(Y) x Puerto Rico Gr. 1 and the two parents.

4. Building new high yielding germplasms: Top cross the elite materials to 3 heterozygous testers with a view to identify new source materials which in combination with testers would provide a further boost in yield.

5. Development of composites with male sterile background: A number of elite composites, such as Amber, C_1, C_2, etc. will be used and the Texas source of male sterility.

Zone 2 (North-west plains)

1. Second cycle of reciprocal recurrent selection in composite Sona.
   i) S_1 lines in reconstituted population, malely, Cuba 11J (Arr)-#-# and J_1(Arr)-#-# will be developed at Delhi.
   ii) J_1(Arr)-#-# will be increased in isolation at Ludhiana, Cuba 11J (Arr)-#-# will be increased at Udaipur while J1(Arr)-#-# x Cuba 11J(Arr)-#-# will be increased at Delhi.
   iii) Reciprocal bi-parents will be devloped at Ludhiana station.
   iV) The top-crosses of the two populations (S1 lines) will be made in *Rabi* and shall be tested in 6 yield trials in *Kharif* 1969 in zone 2.

2. New introductions received from within the country and abroad shall be tested in two yield trials at the main stations of Zone 2, 3 and 4. One trial shall be put up at Delhi while other will be by the IACP(Trials 27 and 28). Materials selected from the trial will be further utilized in the breeding programme.

3. Development of early maturing composite population from different geographic sources. Four sets of dialleles each of 10 parental varieties (selected on the basis of their agronomic performance over a period of 2 to 3 years were selected from the different geographic areas like India, Europe, South America and Russia) will be tested at Delhi, Hyderabad, Pantnagar. Based on the performance early composite populations shall be developed.

4. Development and selection for prolificacy. Following criteria shall be used for selection in prolificacy. Following criteria shall be used for selection in prolific composite.
   i) Number of barren plants under different plant populations
   ii) Number of ears per plant in different plant populations
   iii) Yield per plant
   iv) Yield of the second ear

5. Improvement of Hawaiian sugar sweet corn. Bi-parent and unit selection was practised in Hawaiian sugar. Both sets of populations shall be tested for yield and uniformity and the populations shall be reconstituted.

6. Incorporation of O_2 and fl_2 in elite composite population through back crossing will be continued.

7. Evaluation of different selection procedures, namely, recurrent selection, reciprocal recurrent selection, bi-parental selection, mass and unit selection was practised in composite Sona and appropriate populations have since been reconstituted. These selected population shall be tested against the base population with a view to assessing the level of improvement and efficiency of different procedure.

8. Yield trials: Following yield trials willbe conducted during *Kharif*, 1968.

Trial 8: All released hybrids and composites will be tested to determine the consistency of performance and area of adaptation. This trial shall be continued over a period of 3 years.

Trial 14: Uniform double cross hybrid trial zone 2 shall contribute 15 experimental hybrids.

Trial 16: With composite population in advance generation zone 2 will contribute 30 composites.

Trial 17: Evaluation of reconstituted populations developed through recurrent selection and other procedures.

Trial 18: Composite crosses in F_1 and F_2 generations, selection of materials based on the performance in 1967 *Kharif*

Trial 19 (Zonal) - composite population in F_1 and F_2 generations.
Trial 20 (Zonal) - Experimental hybrids initial screening.
Trial 21 (Zonal) - Early maturing germplasms
Trial 22 (Zonal) - Trial with composites in advanced generations.

9. The varietal collection and elite composite populations shall also be maintained.

Zone 3 (North-East plains)

1. Maintenance of inbred lines, and evaluating them for agronomic characters, diseases and pests.
2. Maintenance and increase of seeds of elite varieties and composite populations.
3. Evaluation of varieties and composites by top crossing to a broad genetic base tester/testers.
4. Conversion of the inbred lines of released hybrids into brachytic plant type by back cross programme and the reconstitution and testing of the dwarf hybrids against their normal counterpart.
5. Bi-parental progency selection in elite composites.
6. Recurrent selection in the composites Bl(Y), Puerto Rico Gr. I and Antigua 2D.
7. Studies on male sterility on the production of seed of hybrids.
8. Breeding for the prolific eared character and protein quantity and quality.
9. Yield trials with the following materials:
   i) Elite composites
   ii) Top crosses of composites in reciprocal recurrent selection
   iii) Bi-parental progenies of Antigua 2D.
   iv) White single crosses
   v) Varietal crosses of early yellow and white varieties.
   vi) New experimental double and double top crosses.

Zone IV (Peninsular India)

A. Testing programme:

1. Hybrids: Promising double crosses of 400 and 4,000 series will be evaluated at all the locations in Zone IV during *Kharif* and at Hyderabad and Arbhavi during *Rabi*. Hybrids 4207, 4227, 4307, 4437, 4147 and 4417 which have yielded 60 to 80% more than Deccan, may be included in uniform cooperative trials in Zones 1, 3 and 4.
2. Top crosses of composites: 11 composites which were received from Mexico have been top crossed to 4 testers (Amber, Jawahar, H_1 and J_1). These will be evaluated in Zone 4.
3. Top crosses of inbred lines: About 100 S_2 lines from composites and biparents and 15 S_3 lines from Deccan will be top crossed to Comp. B as tester parent and tested during *Rabi* 1968 at Hyderabad.
Thirteen U.S. Argentina lines top crossed to two testers will be evaluated at Arbhavi and Chhindwara.
4. Single crosses: The single crosses of the 10 selected inbred lines of Rabi set 2 will be tested at Hyderabad and Arbhavi during *Rabi* 1968.
5. Three-way crosses: Nine three way white crosses of inbreds from the variety Sumerai with (CM 400 x CM 300) as common female parent along with two double top crosses and two varietal crosses will be tested at Chhindwara and Godhra.
6. Advance trials: The entries to be tested were decided at joint meeting and are given under decision taken.

A. Breeding programme*

1. Reciprocal recurrent selections: First cycle comp. BI(BI), BII(BI) and Cuba 11J(Brl) developed at Hyderabad, and Bl(HrI) and BII(HrI) developed at

* According to the Progress Report of Coordinated Maize Breeding Scheme, 1968, ICAR, India.

Chhindwara will be evaluated in Zone IV with 8 replications and 4 rows each. First cycle comp. A2 will be advanced to F_2 and F_3.
The 126 S_1 lines from BI(BrI) will be top crossed to BI(BrI) and lines from BII(BrII) to BI(Brl) respectively.

2. Biparental progeny selection: The first cycle comp. A2 (BbpI), Cuba 11J(B bpI) and J1 x Antigua Gr.I (B bpl) will be evaluated in Zone 4.

The biparental progenies in the first cycle populations will be made in *Radi* 1968.

3. Mass selection: A2(Bm2) and Cuba 11J(Bm2) will be evaluated and further mass selection will be continued.

4. Development of new composites: Comp. BIV and Comp HI will be tested in zone 4 alongwith promising and released composites and also reconstituted composites.

5. Development of new inbred lines:

Inbreeding will be started at Hyderabad in the following:

i) Al x Puerto Rico Gr. I, F3
ii) Coastal Tropical Flints x Doeto, F3
iii) Antigua 1D
iv) C_2
v) Al x Antigua Gr. I, F_3
vi) Antigua 3D

6. Improvement of lines: Back cross programmes for incorporation of opaque 2, prolificacy and dwarfness in selected inbred lines and also in promising comp. will be continued.

B. Agronomy section*

The objective of the project is to study the response of maize germplasms from different parts of the world to various agronomic practices.

Six sets of experiments were conducted at one or more locations during *Rabi* 1966-67 and *Kharif*, 1967. These were experiments on date of planting, nitrogen x plant populations, micronutrient, phosphorus x potash and tolerance of moisture stress and excess. The germplasms selected for the first four sets of experiments were Solan Local representing Indian germplasms, Mexican June Composite (Mexico and South Western United States), A-do-Cuba (the Caribbean area) and Doeto(representing Central and South America). These five germplasms were common at all the locations. Besides a hybrid and an open pollinated variety grown at the location were included as checks.

The results obtained during the year indicated that:

1. Date of planting: In general, planting maize 10 to 20 days before the usual date of planting resulted in higher yields at almost all the locations. The yields in the later plantings depend upon the pattern of distribution of rainfall at the location.

2. N & Plant population experiment:- All the germplasms gave significantly higher yield at 150 kg N/ha as compared to 50 kg N/ha. The differences between 150 and 250 kg N/ha were not significant at Hyderabad, Bajaura, Solan and Dholi. At other locations they were significant. The grain yield of hybrid increased by about 700 and 900 kg/ha at Delhi and Chhindwara by the application of 250 kg/ha as compared to 150 kg N/ha which means about additional profit of rupees one hundred per hectare. There was a definite increase in yield by increasing plant population from 25 to 50 thousands per hectare. 75 thousand plants/ha were beneficial to Ganga 3 and KT 41 at Delhi to all the germplasms at Ludhiana and to Deccan at Hyderabad. Only SSIII at Bajaura , and Solan, Mexican June and Deccan at Chhindwara were adversely affected by high plant populations. For all other germplasms the optimum plant population was between 50 and 75 thousand/ha.

3. P x K experiment: The response to phosphrus was significant at Bajaura, Godhra and Hyderabad. The grain yield of hybrid increased by 12,200 and 3200 kg/ha respectively at these locations by the application of 60 kg P_2O_5/ha.

The response to 50 kg K_2O/ha was significant only at Bajaura and

* According to the Progress Report of the Coordinated Maize Breeding scheme, 1968, ICAR, India.

Chhindwara.

4. Micronutrient experiment: Significant response to zinc was observed at Ludhiana and Chhindwara where 24 kg zinc sulphate/ha increased the grain yield by 1400 and 600 kg/ha at the respective stations. When zinc and iron were applied magnesium and mangense increased the grain yield at Hyderabad.

5. Response to moisture stress: The flowering stage was found to be most critical stage when moisture stress at tasselling stage resulted in the reduction in yield to an extent of 40%. The moisture stress at other stages did not depress the yield significantly.

6. Response to excess moisture: Excess of moisture for three and six days significantly reduced the yield of all the germplasms. The reduction in yield was more when the plants were subjected to excess moisture at knee-high stage than at flowering stage. There were some differences in the tolerance of germplasms to excess of moisture but more data are needed to draw definite conclusions.

C. Pathology section*

The investigations carried out in pathology section are listed below:

1. Bacterial stalk rot control trial: This experiment was repeated this year to study the effect of Clorox solution in controlling the bacterial stalk-rot. There were five replications. The variety was Ganga Hybrid Makka 101.

The data are presented in the table given below. It is clear that there were differences in the incidence of bacterial stalk rot as compared to control plot. Further, it appears that primary infection could not be checked but the rate of spread could be checked by applying Clorox solution when applied at one week interval. The data indicate that the infection increases in late application i.e. in two week interval and four week interval. The control plots showed the maximum infection (14.1%).

S.No.	Treatments	Stand count	Infected plants	%
1.	One week interval	634	58	9.2
2.	Two week interval	700	73	10.5
3.	Four week interval	633	74	11.7
4.	Control	660	93	14.1

2. Selection and development of disease resistant germplasms of maize:

A. Screening of S3 inbred lines of Cuba 11J and Antigua Gr. II against *H. maydis* leaf blight and downy mildew.

Since 1965 *Kharif* screening of Cuba 11J and Antigua Gr.II is being done at UPAU, for resistance against *H. maydis* as well as the downy mildew. Out of 65 cultures tested cultures of Antigua Gr.II in 1966 *Kharif*, only 58 cultures showed resistance in 1967 *Kharif*. Similarly, in Cuba 11J out of 28 cultures tested in 1966 *Kharif* only 16 cultures showed resistance to leaf blight and the downy mildew.

B. Selection of plants in D_1 complex resistant to bacterial stalk rot using artificial inoculation.

Bacterial juice was injected into the first internode of plants of D_1 complex with the help of a hypodermic syringe. The disease appeared after a week to fortnight of inoculation. All such plants which succumbed to the inoculation and fell down were discared and only those which did not show any symptoms of disease were selected for further work. Such plants were maintained through sibbing and biparental pollination as a source of re-

* According to the Progress Report of the Coordinated Maize Breeding Scheme. 1968. ICAR, India.

sistance for future use.

C. Evaluation maintenance and screening of maize germplasms, composites, inbred lines and synthetics against the disease downy mildew and *Helminthosporium maydis*.

1. Composites:- Several lines of different composites were sown in 1967 *Kharif* season to study their reaction to the above diseases for developing disease resistant germplasms. All the lines were inoculated twice artificially at 10 days interval with *H. maydis* inoculum. These lines were also graded for downy mildew. The natural infection of downy mildew fungus was quite severe and some lines could not even attain proper growth and did not reach maturity. It was more severe in B_1 x Cuba 11J and A2 lines. J1 x Coastal Tropical Flints lines were found more resistant than J1 x Cuba 11J and A1 x Antigua Gr. I lines.

2. The list of certain outstanding lines and synthetics which were found resistant to *H. maydis* and downy mildew is given in the table. The rating for both are indicated against each line:

Pedigree	Origin	Downy mildew 1-10	*H. maydis* 1-10
Eto.182-C-1-2-f-f-f-#-#-1-#-#-#	NP66K 4216	1	3
Eto-81B-#-1-f-f-f-#-1-#-#-#	" 4211	1	3
CM 113-#-#-3-#-#	" 4227	2	2
CM 201-#-#-1-#-#-#-#	" 4316	1	1
CM 106-#-#-#-#	" 4293	2	1
A2-Synthetic-#-#-#	" 5373	2	1

Note: #;Sibbing, f;#-#-#-#-#

Collection and isolation work

A. Collection of specimen of the following diseases were made

i) Leaf spots caused by : a) *H. maydis*
b) *H. turcicum*
c) *H. corboum*

ii) Bacterial stalk rot
iii) Bacterial cob rot
iv) Fungal cob rot
v) Downy mildews

B. A number of isolates were made from the different samples of stalk rot for futher study.

C. Collection of diseased material for further use as infection material in field experiments:

i) Downy mildew affected leaves have been collected and preserved in gunny bags.
ii) *H. maydis* affected leaves for inoculation to be used next year.
iii) Chopped bacterial stalk-rot plants.

D. Serological tests of *Corynebaterium* sp. are in progress.

E. Sub-cultures of fungi and bacteria which have been isolated from different maize leaf spots and stalk rot during the *kharif* season were made at regular interval for future use.

D. Entomology section*

The investigations carried out at the different centres are summarised below:

* According to the Progress Report of the Coordinated Maize Breeding Scheme, 1968, ICAR, India.

Delhi Centre

1. Chemical control of *Chilo zonellus* : With a view to find out a suitable insecticide for the control of *C. zonellus* Swinhoe, different insecticides were screened under field conditions. For these studies a hybrid, Ganga 101, was sown in a randomized block design in *Kharif*, 1967. There were seven insecticidal treatments and one control (untreated) each having five replications.

Observations in the standing crop showed that the percentage of infested plants in various treatments varied from 0 to 11.11 in lindane, 1.67 to 6.67 in endrin, 4.44 to 10.00 in BHC, 4.44 to 10.00 in malathion, 5.00 to 18.33 in DDT+BHC, 5.00 to 22.22 in DDT+Lindane and 0 to 26.67 in rogor as against 3.33 to 44.44 in the control (untreated) from time to time. Observations recorded at harvest showed that all the treatments except rogor significantly reduced the number of infested plants as compared to untreated plots.

2. Screening of maize germplasms for resistance to *C. zonellus:*

The germplasms were screened for their resistance to *C. zonellus* under natural infestation. Fourteen germplasms of maize were sown in a randomized block design. Four rows of each of these germplasms were sown in a randomized block design. Four rows of each of these germplasms were replicated three times. Pre- and post-harvest observations showed that there was no significant difference in the number of infested plants and tunnel length in all the fourteen germplasms of maize screened.

3. Building of resistance in promising germplasms: Seeds of Al x Antigua Gr. 1 collected during *Kharif*, 1966, from 82 biparental crosses (R x R = 23 crosses, R x S = 44 crosses and S x S = 15 crosses) were sown in the one row plots and two row plots during *Kharif*, 1967. On the basis of borer resistance alone, seeds were obtained from the progenies of 19 biparents. Similarly, seeds were also collected from 24 biparental progenies. Selected on the basis of both borer resistance and agronomical characters, viz. grain yield, disease resistance, plant vigour, size of the ear, placement of the ear, husk cover, lodging resistance and date of silking etc. Seeds belonging to the above two categories were sown separately in two row plots at Amberpet (Hyderabad) Maize Research Station during *Rabi*, 1967-68 and chain crossed. The crop was harvested to bulk the seed for further trials.

4. Improved technique for the mass rearing of maize stem borers:

The mass rearing of *C. zonellus* on artificial diet (Keaster and Harrendorf, 1965) was continued. *Sesamia inferens* Walk., the pink stem borer of maize could also be reared successfully on the same artificial diet for three successive generations. Fourth successive generation was in progress.

5. Studies on the technique for measuring resistance of maize germplasms to *C. zonellus*

Preliminary field studies to compare the effectiveness of insects reared on artificial diet with those reared on maize stem in evaluating plant resistance correctly, were undertaken during *Kharif*, 1967. For this, a single cross homozygous germplasm of maize, CM 103 x CM 104, was sown in a randomized block design. There were three sets of experiments, viz. insects reared on (i) artificial diet, (ii) maize stem, both reared under controlled conditions of temperature and humidity, and on (iii) stem under field conditions (Stevenson's screen). On each plant in the middle whorl stage of growth, thirty eggs of *C. zonellus* (black head stage) reared under three different conditions were released separately in two row plots replicated three times.

Observations on the borer injury showed that threre was no significant difference in damage in between the borers reared only for one generation on artificial diet and maize stem. The studies will be repeated in 1968.

6. Studies on the influence of time of infestation by *C. zonellus* on the yield of maize crop:

For these studies, maize Him. 123 was sown in a randomized block design. There were four treatments, viz. T1, T2, T3 and T4 and one control (untreated).

T_1 plots were given only one endrin application, 15 days after sowing. Similarly, T_2, T_3 and T_4 plots were given 2, 3 and 4 applications of endrin, respectively, at 15 days interval after sowing. Observations recorded on the infestation at harvest showed that there was significant reduction in the number of infested plants in T_3 and T_4 only i. e. crop protected against *C. zonellus* for 45 and 60 days, respectively.

7. <u>Survey of maize crop for insect pests and their natural enemies</u>:

Survey was carried out twice in Kangra valley, Simla hills and in the plains of Punjab and once only in Kulu valley. In Kulu and Kangra valley, *Chilo* infestation was very low - 0 to 5.0%. In Simla hills the borer attack varied from 4.0 to 53.0% from time to time. In the plains of Punjab, the borer infestation varied from 11.0 to 34.0%.

In South India four contiguous maize growing tracts in Karimnagar, Warangal, Yellareddy and Nizamabad were selected for the survey of maize crop for insect pests and their natural enemies. Observations recorded in the cultivator's field showed that *C. zonellus* was the predominant pest. The average infestation at Karminagar, Warangal, Yellareddy and Nizamabad were 29.0%, 32.0%,29.0% and 31.5% respectively. There was also stray incidence of *Sesamia inferens, Marasmia trapezalis, Rhopalosiphum maidis* and *Chrotogonus sp.* Lady bird beetles, *Chilomenes sp.* were found feeding on aphids.

8. <u>Biological studies on *C. zonellus:*</u> Biological studies on *C. zonellus* carried out under laboratory conditions showed that the average incubation period was 6.4 days. The average larval period was observed to be 23.6 days in June-July and 25.1 days in July-August. In September-October the larvae, after completing 49.2 days, entered into hibernation in the last week of October. The pupal period was 5.2 to 6.2 days for male pupae and 8.6 to 9.5 days for female pupae. Average longevity of the male both was 2.7 days for the female moth.

9. <u>Effect of the date of spring sowing of maize on the incidence of *Atherigona sp.* and loss in yield due to its attack</u>:

For this experiment hybrid, Ganga 3, was sown in a randomized block design. The sowing will be continued upto the last week of April in order to find out as to how long and upto what extent maize is infested by *Atherigona sp.* It was observed that 'dead hearts' were formed in 18.84%, 36.25% and 40.50% of the plants in the 1st, 2nd and 3rd sowings (7th February, 14th February and 22nd February, respectively) due to attack of shoot fly.

On the basis of dissection of 10% of the plants (25 days after sowing), the highest infestation, 62.5% was recorded in the 3rd week of sowing as compared to 37.50%, 59.37% and 50.0% in the 1st, 2nd and 4th sowings respectively. On the basis of egg counts on the plants, the highest number was recorded again in the 3rd sowings (81.25%) as compared to 43.75%, 75.0% and 65.62% in the 1st, 2nd and 4th week sowing respectively. Further studies were in progress.

CHAPTER III

SYSTEMS, METHODOLOGY AND PRACTICES IN THE COORDINATED PROJECT*

In the Coordinated scheme, a uniform system for all the procedures is followed by all the stations covered by the scheme. The uniform procedures are decided every year in the Maize Breeders' Conference. The Coordinated Scheme for maize improvement includes all the disciplines, namely, (i) Breeding, (ii) Pathology, (iii) Entomology and (v) Agronomy. The work to be carried out under the different disciplines are discussed at the time of the Conference. The various systems followed in breeding as discussed herewith.

Maintenanance of seed stock

Each station has some suitable type of seed cabinets (see Plate 35). Seed stocks are stored in numberical order by plot numbers, location and year. The breeding book can be used for recording seed inventory. This inventory should be corrected as and when seeds are used up. Seed stocks are usually kept in water proof envelopes but if the seed quantity is more, they are kept in cloth bags. Origin of the seed is written on the envelopes or on labels and tied on the cloth bag. One label bearing the origin of the seed is always kept inside the envelope or the cloth bag. To keep the seeds viable for 3-4 years, seeds store is airconditioned and the air inside is dehumified constantly. The seed stocks of inbred lines and other important germplasms are replaced by fresh stock every three years.

Record keeping

Data are recorded in field books. The field books are usually of two types. One type of field books are for yield trials while the second type are for breeding materials.

Yield trial field books: These consist of two types. One type contains only the master sheets of the various trials and is used usually for the study of the material grown in trial (Appendix XII). This gives information on the various entries, their origin and the plot numbers for the different replications. Three copies of each are usually made.

The other type is used for recording data in the field. This contains columns for various characters in which data are taken. This book contains only the plot numbers typed in ink which appear in order from the beginning of the last unlike the plot numbers which in case of the first type are randomized (Appendix XIII). The entry numbers are written below plot numbers with a pencil. After the data has been taken, the strips are torn along the perforations, and are arranged according to the entry numbers. For sorting the strips, a special type of box with pigeon holes is used (Plate 36). Since there are four replications, each hole will contain four strips being the same entry number. These four strips with same intry number are then again assembled according to the replication, replication 1 appearing at the top and replication 4 appearing at the bottom and then pasted at the back (see Plate 37).

Breeding block field book: The field book for the breeding block give information on plot numbers, pedigree of material, origin, number of rows grown and columns for various characters on which data are to be recorded.

A uniform pedigree system of nomenclature is followed for the different types of materials developed during the breeding programme.

The pedigree system followed in case of various types of material are discussed herewith. The programme of breeding is written in the book.

i) Inbred lines: The nomenclature consists of three parts, namely, the original variety from which derived, the station, identification and family

* According to information given by Dr. N.L.Dhawan, Dr. Joginder Siingh and Dr. B.K.Mukherjee.

number and the history of breeding (i.e. sibbing or selfing). For instance an inbred line KT41-A21-4-3-1-4-#-# gives information on the following:

Variety name:	(KT 41)
Station identification:	(A)
Family number:	(21)
History of breeding:	(-4-3-1-4-#-#)

represents sibbing and the number of sibs will indicate number of generations of sibbing. After four generations of sibbing (-#-#-#-#) the fifth generation of sibbing is written as (f): For example, KT 41-A21-3-1-4-#-#-#-#-# is written as KT 41-A21-3-1-4-f

ii) Varieties: Varieties are represented by their full pedigree.

iii) Composites: A station which develops a composite from the multiple varietal crosses assigns its own code letter and a number which is not repeated again. Composites which are introduced from outside, the country will retain the original names. Composites developed from varietal crosses are represented with their full pedigree until they are released e.g. a varietal cross Basi x Eto Amarillo was advanced and found a composite and called as A6 (being developed by Delhi and A being its code letter) under experimental stage. On its release, it was named as Vikram. The name given at the time of release is usually some popular vernacular name which would appeal to the farmers.

iv) Top crosses: Top crosses are reported with the full pedigree of the tested and the tester material.

v) Introduced material: Such materials are usually represented by full pedigree and are not given any station code letter.

vi) Double cross and double top cross: Double cross and double top cross are usually given experimental hybrid number. The experimental hybrid numbers are coded that they indicate the zone in which they are produced, the hybrid number and the year in which they are developed. Double crosses developed in the different zones in India recorded as follows:

Zone 1	Code
1	1000 series
2	2000 series
3	3000 series
4	4000 series

For instance, if zone 1 develops an experimental double cross hybrid in 1966, it will be numbered as Expt Hyb. No.1016. The first digit of the code number stands for the zone, the middle two digits give the hybrid number and the last digit indicates the year in which hybrid is produced.

vii) Biparental progenise: Biparental progenies which are produced by crossing two plants at a time within a population are named as BP-A1, BP-A2, BP-A3 and so on. BP stands for biparent, A stands for station code (A being for Delhi), and 1, 2 etc. for the number of biparents.

viii) Reconstituted populations developed by different methods of selection:

For example, if different types of selections are carried out in the base population Puerto Rico Gr. I, then under different selection procedures, the pedigress are written as follows:

a) Reciprocal Recurrent Selection	: Puerto Rico Gr.1 (Arr)
b) Mass selection	: Puerto Rico Gr.1 (Ams)
c) Top cross selection	: Puerto Rico Gr.1 (Asyn)
d) per se selection of inbreds	: Puerto Rico Gr.1 (Aps)
e) Biparental selection	: Puerto Rico Gr.1 (Abp)
f) Unit selection	: Puerto Rico Gr.1 (Aus)

It will be noted that the first letter in the parenthesis relates to station code where the selection has been carried out and is followed by the method of selection in small letters.

The code letters for the different stations of the Coordinated Maize Breeding Scheme are listed below:

Station	Code letter
Delhi	A
Hyderabad	B
Srinagar	C
Pantnagar	D
Ajmer	E
Almora	F
Arbhavi	G
Chhindwara	H
Godhra	I
Ludhiana	J
Kalimpong	K
Bajaura	L
Dholi	M
Gangtok	N
Salan	P

Yiedl trials

Three different types of yield trials are counducted, namely,

a) Uniform yield trials:- These trials are conducted within a zone. They are laid out in a 7 x 7 simple lattice design with minimum of four replications. Out of 49 entries, 45 entries are of the experimental materials and 4 entries are of checks with which the experimental materials are compared.

b) Coordinated trials: These trials are conducted all over the country and includes experimental materials which have already been tested in uniform yield trials and proved promising. These trials are also laid out in 7 x 7 simple lattice design. Each trial includes 43 entries and 6 checks. Usually four replications are used.

c) Advance trials: Advance trials are usually conducted on farmers' fields under the supervision of research staff. This trial generally includes released materials or promising hybrids which have been tested in Coordinated trials. In each station, usually three advance trials are conducted. The maximum number of entries put into these trials are 10 and are laid out in replicated randomized block design.

Method of recording data

Field data are recorded in specially designed field books which have been described earlier. Master sheets for 7 x 7 lattice design with plot number already randomized are available for a large number of trials which have been numbered. Blank master sheets belonging to the particular trial number are filled with pedigree of the materials to be tested and field books are made accordingly.

Uniform procedures have been set for recording the different characters. These procedures for the various characters are discussed below:

i) Yield: Just prior to harvest, plant population counts are made for each plot. The ears of the whole plot are harvested without the husks and total green ear weight are recorded in the harvest sheets or the field books (see Plates 38A*,38B and 38C). Five ears are picked up randomly and two rows of grains from each ear are removed from the ears by means of a moisture sampler collected in plastic bags or cans for determining moisture percentage in the grains at harvest (Plate 39). Ten ears are kept in small cloth bags, labelled and dried in dryers. Later those ears are shelled to determine

* Plate No. 38 to Plate No. 41: By courtesy of the Rockfeller Foundation in New Delhi.

shelling percentage. Using the moisture percentage in grains at harvest, ear weight per plot at zero plant moisutre is worked out. The mean values for ear weight at zero percent moisutre is adjusted by Lattice Covariance for plant stand differences. Grain yield in kilograms per hectare at 15% moisutre is then calculated after making adjustments for shelling percentage as given below:

$$\text{Adjusted ear weight in kg. per plot at 0\% moisture} \times \frac{\text{Shelled weight}}{100} = \text{Grain yield in kg. per plot at 0\% moisture}$$

$$\text{Grain yield in kg. per plot at 0\% moisture} \times \frac{100}{85} = \text{Grain yield in kg. per plot at 15\% moisture}$$

Grain yield in kg. per plot at 15% moisture is then converted into kg. per hectare by flat adjustment based on the plot size.

ii) Moisture content of grains at harvest: About 5-7 of the harvested ears are selected at random and the grains of 2-3 rows are removed from each ear and mixed. The moisture percentage is directly determined by means of Universal Moisture Tester (see Plate 40).

iii) Shelling percentage: The ten ears harvested for each plot are dried, weighed individually and shelled (see Plate 41). Shelling percentage is calculated by dividing the mean weight of the shelled grains by the mean weight of the shelled ears and expressed as percentage.

iv) Days to silk: The number of days to silk is determined by the number of days taken for 75 per cent of the total number of plants in a plot to silk.

v) Vigour (1-5): Plants are graded for vigour from 1-5. Plots with most vigourous plants with thick stem, broad leaves and dark green colour are generally graded while plants which are thin, tall, lanky with yellowish green narrow leaves are graded as 5.

vi) Plant aspect (1-5): It differs from vigour notes in the sense that the size and placement of ears and other agronomic characters are also taken into account. This data is generally taken at the dry silk stage. The best rating is while the poorest is 5.

vii) Notes on insect pest:- Data on the infestation of corn borer (*Chilo zonellus*) is taken in percentages. In a plot total number of plants are counted and also plants showing dead heart or heavy infestation are counted on the basis of infested plants and total plants percentage of infestation is worked out.

viii) Disease notes:

Helminthosporium:

Data is recorded on the basis of rating 1 (good) to 5 (poor) The various grades are shown in Plate 42*.

Physoderma: Same as *Helminthosporium*

Downy mildew: Data recorded in percentages. The total number of plants to number of infested plants per plot are taken into account.

New downy mildew: (*Sclerophthora rayssiae*) Data recorded on the basis of 1(good) to 5(poor).

Bacterial stalk rot: Data to be submitted in percentages. Mean over four replications to be rounded to whole numbers.

Tabulation and analysis of data :

After the data have been recorded, they are transferred from the field books and harvest sheets to the summary sheets. Before the availability of computer facility for analysis, data were analysed in electrical calculators. For this purpose, special proforma have been devised for yield to work out the corrected green weight and adjust it to stand and moisture corrections for all the four replications for each entry (see Appendix XV). The method-

* Plate No. 42: By coutesy of Dr. B.K.Mukherjee.

ology for yield conversion and correction has been described in connection with yield.

Most yield trials are generally laid out in 7 x 7 simple lattice design with four replications. Each entry usually has a two row plot in each replication. The whole field is divided into blocks. Each block contains rows 30 feet in length. The row to row distance is 2.5 feet. Between 30 feet blocks, a gap of 3 feet is kept and after two 30 feet blocks, an alley of 6 feet is kept (see Appendix XIV). The 6 feet alleys are used for irrigation and also for taking plot to plot observations. Sowing of different plots is done always from left to right and the plots are labelled in the same manner. For instance, if the plot numbers start from 1001, it will start from the left as shown above and extend upto the last row in the block (e.g. 1150 in the fig.). The next plot number (e.g.1151) continues just opposite in the next block (see Appendix XIV) and so on. The labels are tied with wire on the first plant of the first row (on the left) of each plot. At the time of sowing 50 seeds are sown in each row but later plants are thinned to 30 to 35 plants keeping plant to plant distance 1' to 9".

Field plot technique

Land preparation: The land should be deep, well drained relatively levelled and graded to facilitate irrigation and drainage. The different operations used for the preparation of the land are as follows:

i) Ploughing: Plough to a depth of 12-15 cm. With a mould-board plough. If there is a hard pan or perennial weeds in the field, a deeper ploughing and sub-soiling is useful. Ploughing should be followed by one or two discing (see Plates 43A and 43B*).

ii) Harrowing: Harrow the soil with a trifal in two directions followed by a spring tooth harrow.

iii) Levelling: After the harrowing, the soil should be levelled with a plane.

Fertilizer application:

Fertilize the crop adequately and properly. The amount of each nutrient should be based on the soil test recommendation. However, in general, 120-150 kg nitrogen (N), 60-80 kg. phosphate (P_2O_5) and 50-60 kg Potash (K_2O) should be applied per hectare. It is desirable to apply zinc sulphate. at the rate of 10-15 kg. per hectare. For the best results these fertilizers should be applied properly and at an appropriate time. Mix thoroughly all of phosphorus, all of potash, one third of the total nitrogen and all of zinc sulphate. Apply these in bands by means of a fertilizer drill (see Plate 44). The bands should be placed at right angles to the directions in which rows are to be made. The remaining nitrogen should be applied in two equal splits, one at knee-high stage and another before tasseling. After drilling the fertilizers, mix them well by means of a spiked-tooth harrow.

Row making and layout: After the fertilizer has been spread and mixed in the soil, rows are made. Furrows are made across the field 75 cm. apart. These furrows are usually 6" deep and also serve as rows. After the rows have been made, the whole field is divided into blocks the details of which have been given earlier.

Planting: Planting of experimental material is usually done by hand. The seeds are usually dibbled within each row (furrow). The seeds are planted at a distance of 18-20 cm. In a 30 ft. row, usually 50 seeds are planted. Later on plant population is thinned to 30-35 plants per row. Thinning is usually done before three weeks from planting.

Irrigation: The fields are irrigated usually by means of gated pipes. Water is allowed to flow gently within rows. Furrow irrigation by siphon or otherwise are also used (see Plates 45A, 45B and 45C).

Weed control: For controlling weeds, a pre-emergence spray of Tafazine at

* Plate No. 43 to Plate No. 53: By courtesy of the Rockfeller foundation in New Delhi.

the rate of 1.0 to 1.25 kg. in 300 liters of water soon after planting and before irrigation is done. This would effectively control all the annual grassy and broad leaf weeds at least for five weeks. Tafazine should be sprayed uniformly and without overlapping. This can be done by using a boom sprayer mounted on a tractor. If Tafazine is not used, the weeds in the rows can be removed by hand hoes and these between the rows by inter-cultivation (see Plate 46). Where tafazine has been used, the inter-cultivation should be done after 3 weeks followed by earthing up at 6 weeks.

<u>Pest control</u>: To control stem borers, spray endrin (0.03%) when the plants are yound and apply granular endrin (2%) in whorls of the plants when they are about 20 cm. tall and thereafter when needed. Dusting of BHC at the seedling stage is also effective (see Plate 47).

<u>Application of minor elements</u>: Minor elements usually are not applied under normal conditions. However, when deficiency symptoms of these start coming up in the crop, spraying of minor elements is resorted to as a correcting measure. Zinc, manganese, magnesium and boron are mostly found lacking. The following desage is used per hectare for foliar spray. 250 gm. each of boron (Boric Acid), manganese ($MnSO4$), and magnesium ($Mg\ SO4$) are dissolved in 180-200 litres of water and sprayed on the foliage by means of a micron sprayer.

<u>Top dressing</u>: The second dose of nitrogen (50-60 kg/ha) in applied as bands on one side of each row when the plants are about knee-high.

The third and final dose of nitrogen (50-60 kg/ha) is applied in similar manner when the tassels begin to appear. This application is very important and should not be delayed since nitrogen requirement is utmost at this time and delaying will result in nitrogen deficiency affecting grain yield.

<u>Water management</u>: Do not allow the plants to wilt due to shortage of moisture especially when the plants are flowering. Irrigate the crop at the first signs of drought wilting. Also do not allow the water to stand in the fields even for 24 hr. else the yield will suffer.

<u>Pollination techniques</u>

Maize is a naturally cross pollinated crop. To obtain desired cross combinations or selfed ears, artificial pollination methods have been devised. Before artificial pollination is carried out, the following materials are required.

1. Ear shoot bags
2. Tassel bags
3. Clipper stapler
4. Fastener clips
5. Silking knife
6. Charcoal pencil
7. Pollination Apron (see Plate 48)

<u>Step 1</u>: The ear shoot when it has emerged out of the axil of the leaf, is cut horizontally with a sharp knife (see Plate 49). After it has been cut an ear shoot bag made of butter paper, is put over it (see Plate 50). This makes the silks be cut uniformly. The ear-shoot bag ward off any pollen floating in the air.

<u>Step 2</u>: When the silk emerge out while can be seen through the bag, a plant which is to be used as male is selected. Only those plants are selected which show a little dehisced anthers at the top of the branch and is expected to shed pollen next day. The tassel is shaken to remove the already shed pollens, covered with a tassel bag and fastened with a clip (see Plates 51A, and 51C).

<u>Step 3</u>: The next day, the tassel bag is shaken well and removed with the pollen inside (see Plate 52). It is immediately folded in half and taken to the plant which is ready for pollination. The ear-shoot bag is removed the pollen is dusted and covered simultaneously with the same tassel bag. The tassel bag is secured by means of the clipper stapler around the stem (see Plates 53A, 53B, 53C and 53D).

CHAPTER IV

HYBRID SEED PRODUCTION AND ROLE OF NATIONAL SEED CORPORATION**

National Seed Corporation was set up in 1963 - at a time when the concept of certified seed was not fully known to the farmers. The farmers. The farmers were also showing their unwillingness to accept the truth of hybrid potential. The Corporation had, therefore, to work strenuously in its seed production, publicity and educational drives to quickly make the farmers aware of the usefulness of hybrid vigour and the superiority of certified seeds. The impact at the initial stages of the programme remained slow but sure. In the subsequent years, when the results of demonstrations of hybrid varieties at farmers' fields became known to the farmers, the response became heavy and extensive. The release of new varieties of hybrid jowar and hybrid bajra in 1964-65 and their performance further convinced the farmers of high yielding potential of hybrids. This resulted in the sudden increase in demand of hybrid seeds. N.S.C. took up the challenge boldly and organised seed production of hybrid maize, to meet the rising demands to full extent.

Broadly NSC's initiative in organising the certified seed production programme in the country helped not only the seed industry in many ways but also provided basic technical know-how about the latest techniques in agricultural production capable of helping in the increase of food production in the country. Important features of this assistance can be summarised as under:

*Development of quality consciousness in seeds
*Introduction of seed certification on large scale in hybrids, vegetables and other crops for the first time in India.
*Popularization of hybrid maize
*Establishment of large number of seed processing plants in the private and government sectors.
*Help indigenous manufacture of seed sowing and processing equipment to replace imports.
*Organization of training programmes for seed producers.
State Government personnel and others for certified seed production.

Organizing the production of certified seeds,is a very big step forward in improving the basic input of agriculture, that is seed, To make certified seed available to the fullest extent is, however, a task of great magnitude and this cannot be handled by one or a few agencies. The cooperation of all interested individuals and institutions is necessary to successfully take up this task. The National Seeds Croporation seeks to provide the necessary assistance and guidance to the programme of organising a certified seed industry in the country, which would assure the farmer of the availability of the best quality seed of the newly evolved hybrids and other varieties.

Seed production efforts

<u>Foundation seed</u>: Availability of reliable foundation seed is the first requisite of certified seed production. Breeder's seed in germplasm quantities is supplied periodically by the various crop breeders. These small quantities of breeder's seed are multiplied for the production of foundation seed. The National Seeds Corporation has set up its own farms for producing high quality foundation seed stocks of different crops. In order to meet the fast increasing demand for certified seed and to boost up certified seed production, NSC is arranging the foundation seed production through contrast growers also on a restricted scale.

The foundation seed crop is inspected by a team of experts drawn from various organisations. These inspections certify the foundation seed crop as to its high quality and genetic purity.

** According to NSC, Plans and Progress by National Seeds Corporation LTD. 1968, New Delhi.

NSC seeks to produce and maintain adequate stocks of foundation seeds to act as buffer during seasons of crop filures.

Certified seed

Quality control: Quality is the key factor in the seed and every effort has to be made to ensure such quality factors as trueness to variety; optimum moisture for safe storage; freedom from weed-seeds and admixtures; and high germination. Seed conforming to such standards and having the proper pedigree is termed "certified seed" and the standards for the same are laid down in advance. NSC ensures that the seed produced under its supervision is above the minimum standards established for the crop. For this NSC maintains a cadre of trained technical personnel. They assist the seed producters in the growing of seed crop and production of certified seeds. It is primarily the responsibility of the producer to follow the recommended practices, such as, removing off-type plants, detas seling etc., so that the crop may be approved for seed purposes. The inspectors may recommend rejection of crops as unfit for seed production if the same do not conform to the prescribed field standards. The inspection staff is primarily to assist seed producers in carrying out production and processing practices which can help them in the production of high quality seed. The inspection and certification services provided by NSC constitute a great asset to the seed producer. The farmer is given definite guidance and is educated on the use of improved agricultural practices. An awareness as to the superiority of the certified seed is also brought to his mind enabling him to distinguish really good seed from the bad one. This is important because the farmer is willing to pay a good price for the seed provided he is sure of the quality.

Seed processing: Field inspection is only one part of quality control. The processing of seeds is the next step. The seed is dried to a prescribed moisture content by artificial means, cleaned and graded and is treated with fungicides and insecticides. Seed testing forms an essential part of the process. Samples of seeds to be sold are drawn and sent to government laboratories for testing germination, moisture content, a purity and other factors. Seeds are put in bags and sealed effectively and a blue tag/label is put as a mark of certification. This tag declares the variety, germination percentage and other quality particulars.

Maintenance of the required standards in the whole process of seed production and processing is very eseential for ensuring overall quality of the seed. It is possible to maintain the standards only by the use of modern seed production and processing equipment. NSC assists the seed producers, state governments and others engaged in seed production in the setting up of processing plants and in the availbility of equipment. In this direction, NSC is also being indigenous manufactures in the production of machinery and equipment which were earlier imported or made available by USAID and other international organizations like Rockefeller Foundation, etc.

Packing: Seed is made available to the farmer in effective package which is moisture proof where necessary. The certified seed is not sold loose but only in convenient packages which are prepared in different suitable sizes. The packaging material used is generally either cloth, polythene or polythene inside of cloth bags. In all cases it is ensured that the packages are sealed in a manner that they may not be tampered with. The farmers' assurance that the seed in the bag is pure, is the presence of the blue label/tag and the seal on each seed bag.

In every seed package a leaflet giving details of cultural practices is made available. The instructions provide the recommended cultural practices on swoing, fertilizer application, weeding, plant protection measures etc. The interest of the farmer is best served not only by giving him good seed but also by providing simultaneously the know-how necessary to make the best use of the seed. The leaflet put inside each certified seed bag provides this information.

Hybrid seed producer:

The production of hybrid seeds is a highly technical process. It needs training, skill and personal supervision. The seed crop is to be watched right from sowing up to harvesting. Sowing, cultivation, manuring, detasseling and harvesting has to be done right and at proper time. At the same time, it is within the reach of a progressive farmer to grow a good crop. The National Seeds Corporation gives necessary guidance wherever possible in raising the seed crop. Literature on various aspects of seed production is available with NSC and can be supplied free on request.

As a policy, each State Government is responsible to produce enough seed for achieving its target. The Corporation supplies foundation seed to State to State Governments who, in turn, supply it to the registered growers for production of certified seeds. In the event of a shortage, the Corporation organizes seed production by contracting with farmers for procurement of seed at pre-determined prices, very often in off-seasons. For instance, the Corporation has been growing paddy seeds and hybrid seeds of maize, sorghum and bajra in the rabi-summer season in south. Similarly, an initial increase of wheat seed of newly evolved varieties was arranged in Ootacamund hills in the *Kharif* season of 1967. Number of seed growers of hybrids in the country has been speedily going up, this number being 1,332 in kharif, 1967 only, state-wise break-up, is given in Table 21.

The National Seeds Corporation conducts regularly short courses in seed production. Seed producers can avail of this facility.

The main requirements for becoming a certified seed producer are listed below:

I.

A. Technical method

1. Foundation seed: The producer must get his foundation seed supplies from the NSC.

2. Isolation requirements: The seed production plot shall have a minimum isolation distance as prescribed in the seed certification standards.

3. Selection of land: The recommended initial minimum unit of seed production should be 25 acres with a scope of further expansion, either individully or with the help of other growers by forming a cooperative, an association or a company.

4. Growing the seed crop: Full instructions regarding all the operations connected with producing a seed crop are available on request. It will be in the interest of the producer to follow these instructions properly.

5. Detasseling and roguing: Detasseling in the case of maize and roguing in the case of sorghum and bajra are the most important operations. Any mistake or lack of attention on the part of producer may lead to rejection of his crop. The producer must inform the Corporation a week before the flowering is expected to start. The new producers will be given necessary instructions for proper detasseling and roguing. Each seed field will be inspected for proper detasseling, roguing, isolation etc., by the representatives of the Corporation.

6. Harvesting of the crop: The harvesting operation should be done after obtaining the approval of the Corporation's representative in the area.

7. Drying and processing: Drying, shelling or threshing, cleaning and processing will be done under the supervision of the Corporation's representative.

Table 21. Number of hybrid seed Producers state-wise*

S.No.	Name of state	No. of producers
1.	Andhra Pradesh	126
2.	Assam	-
3.	West Bengal	2
4.	Bihar	19
5.	Delhi	3
6.	Haryana	35
7.	Himachal Pradesh	32
8.	Jammu and Kashimir	2
9.	Kerala	1
10.	Madras	4
11.	Madhya Pradesh	176
12.	Maharashtra	179
13.	Mysore	393
14.	Orissa	9
15.	Punjab	241
16.	Rajasthan	31
17.	Uttar Pradesh	79
		1332

* According to NSC, Plans and Progress by National Seeds Corporation L.T.D., 1968. New Delhi.

B. Certification requirements

The certification of the seed will be subject to the following general conditions:

1. The requirements in respect of isolation, detasseling, roguing, etc. will conform to the minimum certification standards.
2. The moisture content in the seed at the time of bagging shall not exceed 12%.
3. The seed shall meet the minimum standards of purity and germination.
4. Screen sizes used for grading must have prior approval of the seed inspection officer.
5. Certification tags and seals will be supplied by the NSC on cash payment. Other certification material can be supplied by the Corporation on cash payment if indent is placed well.in time.

II. Estimated cost of production

1. Entire cost of land preparation, sowing, irrigation, interculture, manures and fertilizers, roguing, detasseling, harvesting etc. will be met by the producer.
2. Estimated cost on major items is as follows:

Cost of foundation seed	Rs./acre	80.00
Inspection fee	"	25.00
Approx. cost of fertilizers required	"	150.00
Approx. cost of plant production	"	30.00
Approx. cost of detasseling or roguing	"	15.00
Total		300.00

3. Drying and processing cost:

A. Drying and processing cost per quintal of finished seed — 20.00(Approx.)

B. Cost of certification material viz. bag, tag, leaflet, seed treatment, material, thread, seal etc. — 14.00/q.

Since the inception of National Seed Corporation in 1963, considerable progress has been made in the multiplication of hybrid maize as can be seen from Table 22 and Fig. 11, the acreage under foundation seed production of hybrid maize was 189.0 in 1963 but by 1967 it increased to 2394.0.

The area planted to certified seed production also increased from 1607. acres in 1963 to 20,000. acres by 1967. The total production of certified seed was only 8.206 quintals but by 1966 total production increase to 7632 quintals. The popularity of hybrid maize among the farmers can be judged from the fact that while in 1963 only 1.22% of the total maize acreage of the country was under hybrid maize, by 1967 the total area under hybrid maize increased to 10.58% (Table 23).

Table 22. Progress of hybrid maize seed production in India*

Period	Acreage under foundation seed production of hybrid maize (Inbreds, single cross and varieties)	Area planted to certified seed (acres)	Production of certified seed (quintals)
1960-61	-	4.5	45.8
1961-62	90.0	191.5	1341.6
1962-63	180.0	1154.5	6861.5
1963-64	189.0	1607.0	8226.0
1964-65	276.0	2188.0	12678.0
1965-66	783.0	8568.0	30795.0
1966-67	1355.0	14624.0	76320.0
1967-68	2394.0	20000.0	-

Table 23. Area under Hybrid Maize*

Period	Area planted to commercial maize (hectares) A	Area planted throughout India (ha) B	A/B x 100
1960-61	312	4,353,500	0.0071
1961-62	9145	4,493,200	0.20
1962-63	46770	4,579,400	1.02
1963-64	56071	4,584,200	1.22
1964-65	86417	4,591.100	1.88
1965-66	209908	4,764,700	4.41
1966-67	520222	5,073,800	10.25
1967-68	590247	5,576,700	10.58

* According to NSC, Plans and Progress by National Seeds Corporation, 1968, New Delhi.

Future outlook

In the last five years the National Seeds Corporation has promoted a hybrid seed industry and popularized certified seeds of vegetables. The Corporaton's activities in the coming years would be further strengthened in various direction, the more important of which are indicated below:

Foundation seed: In addition to producing foundation seeds of hybrids and composites of maize, jowar and bajra, the Corporation will undertake production of foundation seed of varieties of all-India importance. The scope of foundation seed production will be extended to cover commercial and fodder crops.

Pre-release multiplication: It is well known that many times when a variety is released, farmers are not able to obtain seeds thereof. Such a situation is sometimes exploited by certain individuals. To prevent such occurrences, the Corporation will undertake pre-release multiplication of seeds as soon as a variety is known to be promising. Though this means a certain measure of risk that the seed produced has to be discarded if the variety is not released the objective is to make available sufficient quantity of foundation seed along with the release of each variety.

Breeder seed: The Corporation will place advance orders at research stations to facilitate the production of breeder seed in adequate quantities and in accordance with prescribed procedures.

Certified seed: The timely availability of quality certified seeds is of great importance to the agricultural progress of the country. Farmers must be able to obtain seeds, which are reliable, at the time and place they want. The Corporation proposes to develop a marketing system both for its own direct sales and for sales by other seeds organizations so that there is extensive availability of high quality seed to the farmers. A major bottleneck in the agricultural development programmes will thus be removed. The varieties and quantities of production for certified seed that will be taken by the Corporation will be determined in the light of farmers' performance and the activities of other agenicies in the field.

New technologies: The Corporation is dedicated to forge-ahead with new varieties and new technologies in the field of seed. Constant efforts are being made to improve the processing and storage techniques and to try out new and promising varieties in the field. As a part of its endeavour to spread new processing technology, the Corporation will provide active guidance to seed companies and state governments in setting up processing plants. It will also set up a few seed processing plants on its own and on behalf of state governments. It will provide consultative services in this field and also undertake processing of seeds on a custom basis. As a major seed organization the Corporation aims at serving the farmers in all their requirements.

The lines of activity given above are only indicative of the Corporation's endeavour to explore the avenues by which it can be of greater use to the farmers. As a leader in the field of seed interested in promoting the entire seed industry, the Corporation will continue to provide active assistance to the states and to other seed organizations in private cooperative and public sector so that there is a vigorous and healthy seed industry operating and serving the interest of farmers.

Exports: With the vastly increased availability of quality seed of field crops as well as vegetables, it has now become possible to step up the export of seeds to foreign countries. The Corporation proposes to make intensive efforts to explore foreign markets and step up export of seeds produced by the Corporation. The Corporation will also assist other agencies in the field who desire to export seeds to foreign countries. With this end in view, the Corporation proposes to arrange for the testing of suitable varieties of seeds grown in India and in foreign countries and also evaluate possibilities of seed production of varieties suitable for foreign countries.

NSC units: National Seeds Corporation Offices have been opened in almost all the major cities in almost all the states. This helps in speedy and efficient distribution of seeds to Indian farmers. A list of address of NSC units is given in Appendix XV.

CHAPTER V

STORAGE OF MAIZE SEED*

All the grain that farmer grows does not reach to consumer. Much of it is wasted in storage by insects, rodents and fungi. The total loss, so caused, has been estimated to be of the value of Rs. 3 to 4 bilions annually. Ironically about the same value, India expend in importing grain from various countries to feed Indian teeming millions. This implies that through elimination of losses in storage alone, we could hope for sell sufficiency. This problem, thus demands serious study and confrontation.

In case of maize, the problem, of late, has become quite serious. With the availability of a number of new high yielding maize hybrids and composites, there is now more maize in farm storage than ever before. This has got to be saved from the ravages of the storage pests.

Losses through insect infestation

Most of the grain go waste due to damage by insects, rodents and fungi. Out of several hundred species of insexts that are associated with stored grain and their products, the following are far more destructive to maize than others:

1. *Sitophilus oryzae* Linn (Rice weevil)
2. *Rhizopertha dominica* Feb. (Lesser grain borer)
3. *Tribolium castaneum* Staint. (Red rust flour beetle)
4. *Cadra Cautella Walk* } Grain moths
5. *Corcyra cephalonica* Staint } Grain moths
6. *Sitotroga cerealella* Olive. } Grain moths

However, of these, rice weevil, lesser grain borer, and grain moth (*S. cerealella*) are the three main culprits, responsible for maximum damage to maize in stores. Whereas, the red rust flour beetle, which is also popularly known as scavenger beetle, feeds on the material which has already been infested by other insect pests.

Losses by these insect are caused in two ways, one by feeding and resultant loss in weight and nutrients of the grain and other through various types of contamination.

The adult female insect lays eggs on the grain, other articles of the store and even sometimes on cracks and crevices of walls and flours. The larva on hatching starts feeding on the grain. However, in case of beetles, both larva as well as adult damage the grain.

Reduction in weight and nutrients from insect feeding is maximumum during rainy season, particularly between July to September. Seed germination is also not infrequently affected by insect and mite feeding on the embryo. In fact, larva of certain species of insects like red rust flour beetle has been known to be selective in attack. The embryo, often being the main target.

Secondary losses to grain are caused by heating which is most common, particularyly in mechanised farms, where harvesting is done with combines which tend to bring grain into store, faster and often with high moisutre content. The lack of proper storage facilities and the resulting pressure on driver capacity during harvesting, result in grain being inadequately handled. Such grain becomes an ideal medium for breeding of insects, endemic infestation of which exists in most of the farm stores. The metabolic heat produced due to breeding of insects after a few weeks causes hot spots which spread rapidly through much of bulk. The affected grains are often reduced to a mouldy mass.

* According to Let not these pests damage your stored maize by Dr. B.P.Khare and Shri H.N. Singh. India.

Losses due to fungi

Fungi and bacteria are usually present in grain and grain products. Ripening grain in the field is generally infested subepidermally with fungi, mainly *Alternaria* which can bause discolouration and loss of germination, unless the moisture content is promptly reduced to or below 14%. There is also a group of storage fungi, particularly *Aspergillus* (with a number of species of *Penicillium* being involved at higher moisture contents and lower temperature) which seldom invades grain before harvest. However, in storage, it has been found to be responsible for discolouration, and loss of germination besides contributing markedly to the risk of grain heating. The affected grains, if consumed, could be injurious to human beings. As for instance, *Aspergillus flavus* can cause liver tumour, cirrhosis and other mammalian troubles.

Control

Store houses: Infestation in stores is mostly transmitted through rats. Besides, endemic infestations in the store that has not been treated or the neighbouring infested stores can be a ready source of infestation. Infested sacks, containers, carts and other transport too contribute in the spread of infestation. The treatment of such infestation involves, thorough sweeping and scrubbing of godowns and their surroundings, removal of bird nests, filling or rat holes, cracks and crevices in stores.

Stores should be sprayed both from inside and outside with a suitable insecticide, e.g., DDT 2.5% water dispersible powder, in one continuous spray. The transport for stored grain can also be treated in the same way. Old bags and other containers, however, should be fumigated with a suitable fumigant, particularly aluminium phosphide.

Seed: Mixing of seed with poisonous dusts like DDT 3% and Malathion 2% ensures effective and long-term protection against insects. All the same, it does not affect the viability of seed. Wet treatment of seed with DDT 50% wettable powder at the rate of 2 oz. per gallon of slurry has also been reported to be effective.

Malathion 2% dust can be mixed at the rate of one kg. in two metric tons of seed. Besides spray of Malathion premium grade 50% emulsifiable liquid 25 cc. mixed in one litre of water has also been found to give a good control.

Grain: It would be advisable not to treat the grain with any poisonous chemical which is stored for consumption purposes. In such a case, surface treatment of bags with Malathion 50% E.C. liquid mixed with water in the ratio of 1:300, DDT 50% W.P. mixed with water in the ratio of 1:25 has been found to be quite effective. The admixture thus formed in each case can be sprayed over the bags at the rate of three litres per 100 square metre.

In case, infestation build-up is noticed at any stage, it would be desirable to fumigate with any of the suitable fumigants like aluminium phosphide (2 tablets/ton of grain), Ethylene di-bromide (460 ml./20 cub. metre space) and Ethylene di-chloride and Carbon Tera-chloride. ED/CT Mixture (30-35 lb./1000 md. of grain).

Protection against fungal attack :

Grain with seed coat mamaged by insects or during handling is more susceptible to invasion of storage fungi and rapidly affects the germination of seed. The affected grains, if consumed, could also be harmful to human beings.

Mould growth, therefore, should be prevented by lowering down the temperature of grain and moisture content in storage (should not exceed more than 14%). Fungicide tests have not given satisfactory results. In such a case, sun drying of mouldy grain has been found to be profitable.

CHAPTER VI

MAIZE IN INDIA -An analysis

Having been associated with work in maize in India for the last one year and having participated in almost all the phase of Coordinated Maize Breeding Project, I have analysed to some extent the present and future of maize in India.

India is a vast country lying between 8°N and 36°N in latitude; it has subtropical and mild temperate climate. Maize, therefore, can be grown almost all the year round in one or the other place of the country. At present, there is also no lack of high yielding hybrids and varieties but still maize production in India rates far behind as compared to other countries. What are the reasons or bottlenecks limiting the maize production and hindering India from being one of the major exporters of maize? I shall attempt to enumerate some of the reasons which, I think, are responsible for such a slow growth in overall production of maize. A look at the total cropped area and area under good irrigation indicates that the irrigation facilities are much less than adequate and most of the farmers are at the mercy of timely and adequate rainfall. Vagaries of rainfall can be considered as a major important climatic factor limiting the yield of maize grown during *Kharif* season.

The maize grown in India, primarily as a rainfed crop, during *Kharif* season. The amount and distribution of rainfall varies widely from year to year. Besides, it often so happens that either too much or too little rainfall is received during one or the other stage of the crop. Stormy winds accompanied by rains are common in the months of September of October in Tarai region as also in Bihar. These often cause extensive damage to vast areas of maize by inducing lodging and stalk breakage. Under such conditions, even improved varieties would not be of much help and total production, therefore, suffers.

It is, therefore, imperative that irrigation facilities are developed in each village. Tubewells, canals and other resources should be improved. Though, work on these lines have started since the last so many years, the progress seems to be too slow.

Almost all through the Northern Plains region, sizable areas under maize are subjected to water-logging during one or other part of the season. As is well-known, maize does not like wet feet and grain yield is drastically reduced with water-logging lasting for even two or three days. Under these conditions, the roots are damaged due to want of aeration and a large amount of soil nitrogen goes back to atmosphere because of denitrification. This is the reason, why in these areas, maize yields well only once in two or three years. Such areas could, therefore, be considered as marginal for maize production.

The damage due to excessive rains could be reduced to a great extent, if the land is levelled and graded properly and if the field drains are provided to take away the excess of water during heavy rains. This surface drainage helps to prevent rise in water-table and water-logging. The farmers could open these drains every 20 to 25 meters, depending upon the slope in their field. Planting maize on ridges is beneficial, as it allows enough aeration for the roots during periods of excessive rainfall.

The Indian farmers make use of manures and fertilizers only sparingly. The maize fields in India, in general, therefore, receive little quantities of manures and fertilizers. The hunger symptoms on the crop are often marked. Under such conditions, it is, therefore, not possible to fully exploit the yield potential of this otherwise high yielding crop. Maize hybrids and composites, in particular, are crops of high fertility condition. These have been known to respond economically upto 150 to 250 kg.N/ha. The maize crop gives 15 to 25 kg. grain per kg. N applied upto these levels (usually 4 kg. grain pays for 1 kg. N).

The response to phosphorus and potash depends very much on the fertility status of the soil and previous history of fertilization. If the soil test indicates low or medium available phosphorus, an increase in the grain yield of the order of 50 to 200 per cent could be realised. Very few farmers are aware of this fact but rarely get the soil test done.

Maize corp is highly sensitive to deficiency of zinc in the soil. The crop remains stunted and develops lighter coloured bands between midrib and edges of the upper leaves. Zinc deficiency has been observed in maize crops in some areas in Punjab, Kashmir, Delhi, Tarai, Andhra Pradesh and Gujarat.

A timely application of these fertilizers, is, therefore, of prime importance.

The farmers in India, in general, are very careless about maintaining the recommended plant population.

The agronomic experiments have shown that there should be about 50 to 65 thousand maize plants per hectare to exploit the yield potential of the hybrids or composites. However, the plant stand in many maize fields is very low because of several reasons. Improper planting methods, water-logging or prolonged dry period during seedling stage, damage done by rats and crows and dead hearts caused by shoot fly or shoot borers could result in lower plant stand. Adequate steps should be taken by the farmers to avoid loss of plant stand.

Timely weed and pest control is very much neglected in the farmers' fields.

Proper management in maize field calls for timely and adequate measures to control weeds, as maize is a very poor competitor of weeds. Two or three hand weedings and two or three cultivations are usually required to control weeds. Use of simazin or attrazin at the rate of 1 to 2 kg. of 50 W.P. material in 200 litres of water per hectare as a pre-emergence spray, eliminates most of the annual grassy and broad-leaf weeds for at least six to eight weeks from planting. The use of these herbicides ensures adequate weed control even when the rains do not allow any cultural weed control operation.

Shoot borers and shoot fly could do considerably damage to plant stand and/or to the grain yields. Timely use of insecticides would help escape damage from these insects. Leaf blight and stalk rot diseases could be very serious in humid conditions. The best approach to the problem is to develop and use resistant variety, composite or hybrids of maize.

These are some of the factors which have to be tackled at the farmers' fields.

Considering the research in maize, I have no doubt that India has opended new frontiers in maize breeding. The development and release of composites speak volumes in favour of maize scientists in India and particularly of Dr. N. L. Dhawan, the doyen of maize research in India. Under his dynamic and enthusiastic guidance, maize research in India has progressed so much in such a short time. Indian scientists are engaged in meeting the challenge of some of the difficult problems like developing disease and pest resistant hybrids and varieties, developing lodging resistance compact hybrids, hybrids to withstand high population and high fertilization, etc. Dr. Dhawan and his colleagues have played their role admirably and the future of the maize breeding scheme seems to be extremely bright and promising.

Coming back to the production of hybrid seed and extension activity, there are many works left to be done. The expansion of seed production business has been very limited and confined to a solitary semi-Government concern. Private seed companies are few and even these are not inclined to produce the seeds or support research in this direction.

Extension activity is very limited and little attempts are being made to educate the Indian farmer about the improved cultural practices. The farmers are also very slow and reluctant in taking up the new methods. They are still following the age-old practices and get contented with whatever yield may obtain from their holdings.

The prospects, however, are not that bleak. The farmers of Punjab are getting aware of the new agriculture revolution and are dissipating this message of new light and hope to their brethren in other parts of the country.

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Plate 1 Brawn stripe downy mildew

1- A

1- B

Plate 2 Downy Mildew

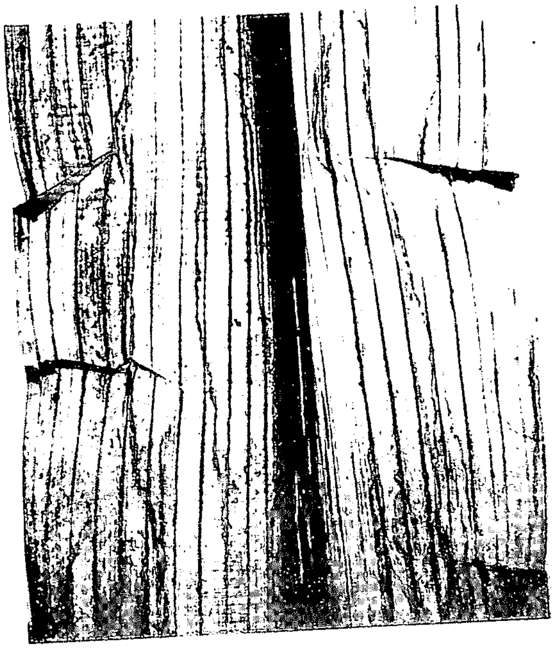


Plate 3 Leaf rust

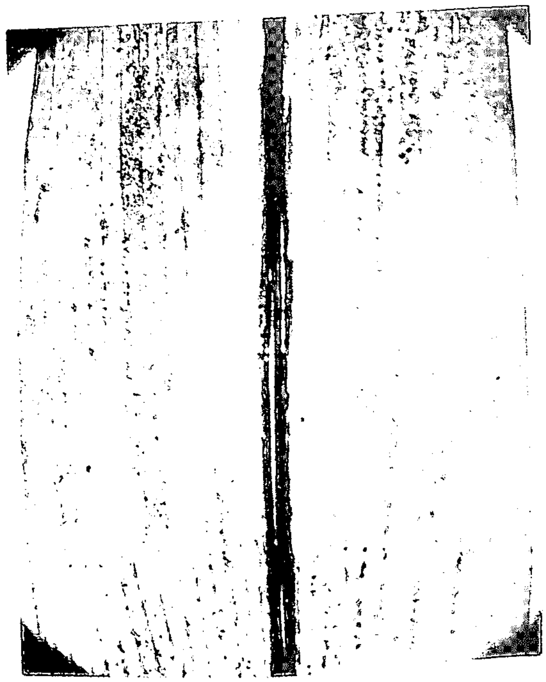
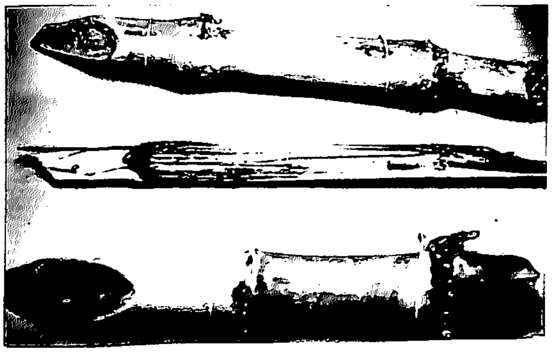


Plate 4 Black bunde

4- A



4- B

Plate 5 Charool rot

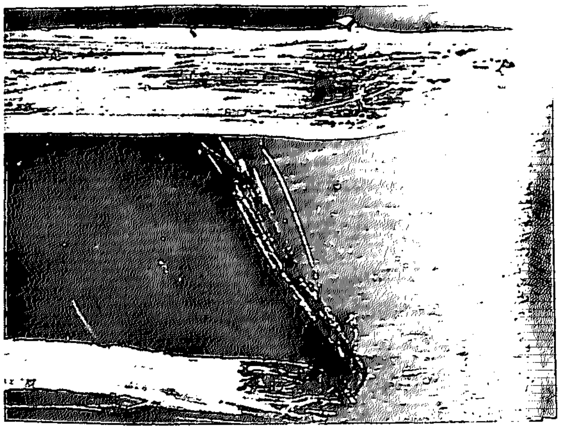


Plate 6 Common sumat

Plate 7 Stem borer damage

7-A

7-B

Plate 7 Stemborer damage -C

Plate 8 Grass hopper damage

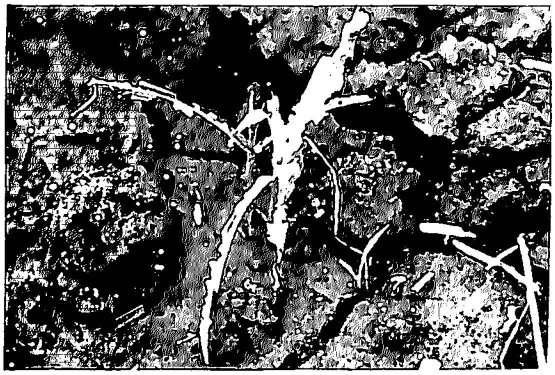


Plate 9 Grain type of Indian local variety, hybrid and US hybrid

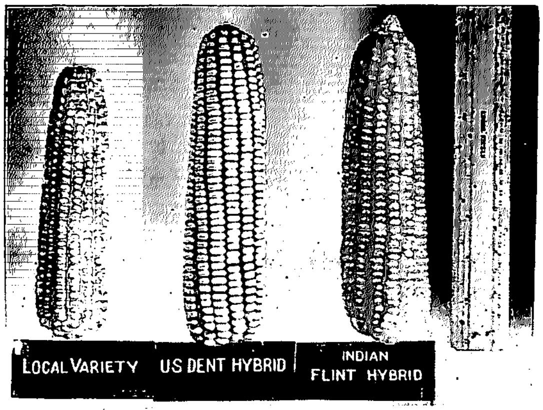
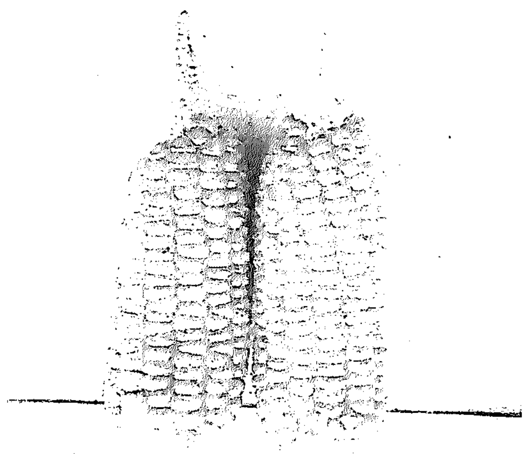


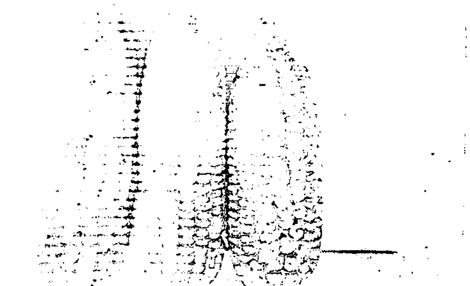
Plate 10 Elite in red line CM 104

10-A



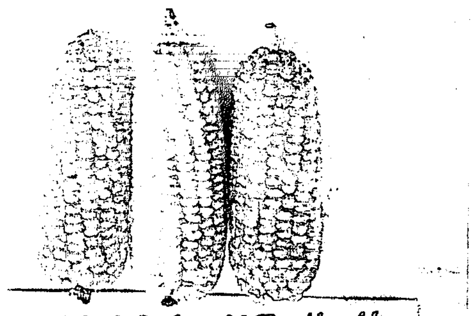
CM 104-#-bulk 2-#

10-B



CM 104-#-bulk 1-#

10-C



CM 104-115-#-#

Note; (1) CM indicater "Coorainated Maize" meaning that the particular line was evalved under the All-India Coordinated Maize Inprorement Scheme.
(2) # indicates sibbing.

Plate 11 Elite inbred line CM 106

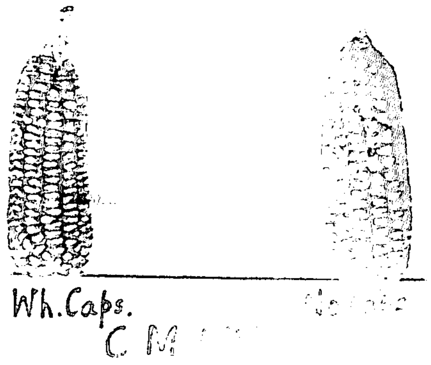


Plate 12 Elite inbred line CM 109

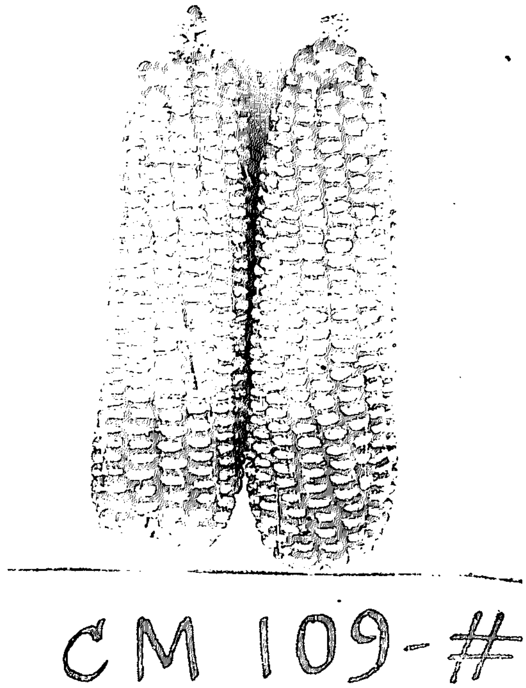


Plate 13 Elite inbred line CM 110

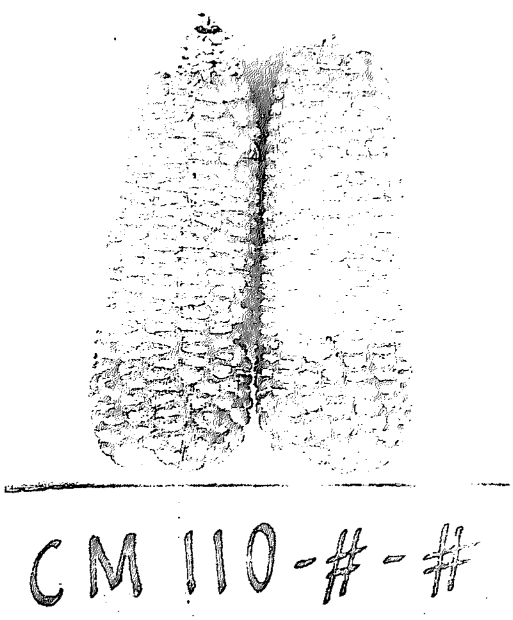


Plate 14 Elite inbred line CM 112

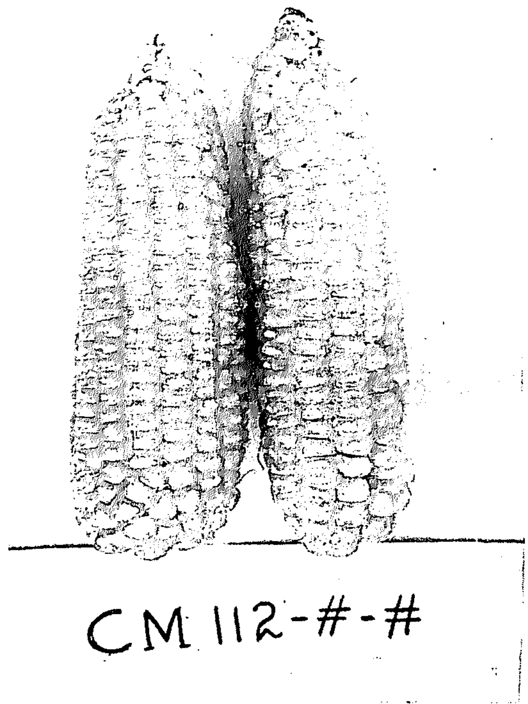
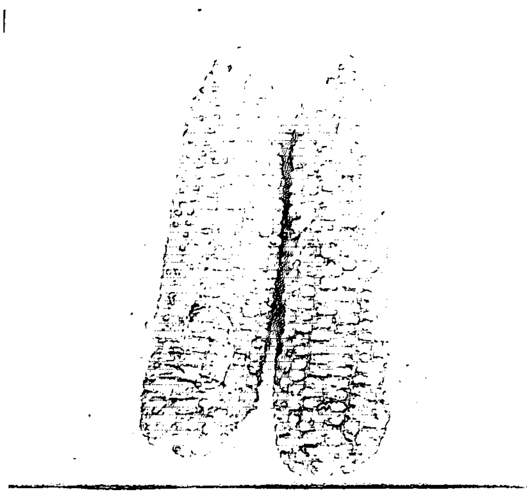
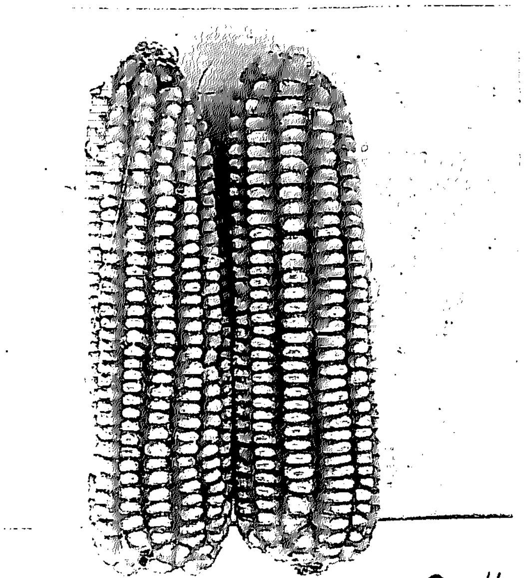


Plate 15 Elite inbred line CM 113



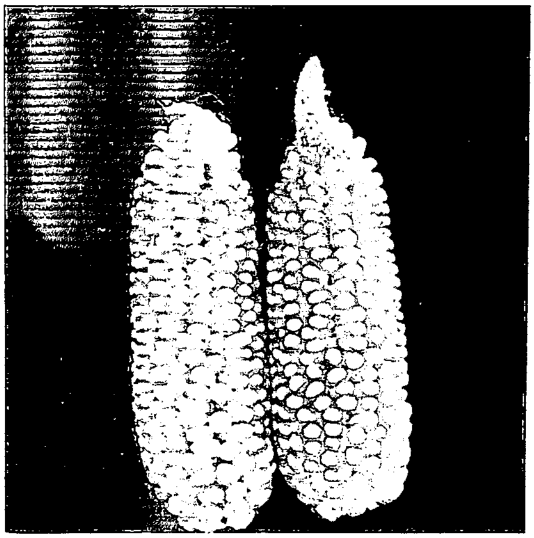
CM 113-#-bulka-#

Plate 16 Elite inbred line CM 201



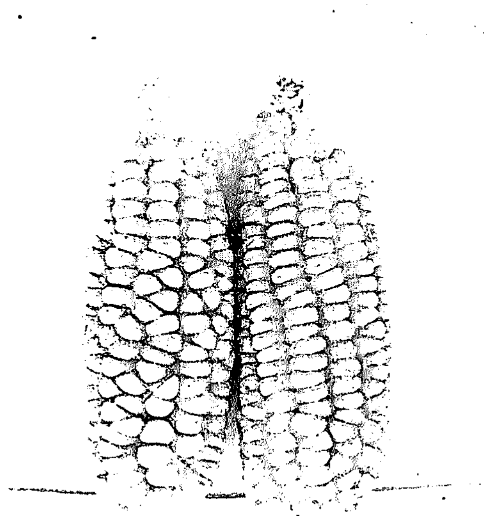
CM 201-# bulk2-#

Plate 17 Elite inbred line CM 202



CM 202-# bulk-1-#

Plate 18 Elite inbred line CM 205



CM 205-#

Plate 19 Elite inbred line CM 300

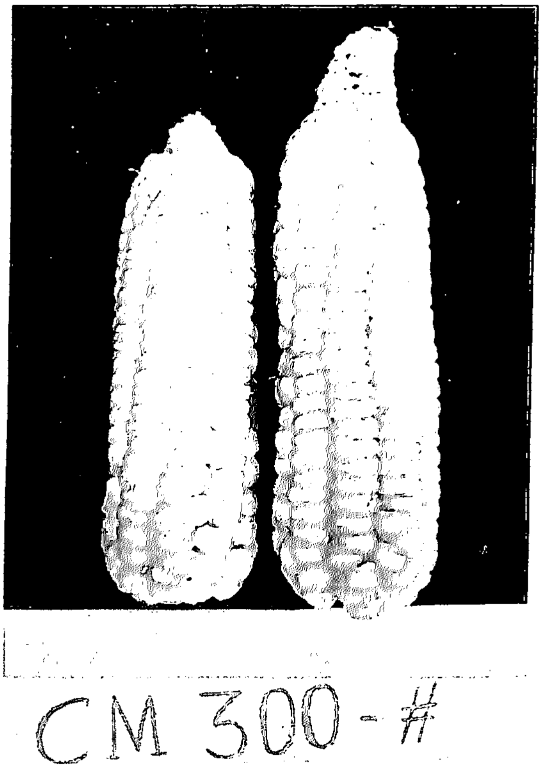


Plate 20 Elite inbred line CM 400

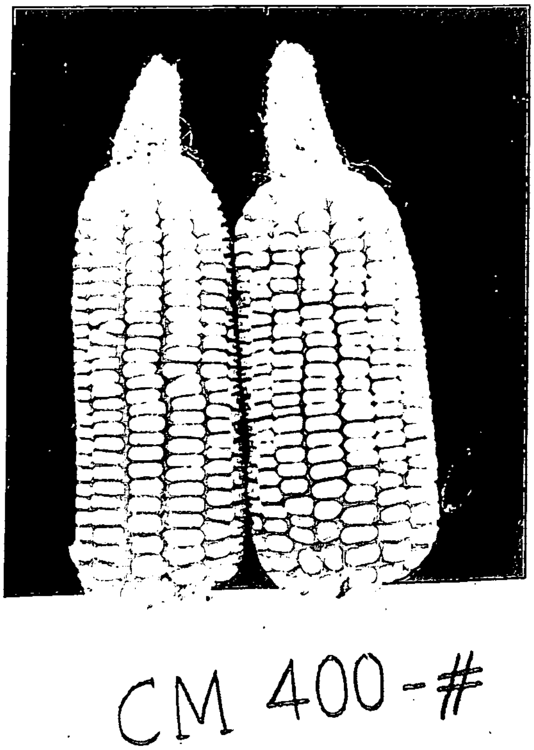


Plate 21 Antigua Gr. 1 CM 500

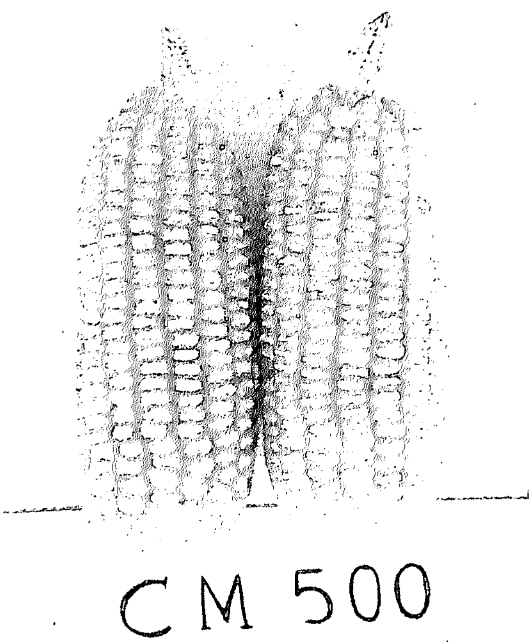


Plate 22 Some of the released hybrids

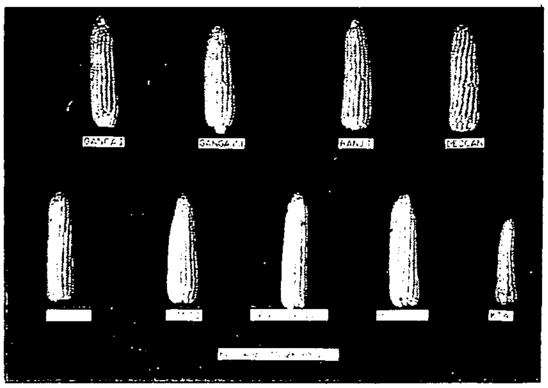


Plate 23 Male parents of released hybrid

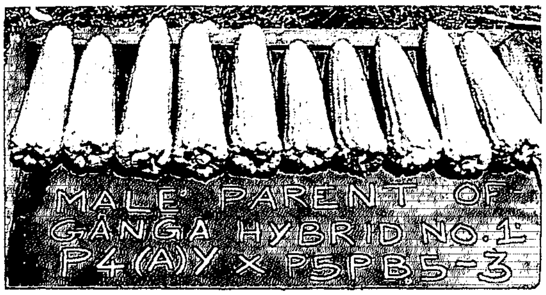


Plate 24 Male parents of released hybrid

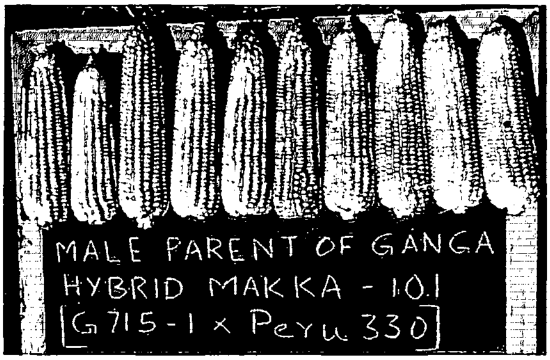


Plate 25 Male parents of released hybrid

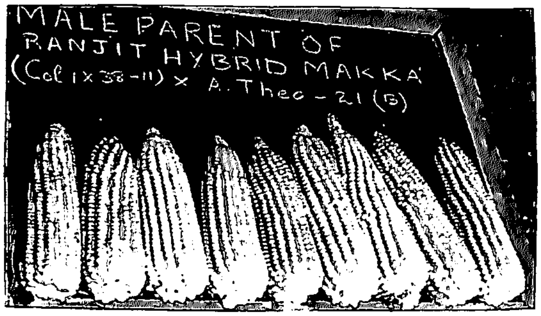
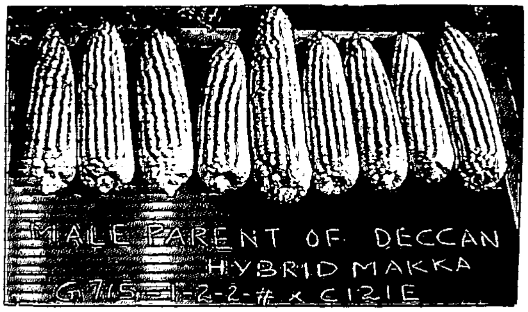
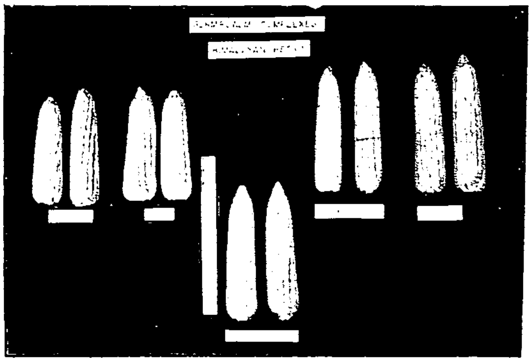


Plate 26 Male parents of released hybrid



'Plate 27 Hybrid vigour in varietal cross 27-A



27-B

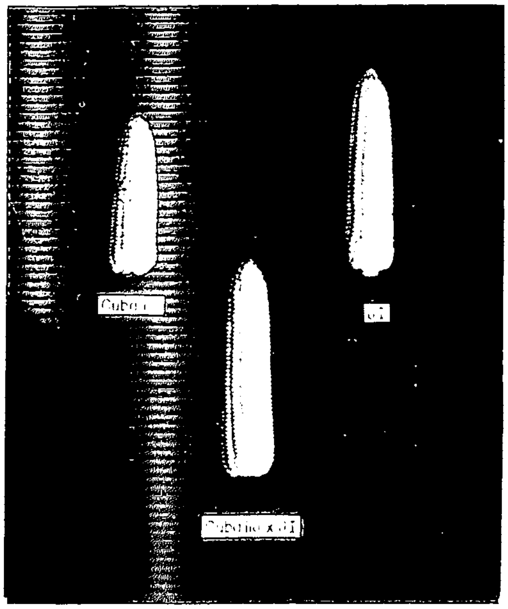


Plate 28 Biparental progeny breeding

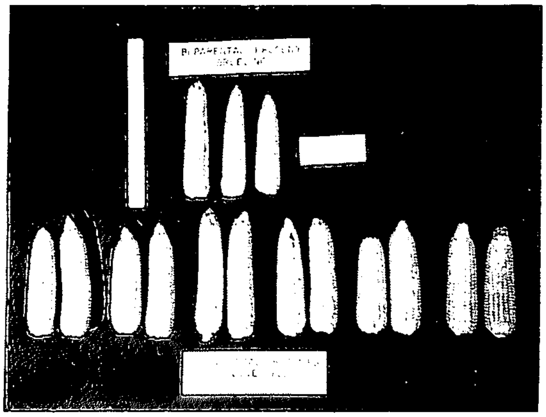


Plate 29 Release composites

29- A

29- B

29- C

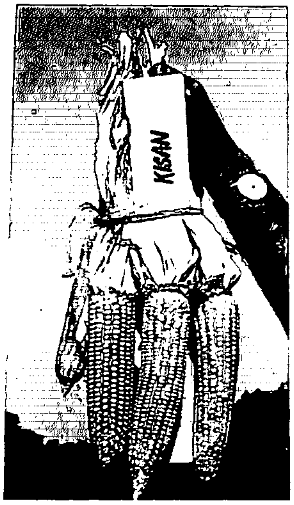
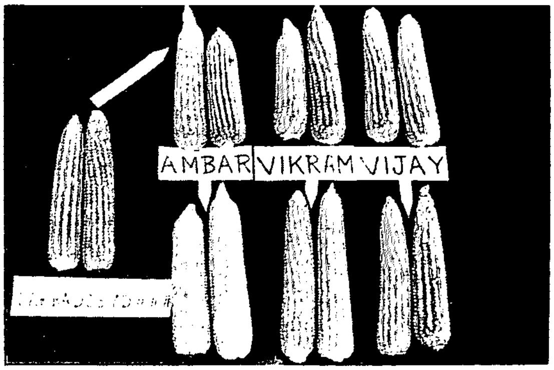
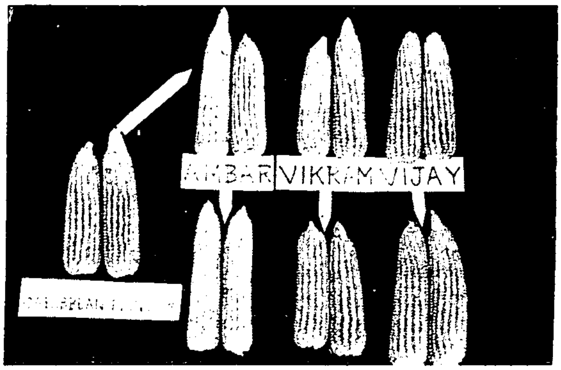


Plate 30 Future improvement of released composites

30-A



30-B



30-C

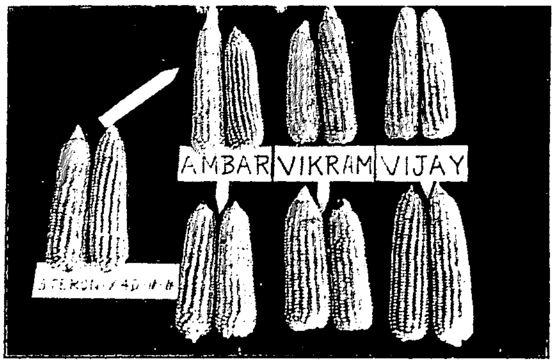
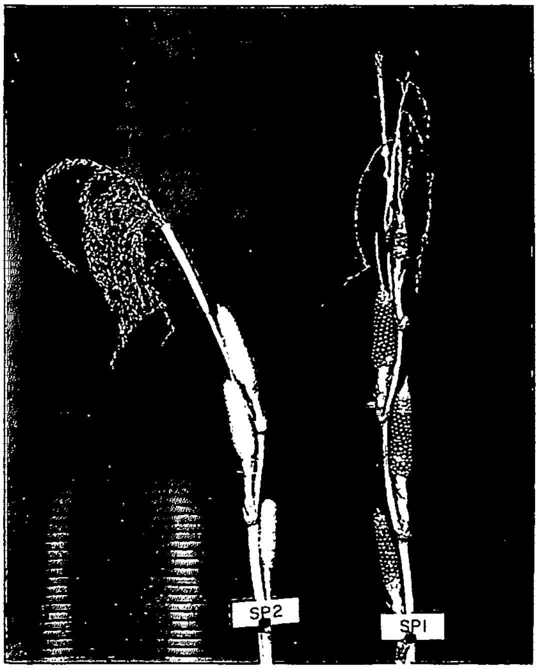


Plate 31 Sikkim primitive maize-A living fossil but source for prolificacy

31-A



31-B

Plate 32 Multi-eares segregates

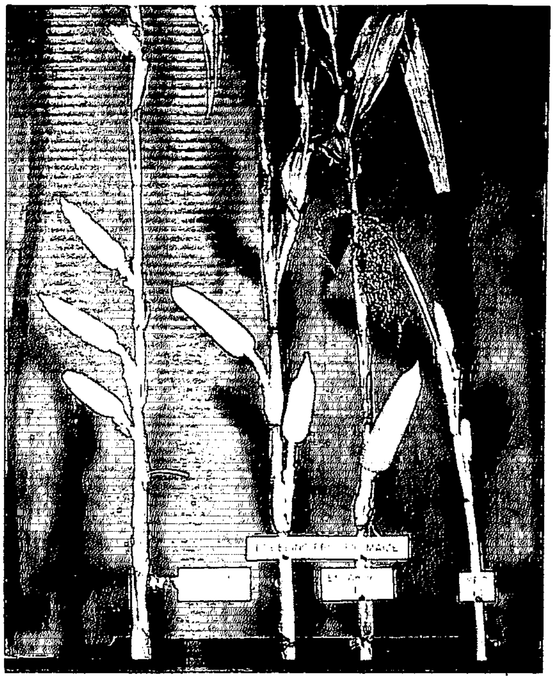
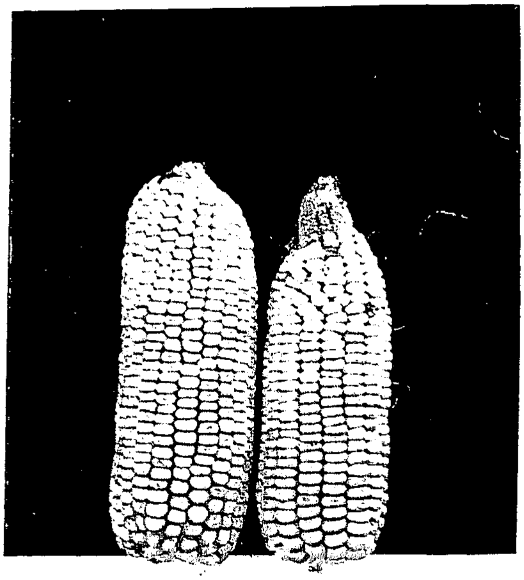
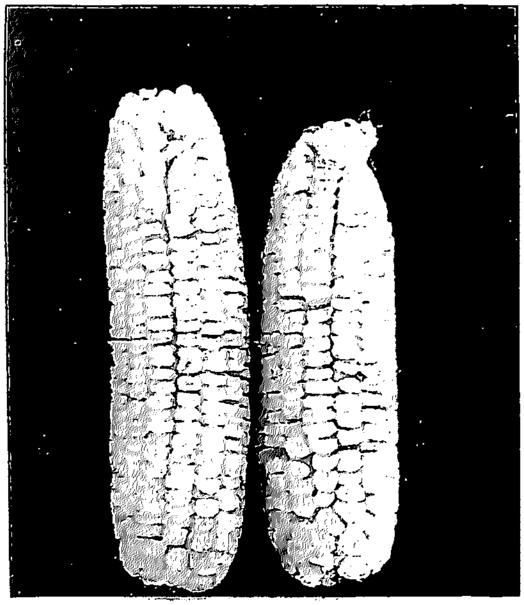


Plate 33 High lysine opaque composite



OPAQUE COMPOSITE

Plate 34 Sweet corn composite



SWEET CORN COMP

Plate 37 Method for puttng of data strips

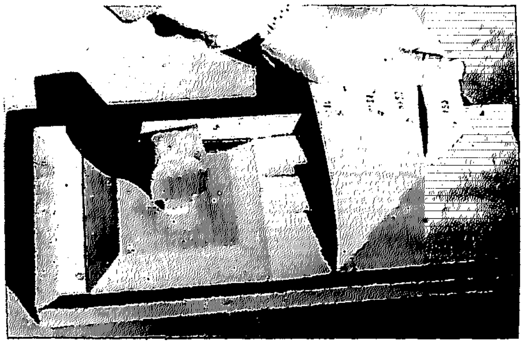


Plate 35 Seed storage cabinets

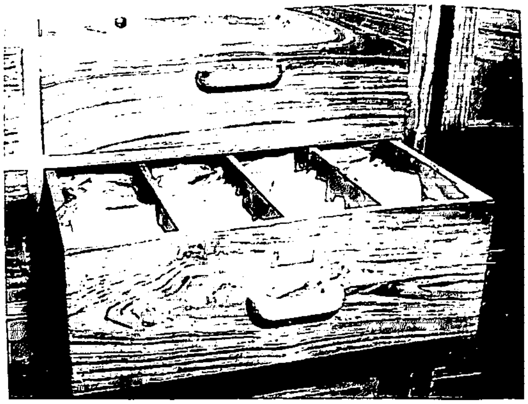


Plate 36 Apparatus for sorting out data entry-replication wise

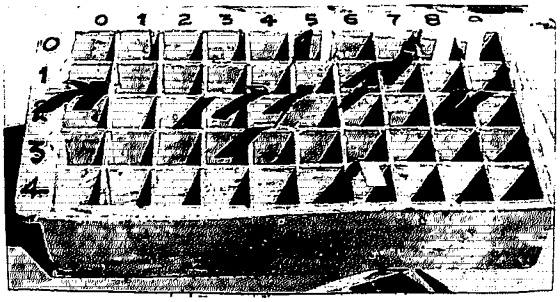


Plate 38 Harvesting and weighing

38-A

38-B

38-C

Plate 39 Taking of moisture sample

Plate 42 Scale for Rating *Helminthosporium Turcicum* **Leaf blight**

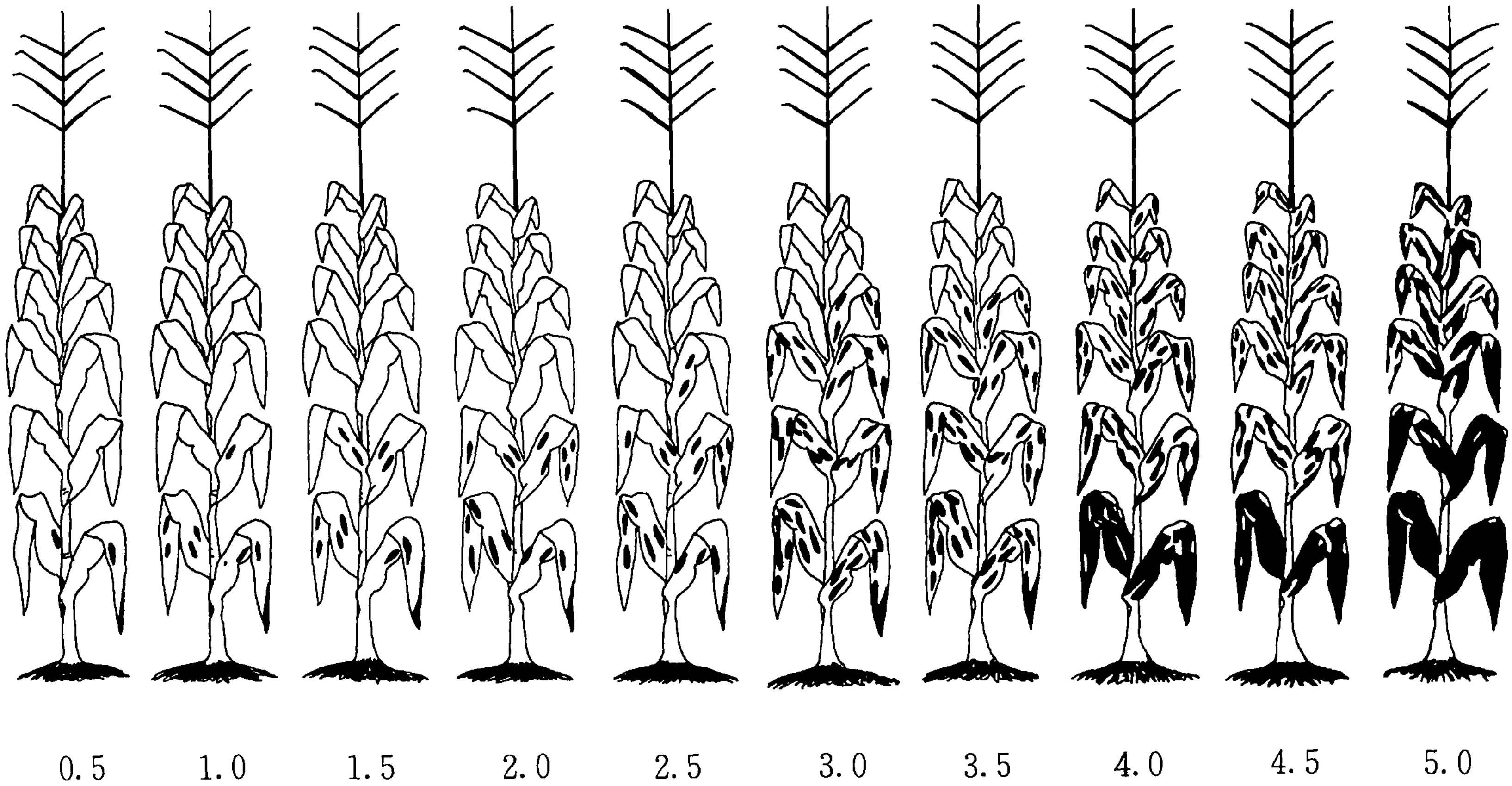
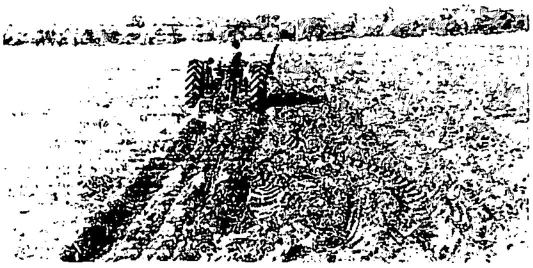


Plate 40 Moisture testing of grains with the universal moisture tester

Plate 41 Shelling of ears

Plate 43 Ploughing 43-A



43-B

Plate 44 Fertilizer application

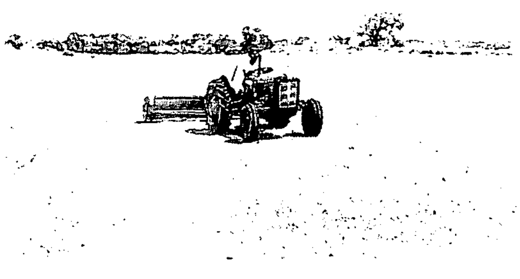
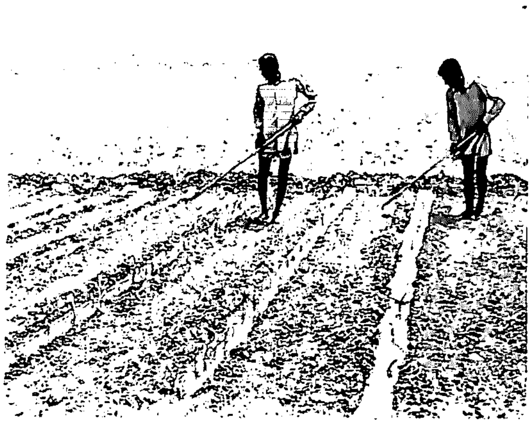


Plate 45 Irrigation

45-A



45-B

45-C

Plate 46 Inter cultivation

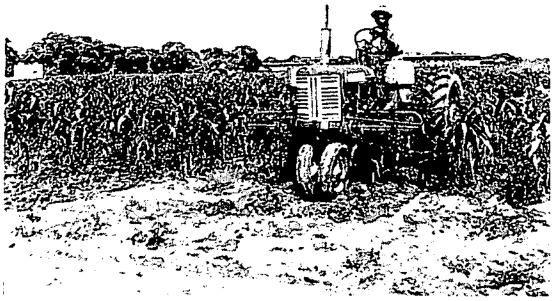


Plate 47 Dusting of insecticides

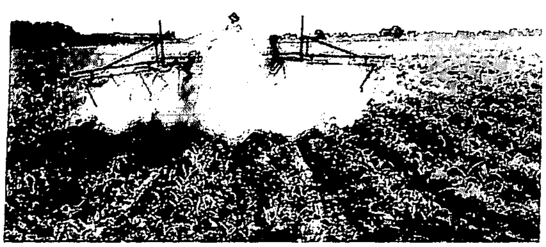


Plate 48 Pollination apron

Plate 49 Cutting of ear shoot for uniform silking

Plate 50 Putting ear shoot bag

Plate 51 Putting tassel bag

51-A

51-B

51-C

Plate 52 Collecting pollen

Plate 53 Pollination Procedures

53-A

53-B

53-C

53-D

Appendix 1 Claimatclogical data of different stations ※

I —(1) Srinagar

Latitude: 34°05'N.
Longitude: 74°50'E.
Height above M.S.L. 1586 meters

Month	Station level pressure mb.	Air temperature mean of Daily Max. °C	Daily Min. °C	Relative humidity %	Rainfall monthly total mm.	Mean wind speed km.p.h.
January	845.7	4.4	-2.3	88	72.8	3.6
February	844.2	7.9	-0.8	87	72.3	4.5
March	843.4	13.4	3.5	84	104.1	5.6
April	843.0	19.3	7.4	77	78.1	5.3
May	840.5	24.6	11.2	71	63.4	4.3
June	836.7	29.0	14.4	75	35.6	4.1
July	834.4	30.8	18.4	73	61.0	4.0
August	835.6	29.9	17.9	79	62.8	3.6
September	839.8	28.3	12.7	77	31.8	3.7
October	644.7	22.6	5.7	82	28.7	3.3
November	846.5	15.5	-0.1	85	17.5	3.0
December	846.4	8.6	-1.8	88	35.9	3.4
Annual total or mean	841.7	19.5	7.2	81	564.0	4.0
Number of years	30	30	30	30	30	30

I —(2) Almora

Latitude: 29°35'N
Longitude: 79°40'E
Height above M.S.L. 1,280 meters

Based on observation from 1964 to 1968

Month	Air temperature mean of Daily Max. °C	Daily Min. °C	Rainfall monthly total mm.
January	20.8	0.3	34.6
February	23.7	2.1	50.7
March	27.6	3.3	49.3
April	32.9	7.2	30.6
May	37.0	10.0	23.8
June	37.8	13.6	116.9
July	32.4	15.3	340.7
August	31.8	15.3	251.8
September	31.8	12.1	105.4

---contd

* Compiled from the data of Climatological Tables of Observatories in India (1931-1960)

Appendix I-(2) (Cont'd)

Month	Air temperature mean of Daily Max. °C	Air temperature mean of Daily Min °C	Rainfall monthly total mm.
October	30.3	7.9	11.6
November	25.3	3.5	4.0
December	21.8	1.7	21.0
Annual total or mean	29.5	7.7	1,040.4
Number of years	5	5	5

I —(3) Simla for Solan

Latitude: 30°06'N.
Longitude: 77°10'E.
Height above S.M.L. 2202 meters

Month	Station level pressure mb.	Air temperature mean of Daily Max. °C	Air temperature mean of Daily Min. °C	Relative humidity %	Rainfall monthly total mm.	Mean wind speed km.p.h.
January	781.7	8.5	1.9	48	65.2	3.9
February	780.8	10.3	3.1	45	47.6	4.3
March	781.5	14.4	6.8	37	58.1	4.7
April	781.8	19.2	11.2	32	37.6	4.5
May	780.5	23.4	15.0	34	53.7	4.4
June	778.0	24.3	16.2	53	147.5	3.7
July	776.8	21.0	15.6	86	414.5	2.8
August	778.3	20.1	15.2	89	385.4	2.4
September	780.8	20.0	13.8	75	195.2	2.7
October	784.3	17.9	10.8	47	45.4	3.1
November	783.9	15.0	7.5	31	6.7	3.1
December	782.9	11.3	4.2	36	23.7	3.5
Annual total or mean	780.9	17.1	10.1	51	1480.6	3.6
Number of years	30	30	30	30	30	30

I —(4) Gangtok*

Latitude: 27°15'N
Longitude: 88°40'E
Height above M.S.L. 1370 meters

Month	Air temperature mean of Dailey Max. °C	Air temperature mean of Daily Min. °C	Rain fall Monthly total mm.
January	14.07	0.11	25.4
February	15.06	1.61	64.5
March	19.06	5.39	130.0
April	21.33	8.39	290.3
May	22.44	10.28	494.0
June	23.28	10.72	526.3
July	23.57	13.33	632.5
August	23.97	13.11	576.3
September	23.28	12.60	490.2
October	21.56	9.11	135.6
November	18.17	4.89	46.5
December	15.72	1.17	22.6
Annual total or Mean	20.12	7.70	3,434.2

* According to information given by Sikkim Maize Breeding Center

I —(5) Kalimpong

Latitude: 27°04'N.
Longitude: 88°28'E.
Height above M.S.L.1209 metres

Month	Station level Pressure mb.	Air temperature mean of Daily Max. °C	Air temperature mean of Daily Min. °C	Relative humidity %	Rain fall monthly total mm.	Mean wind speed km.p.h.
January	881.4	15.5	7.8	78	13.6	8.6
February	880.3	16.7	9.1	77	18.7	8.8
March	879.5	20.6	12.2	70	34.3	9.5
April	878.6	23.1	15.0	72	71.3	10.2
May	876.7	24.1	17.3	82	146.0	9.0
June	874.0	24.4	18.9	88	405.3	7.8
July	873.6	24.1	19.2	87	635.0	7.4
August	874.6	24.3	19.3	87	488.7	7.5
September	876.8	24.1	18.8	89	343.7	7.5
October	880.0	23.3	16.1	82	87.6	8.4
November	881.5	20.0	11.6	78	13.2	8.7
December	881.9	17.3	8.8	76	4.9	8.7

---Contd.

Appendix I-(5) (Cont'd)

Annual total or mean	878.3	21.5	14.5	81	2262.3	8.5
Number of years	30	30	30	30	30	30

I—(6) New Delhi (Safdarganj)

Latitude: 29°35'N.
Longitude: 77°12'E.
Height above S.M.L. 216 meters

Month	Station level pressure mb.	Air temperature mean of Daily Max. °C		Relative humidity %	Rainfall monthly total mm.	Mean wind speed km.p.h.
		Daily Max. °C	Daily Min. °C			
January	992.2	21.3	7.3	72	24.9	8.4
February	989.7	23.6	10.1	59	21.8	10.1
March	986.9	30.2	15.1	47	16.5	10.8
April	983.2	36.2	21.0	32	6.8	10.9
May	978.3	40.5	26.6	31	7.9	12.9
June	974.5	39.9	28.7	48	65.0	14.6
July	974.3	35.3	27.2	73	211.1	10.5
August	976.3	33.7	26.1	77	172.9	9.1
September	980.3	34.1	24.6	70	149.7	9.6
October	986.6	33.1	18.7	54	31.2	6.3
November	990.5	28.7	11.8	46	1.2	6.7
December	992.3	25.4	8.0	63	5.2	7.6
Annuel total or mean	983.8	31.7	18.8	56	714.2	9.8
Number of years	30	23	23	23	23	23

I—(7) Ludiana

Latitude: 30°56'N.
Longitude: 75°52'E.
Height above M.S.L. 247 metres

Month	Station level pressure mb.	Air temperature mean of		Relative humidity %	Rainfall monthly total mm.	Mean wind speed km.p.h.
		Daily Max. °C	Daily Min. °C			
January	988.6	20.2	5.8	83	34.6	2.6
February	986.2	23.3	8.4	78	33.7	3.2
March	983.5	29.0	12.9	67	29.1	3.9
April	980.1	36.5	18.5	47	11.0	4.0

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Appendix I-(7) (Cont'd)

Month	Station level pressure mb	Air temperature mean of Daily Max. °C	Daily Min. °C	Relative humidity	Rainfall monthly total mm.	Mean wind speed km.p.h.
May	975.0	41.2	24.2	37	9.5	4.8
June	971.3	41.1	27.1	49	54.4	4.9
July	971.2	36.0	26.7	74	187.5	4.2
August	973.2	34.7	26.1	79	175.0	3.4
September	977.4	35.3	23.9	74	118.5	2.9
October	983.3	33.9	17.5	64	33.9	2.2
November	987.3	28.8	10.1	64	3.0	2.0
December	988.8	22.9	6.2	79	14.3	1.9
Annual Total or Mean	980.5	31.9	17.3	66	704.5	3.3
Number of years	30	30	30	30	30	30

I —(8) Ajmer

Latitude: 26°27'N.
Longitude: 74°37'E.
Height above M.S.L. 486 meters

Month	Station level pressure mb.	Air temperature mean of Daily Max. °C	Daily Min °C	Relative humidity %	Rainfall montly total mm.	Mean wind speed km.p.h.
January	961.6	22.2	7.3	65	11.7	3.4
February	959.6	25.3	9.9	53	6.1	4.4
March	957.7	30.7	15.7	40	5.9	6.3
April	954.9	35.9	21.9	31	3.0	8.4
May	951.3	39.5	27.3	39	9.3	13.1
June	947.1	38.1	27.7	56	66.5	14.6
July	946.0	33.2	25.6	75	187.4	11.6
August	947.9	30.9	24.3	80	174.6	9.5
September	951.9	32.1	23.7	70	71.0	8.4
October	957.5	32.9	17.8	52	16.5	4.0
November	960.9	28.9	10.9	54	3.7	2.5
December	962.0	24.4	7.7	62	1.7	2.5
Annual total or mean	954.9	31.2	18.3	56	557.4	7.4
Number of years	30	30	30	30	30	30

I —(9) Pantnagar

Latitude: 27°25'N
Longitude: E
Height above M.S.L. 260 meters

Month	Air temperature mean of Daily Max. °C	Daily Min. °C	Relative humidity %	Rainfall monthly total mm.
April	—	16.1	40	14.0
May	40.2	19.3	30	6.1
June	38.8	24.2	52	181.5
July	32.8	25.1	90	427.9
August	32.2	24.5	83	460.4
September	32.4	23.3	79	226.1
October	31.8	15.7	62	17.6
November	26.8	10.0	63	2.8

I —(10) Patna for Dholi

Latitude: 25°37'N.
Longitude: 85°10'E.
Height above M.S.L. 53 metres

Month	Station level pressure mb.	Air temperature mean of Daily Max. °C	Daily Min. °C	Relative humidity %	Rainfall monthly total mm.	Mean wind speed km.p.h.
January	1011.5	23.6	11.0	71	21.1	5.1
February	1008.7	26.3	13.4	62	20.2	6.3
March	1005.3	32.9	18.6	45	6.7	7.6
April	1001.8	37.6	23.3	41	8.2	8.8
May	997.4	38.9	26.0	56	28.3	9.8
June	993.6	36.7	27.1	71	139.0	9.0
July	993.6	32.9	26.7	81	265.8	8.6
August	995.4	32.1	26.6	83	307.1	7.5
September	999.2	32.3	26.3	80	242.5	6.7
October	1005.4	31.9	23.0	70	62.8	4.7
November	1009.5	28.9	16.1	62	5.7	3.6
December	1011.6	24.9	11.7	67	2.4	4.1

---Contd.

Appendix I-(10) (Cont'd.)

Month	Station level pressure mb.	Air temperature mean of		Relative humidity %	Rainfall monthly total mm.	Mean wind speed km.p.h.
		Daily Max. °C	Daily Min. °C			
Annual total or mean	1002.7	31.6	20.8	66	1109.8	6.8
Number of years	30	30	30	30	30	30

I —(11) Hyderabad (Begampet)

Latitude: 17°27'N.
Longitude: 78°28'E.
Height above S.L. 545 metres

Month	Station level pressure mb.	Air temperature mean of		Relative humidity %	Rainfall monthly total mm.	Mean wind speed km.p.h.
		Daily Max. °C	Daily Min. °C			
Janurary	954.3	28.6	14.6	78	1.7	8.1
February	952.7	31.2	16.7	64	11.4	8.9
March	951.3	34.8	20.0	54	13.4	9.6
April	949.3	36.9	23.7	51	24.1	10.9
May	946.1	38.7	26.2	50	30.0	12.4
June	944.3	34.1	24.1	71	107.4	23.8
July	944.0	29.8	22.3	83	165.0	22.1
August	945.2	29.5	22.1	82	146.9	18.3
September	947.0	29.7	21.6	82	163.3	12.6
October	950.3	30.3	19.8	73	70.8	8.9
November	953.0	28.7	16.0	68	24.9	8.0
December	954.5	27.8	13.4	71	5.5	7.4
Annual total or mean	949.3	31.7	20.0	69	764.4	12.6
Number of years	30	30	30	30	30	30

I —(12) Dohad for Godhra

Latitude: 22°50'N.
Longitude: 74°16'E.
Height above M.S.L. 333 metres

Month	Station level pressure mb.	Air temperature mean of Daily Max. °C	Daily Min. °C	Relative humidity %	Rainfall monthly total mm.	Mean wind speed km.p.h.
January	978.1	26.9	12.1	57	3.0	8.9
February	976.9	30.3	14.5	48	1.7	10.0
March	974.9	34.9	19.3	37	1.6	13.3
April	972.6	38.4	24.0	38	1.5	17.2
May	969.5	39.4	26.0	58	0.3	26.1
June	966.2	35.9	25.6	75	92.1	29.6
July	965.0	30.4	24.0	87	255.3	29.1
August	966.2	29.0	23.0	89	205.6	22.4
September	970.0	30.3	22.6	85	175.6	16.8
October	974.6	33.3	20.0	70	31.1	8.7
November	977.6	31.5	15.3	58	11.1	6.7
December	978.8	29.1	12.7	57	1.3	6.0
Annual total or mean	972.5	32.5	19.9	63	788.2	16.3
Number of years	30	24	24	24	30	21

I —(13) Chhindwara

Latitude: 22°06'N.
Longitude: 79°00'E.
Height above M.S.L. 685 Meters

Month	Station level pressure mb.	Air temperature mean of Daily Max. °C	Daily Min. °C	Relative humidity %	Rainfall monthly total mm.	Mean wind speed km.p.h.
January	939.2	25.5	10.6	67	23.2	4.4
February	937.4	29.0	12.8	52	1.7	5.1
March	936.1	32.9	17.0	39	12.9	5.6
April	934.1	36.4	21.9	34	12.5	6.5
May	930.0	39.4	26.1	33	13.3	7.6
June	927.1	35.2	24.9	64	146.4	9.5
July	926.3	28.4	22.4	87	319.4	8.1
August	927.2	27.7	21.9	87	283.3	8.0
September	930.3	29.0	21.3	82	188.3	6.4
October	935.2	29.3	17.7	71	69.3	4.2
November	938.8	27.7	11.8	58	21.5	3.9
December	939.7	26.8	9.8	65	2.5	3.3
Annual total or mean	933.5	30.6	18.2	62	1094.1	6.1
Number of years	10	10	10	10	10	10

I —(14) Bangalore for Arbhavi

Latitude: 12°58' N.
Longitude: 77°35'
Height above M.S.L. 921 metres

Month	Station level pressure mb.	Air temperature mean of Daily Max. °C	Air temperature mean of Daily Min. °C	Relative humidity %	Rainfall monthly total mm	Mean wind speed km.p.h.
January	913.1	26.9	15.0	77	3.3	10.4
February	912.3	29.7	16.5	67	10.2	9.7
March	911.4	32.3	19.0	63	6.1	9.4
April	910.3	33.4	21.2	70	45.7	9.0
May	908.2	32.7	21.1	75	116.5	11.5
June	907.1	28.9	19.7	82	80.1	17.1
July	907.2	27.2	19.2	86	116.6	17.5
August	907.7	27.3	19.2	86	147.1	15.2
September	908.9	27.6	18.9	85	142.7	12.1
October	910.3	27.5	18.9	83	184.9	8.2
November	911.6	26.3	17.2	78	54.3	8.5
December	912.8	25.7	15.3	78	16.2	9.6
Annual total or mean	910.1	28.8	18.4	77	923.7	11.5
Number of years	30	30	30	30	30	30

APPENDIX II

Area under maize in different states* (thousand hectares)

State	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60
Andhra Pradesh	175.6	187.8	187.8	189.4	189.4	205.6	190.6	184.1
Assam	15.0	14.6	15.4	15.4	15.4	16.6	15.0	13.8
Bihar	450.0	269.0	377.0	254.0	401.0	370.0	468.0	916.0
Bombay	210.4	223.8	204.0	225.4	178.8	-	-	-
Delhi	0.8	1.2	1.6	1.2	1.6	1.6	1.2	1.2
Haryana	-	-	-	-	-	-	-	-
Himachal Pradesh	112.1	109.7	112.1	112.5	113.7	115.4	114.5	117.0
Gujarat	-	-	-	-	-	196.7	201.5	187.8
Jammu and Kashmir	149.7	160.3	95.5	184.9	208.4	140.4	210.4	207.2
Kerala	0.4	0.4	0.4	(a)				
Madhya Pradesh	447.2	425.3	412.8	421.3	424.1	451.6	464.6	462.1
Madras	6.1	12.5	8.1	4.9	5.3	5.7	6.5	6.1
Maharashtra	-	-	-	-	-	27.5	28.3	26.3
Manipur	-	-	-	-	-	-	-	-
Mysore	10.5	10.9	10.9	13.4	13.4	10.5	10.5	10.5
Orissa	9.0	9.0	10.0	10.0	9.0	9.0	9.0	9.0
Punjab	396.6	395.4	387.7	406.3	408.3	463.0	501.8	539.4
Rajasthan	422.9	528.9	539.0	540.2	497.8	586.4	580.3	604.3
Uttar Pradesh	860.3	1025.9	1049.7	959.5	1017.0	1083.3	1093.4	1091.8
West Bengal	63.9	62.7	63.1	66.8	51.4	53.8	54.2	56.3
Total India	3604.9	3869.1	3749.3	3695.5	3740.9	4078.8	4265.3	4332.5

*Compiled from the data of Area, Production and Yield of Principal Crops in India 1949-50 to 1967-68. Ssmmary Table

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APPENDIX II (Cont'd)

State	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68
Andhra Pradesh	176.8	195.5	180.1	202.0	206.7	215.6	227.0	252.8
Assam	14.2	15.0	17.0	20.4	21.8	23.6	23.7	24.4
Bihar	770.0	825.0	859.0	821.5	744.6	743.4	857.9	989.1
Bombay	-	-	-	-	-	-	-	-
Delhi	1.2	1.2	1.2	1.0	0.6	0.9	1.5	1.6
Haryana	-	-	-	-	-	85/0	87.0	117.3
Himachal Pradesh	114.5	116.5	117.0	121.9	119.8	220.5	230.6	255.8
Gujarat	191.0	217.7	223.4	240.1	236.4	230.1	225.2	239.7
Jammu and Kashmir	216.1	231.5	250.1	240.1	250.1	249.0	240.5	251.0
Kerala				-	-	-	-	-
Madhya Pradesh	454.9	476.7	477.1	489.9	494.8	525.7	559.3	589.2
Madras	6.1	5.7	5.7	5.9	3.2	2.9	3.0	2.9
Maharashtra	26.3	27.1	25.5	27.8	29.0	29.5	38.1	38.9
Manipur	-	-	-	-	-	5.1	7.6	5.1
Mysore	10.9	10.9	11.3	14.3	13.9	12.9	15.2	15.4
Orissa	9.0	13.0	13.0	20.4	21.7	47.0	52.9	55.2
Punjab	562.9	524.5	582.3	585.4	591.0	412.0	444.0	469.2
Rajasthan	647.1	679.6	694.0	669.7	709.4	740.6	740.4	745.5
Uttar Pradesh	1048.9	1085.5	1078.1	1086.4	1120.5	1170.0	1261.8	1472.1
West Bengal	56.3	52.6	55.0	54.5	54.4	50.3	49.1	51.5
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Total	4353.5	4493.2	4579.4	4584.2	4618.0	4764.7	5073.8	5576.9

APPENDIX III

MAIZE PRODUCTION IN DIFFERENT STATES* (thousand tons)

State	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60
Andhra Pradesh	198.0	134.0	128.0	112.0	113.0	118.0	118.0	108.0
Assam	8.0	9.0	7.0	7.0	7.0	8.0	7.0	6.0
Bihar	450.0	269.0	377.0	254.0	401.0	370.0	468.0	916.0
Bombay	81.0	263.0	180.0	187.0	84.0	-	-	-
Delhi	1.0	1.0	1.0	(b)	1.0	1.0	(b)	1.0
Haryana	-	-	-	-	-	-	-	-
Himachal Pradesh	65.0	64.0	66.0	74.0	74.0	70.0	139.0	107.0
Gujarat	-	-	-	-	-	197.0	265.0	82.0
Jammu and Kashmir	121.0	157.0	69.0	135.0	151.0	103.0	190.0	173.0
Kerala	(b)	(b)	(b)					
Madhya Pradesh	198.0	216.0	221.0	194.0	189.0	186.0	461.0	304.0
Madras	6.0	13.0	9.0	5.0	6.0	6.0	7.0	7.0
Maharashtra	-	-	-	-	-	15 .0	14.0	13.0
Manipur	-	-	-	-	-	-	-	-
Mysore	4.0	7.0	5.0	6.0	6.0	8.0	9.0	9.0
Orissa	9.0	9.0	10.0	10.0	9.0	9.0	9.0	9.0
Punjab	587.0	523.0	440.0	395.0	651.0	625.0	501.0	699.0
Rajasthan	247.0	648.0	573.0	524.0	313.0	556.0	553.0	513.0
Uttar Pradesh	805.0	665.0	801.0	616.0	479.0	785.0	611.0	1013.0
West Bengal	45.0	42.0	41.0	45.0	38.0	39.0	36.0	46.0
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Total	2825.0	2991.0	2928.0	2561.0	3029.0	3100.0	3408.0	4006.0

* Compiled from the data of Area, Production and Yield of Principal Crops in India. 1959-50 to 1967-68. Sammary Table.

APPENDIX III (Cont'd)

State	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68
Andhra Pradesh	143.0	174.0	138.0	162.0	252.6	182.9	172.8	307.0
Assam	6.0	7.0	8.0	9.5	10.9	12.3	12.7	13.1
Bihar	770.0	825.0	858.0	893.0	584.4	757.2	948.7	1129.8
Bombay	-	-	-	-	-	-	-	-
Delhi	1.0	(b)	(b)	0.3	0.1	0.5	0.8	0.6
Haryana	-	-	-	-	-	102.0	86.0	127.7
Himachal Pradesh	116.0	155.0	154.0	172.1	192.4	293.4	364.1	436.5
Gujarat	230.0	295.0	267.0	239.3	301.9	210.0	145.2	280.5
Jammu and Kashmir	199.0	215.0	241.0	189.9	214.5	159.2	221.8	190.8
Kerala								
Madhya Pradesh	506.0	429.0	440.0	603.2	556.8	479.2	454.2	457.9
Madras	7.0	6.0	6.0	6.5	3.5	3.2	3.2	3.1
Maharashtra	13.0	14.0	13.0	19.9	21.8	22.0	47.0	52.7
Manipur	-	-		-	-	11.3	33.8	5.0
Mysore	9.0	11.0	11.0	10.7	11.6	7.7	10.5	9.0
Orissa	9.0	13.0	13.0	12.2	17.7	32.9	49.4	50.4
Punjab	617.0	652.0	523.0	810.8	788.0	681.0	614.0	773.3
Rajasthan	635.0	629.0	750.0	609.4	779.9	641.7	613.7	1024.7
Uttar Pradesh	619.0	683.0	915.4	777.9	888.2	1121.0	1076.1	1167.2
West Bengal	35.0	29.0	35.0	35.7	38.8	42.5	39.6	45.8
Total	4006.0	3915.0	4202.0	4449.0	4658.1	4760.0	4893.6	6275.1

APPENDIX IV

Yield per hectare(kg/ha) in different states*

State	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60
Andhra Pradesh	1146	725	693	601	621	583	842	596
Assam	534	628	463	463	463	490	475	443
Bihar	652	399	602	488	695	540	618	1160
Bombay	391	1072	897	455	-	-	-	-
Delhi	1255	899	628	628	628	628	398	837
Haryana	-	-	-	-	-	-	-	-
Himachal Pradesh	590	593	599	641	661	617	1233	929
Gujarat	-	-	-	-	-	1017	1375	444
Jammu and Kashmir	822	995	734	739	735	741	917	849
Kerala	-	-	-	-	-	-	-	-
Madhya Pradesh	450	516	545	467	446	418	1009	668
Madras	1004	1053	1130	1046	1159	1076	1099	1171
Maharashtra	-	-	-	-	-	554	502	502
Manipur	-	-	-	-	-	-	-	-
Mysore	390	651	465	456	456	772	869	869
Orissa	370	370	405	418	399	390	418	411
Punjab	1504	1344	1153	988	1620	1381	1014	1317
Rajasthan	583	1245	1081	985	639	964	934	863
Uttar Pradesh	951	657	776	652	979	734	569	943
West Bengal	715	680	660	685	751	735	675	831
India	796	786	794	704	821	772	812	936

*Compiled from the data of Area, Production and Yield of Principal Crops in India. 1949-50 to 1967-68, Summary Table.

APPENDIX IV (Cont'd)

State	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68
Andhra Pradesh	822	890	766	806	1222	848	761	1214
Assam	430	467	471	466	500	521	536	537
Bihar	973	1007	1038	1087	785	1019	1106	1142
Bombay	-	-	-	-	-	-	-	-
Delhi	837	?	?	300	667	556	533	375
Haryana	-	-	-	-	-	1200	989	1089
Himachal Pradesh	1029	1331	1316	1412	1606	1331	1520	1706
Gujarat	1224	1335	1196	997	1277	913	645	1170
Jammu and Kashmir	936	928	964	791	858	639	922	760
Kerala				-	-	-	-	-
Madhya Pradesh	1130	900	922	1231	1115	912	812	1117
Madras	1171	1053	1053	1017	1094	1103	1067	1069
Maharashtra	502	517	510	716	752	746	1234	1355
Manipur	-	-	-	-	-	2216	4447	902
Mysore	837	1009	973	748	835	597	691	584
Orissa	411	382	382	598	816	691	934	913
Punjab	1114	1243	898	1385	1333	1653	1383	1648
Rajasthan	998	926	1081	910	1099	867	829	1375
Uttar Pradesh	560	629	915	716	793	958	853	793
West Bengal	632	551	636	655	713	845	807	889
India	914	935	972	989	1009	999	964	1125

APPENDIX V* List of outstanding inbred lines

Pedigree	Parental Source	Zones in which the lines performed well			
		1	2	3	4
A-1-2-#-#-1-#	India	*			
AS5-A2a-1-2-#-#-1-1-1-#	"			*	
AS5-A20-1-2-#-#-1-1-1-2	"			*	
Basi E-90	"		*		
Basi E-102	"		*		
Basi E-103	"		*		
BPL3-A1-2-#-#-1-#-#	"			*	
BPL3-A1-2-#-#-#-#-1	"			*	
BPL3-A1-2-#-#-#-#-2	"			*	
BPL3-A1-2-#-#-#-#-3	"			*	
DK-A1-1-#-#-4-#	"		*		
DK-A1-1-#-#-1-#	"		*		
D-A1-#-#-1-#-#-#	"			*	
D-A1-5-f	"		*	*	*
GdGk1-A1-1-3-1-#-#-#-⊗bulk	"	*	*		
GdGK1-A1-1-4-1-#-#-#	"	*			
GdGk1-A1-1-3-1-f-#	"	*		*	*
G2-3	"		*	*	
G7(B)-#	"		*	*	*
Jalna(y)-4-2-#	"		*	*	
Jalna(y)-4-3	"		*		
KT41-A14-#-2-#	"			*	
KT41-A15-#-#-#-#	"	*	*	*	
KT41-A25-#-#	"		*	*	
KT41-A64-2-#-#	"		*	*	
KT41-A137-#	"		*		
KT41-A256-1	"		*		
Knr-1-B35-1-1-2-#-2	"				*
Knr-1-B35-1-1-2-2	"				*
Knr-1-B35-1-1-2-2-1	"				*
Knr-1-B35-1-1-2-#-1-#	"				*
LYEK(574)-4-1-1-#	"	*			
Mid(R)-2(b)-#	"		*	*	*
PB5A-1-2wh	"	*	*		
PB4 Bulk-3-#	"		*	*	*
PH3-A6-#-#-#-#	"		*		
PH3-A6-#-1-#	"		*	*	
P2P2-A1-1-#-#-5	"		*	*	
P5P2-A7-5-#-#-#-#	"			*	
P5PB5-3-f	"		*	*	*
P4A(y)-1-3y-#	"		*	*	*
P4-A2-1(TC)-5-1-1-1-#-#-#	"		*		
P4'-1(A)-3y	"		*	*	*
P4'-1(B)-2	"	*	*		
P4'-1(B)-4-#-#	"		*	*	
P4'-2-1-(y)	"		*		
P4'-5y-3y	"		*		

* According to the Progress Report of the Coordinated Maize Breeding Scheme, 1962, ICAR, India.

APPENDIX V (Cont'd)

Pedigree	Parental source	Zones in which the lines performed well 1	2	3	4
Pia-Al-#-#-#-2	India			*	
P6-Al-1-#-#-#-1-#	"			*	
Pia-Al-#-#	"			*	
S1-JLW-86-⊗bulk	"			*	
S2 5011-1-1	"			*	
S2 5011-1-7-#	"			*	
S3 KT41-216-#	"			*	
S3 MY-188-#	"			*	
S4 4503-1-⊗bulk	"			*	
S5 4925-2-⊗bulk	"			*	
Tin-Al-2-1-1-#-#-2	"		*	*	
Tin-Al-2-1-1-f-#	"	*	*	*	
WRK(II)-1-2-1-1-1-5-1-1-1-#	"	*			
WRK(II)-1-2-1-1-1-5-1-1-1-1	"	*			
YRK(40)-88-1-1-#	"	*			
YRK(40)-72-1-1-#	"	*			
A Theo-1A-1-f-#-#-#	Colombia	*	*		
A Theo-21(B)-#-2-f	"		*	*	*
A Theo-21(B)-f-#-3-f-#-#	"		*	*	*
A Theo-29C-f-f-#-#	"		*	*	
A Theo-198C-1-f-#	"		*		
A Theo-29C-f-f-#-#-#	"	*	*	*	
A Theo-1126C-f-f-#-#	"	*	*	*	*
B1 Theo-A186-1-f-#	"	*	*		
B1 Theo-17B-#-2-1-f-#-#	"	*			
Col 1-325B-1-#-1-f-#-#-#-#	"		*	*	*
(Col 1x38-11)(lot no. etc)(3a7mez)-f-f-#	"		*	*	*
Desc 2-#-29-#-#a-#-#b-f-f	"			*	
Desc 1-#-88-1-f-f-#-#	"		*	*	
Desc 2-229-1-1-f-f-#-#-#-#	"		*	*	*
Eto-#-B2-3-#	"				*
Eto-1-1-2109-f-#-#	"		*	*	
Eto-3-1-f-#-#	"	*		*	
Eto-3-1-f-#-#-#-#-2	"				*
Eto-13-#-#-#-#-2-f-f	"		*	*	
Eto-20A-f-f-#-#-#-#-1	"			*	
Eto-25-f-#-1-f-#	"		*		
Eto-25A-#-1-f-⊗bulk-#-#-#	"		*		*
Eto-25A-#-1-f-f-#-#	"		*		
Eto-25A-f-#-1-f-#-3-#-#-#	"				*
Eto-25A-f-#-1-f-#-3-#-#-2	"				*
Eto-28A-1-f-f-#-#-#-#	"		*		
Eto-70B-2-f-f-#-#-#-#	"		*		
Eto-81-f-f-#-#	"		*	*	*
Eto-81-#-#-#-2-#-1-#-2-f	"		*	*	*
Eto-81B-#-1-f-f-#-#	"		*	*	
Eto-182-1-f-f	"		*	*	*
Eto-182-1-2-f-f-#-#	"	*			
Eto-182-1-2-f-f-#-#-3	"			*	
Eto-185C-1-#-6-f-f	"			*	*
Eto-246-f-f-#	"		*	*	*
Eto-249B-#-#-#-#b-#-#-#-#	"			*	*

APPENDIX V (Cont'd)

Pedigree	Parental Source	Zones in which the lines performed well			
		1	2	3	4
AdeC-A122-#-#-#-#	Caribbean		*		
AdeC-A151-#	"		*	*	
AdeC-A151-1-1	"		*		
AdeC-A187-#-#-#	"	*			
AdeC-A257-#-#	"		*		
AdeC-295-#-3	"		*		
AdeC-A397-#-#-#-2-#-3	"		*		
AdeC-A397-1-#-#-#	"		*		
AdeC-A397-1-2-#	"		*	*	
AdeC-A406-#-2	"			*	
AdeC-A405-2-1	"		*		
AdeC-A406-2-2	"	*	*		
AdeC-A406-2-#	"		*		
AdeC-A408-2-#	"	*	*	*	*
AdeC-A408-#-#	"	*	*		
AdeC-A408-2-#a	"	*	*	*	
AdeC-A408-4-1	"		*	*	
AdeC17-A1-2-#-#-1-#	"	*	*	*	*
Cuba 1-#-#-4-1-f-#-#-#-#	"	*			
Cuba 2-#-2-#-2-f-#-#-1-#-#	"	*	*	*	*
Cuba 2-1-#-#-1-f-#-#-#-#	"		*		
Cuba 2-24-#-#-#-#-1-f-#	"	*		*	
Cuba 24-#-#-#-#-1-#-#-#-#-1-f	"	*	*	*	
Cuba 43-#-#-1-3-#-2-f-#-#-#	"			*	
Cuba 312-A20(b)-f-#-#-	"		*		
Cuba 312-A23-f-#-#	"		*		
Cuba 312-A306-f-#	"	*	*		
Cuba 312-A219-f	"		*		
Cuba 312-C2	"	*			
Cuba 342-2-2-f-#-#	"			*	
Cuba 342-#-281-#-#-#	"		*		
Cuba 342-#-A262-#-#-#	"	*	*		
Cuba 342-2-2-f-#-#-#	"	*	*	*	
Cuba 362-26-f	"	*			
Peru 330-A4-#-#-#	Peru		*	*	
Peru 330-#-#-327B-f-#	"		*	*	*
Peru 330-#-#-329C-1-f-#	"		*	*	*
Peru 330-A8-#-#-3-#	"	*			
Peru 330-A8-#-#-4-#	"	*			
Peru 330-A4-#-#-#-#	"	*			
Peru 330-A38-3-#	"	*	*		
Baj VS5-#	Mexico				*
Bar-2-#-#-#	"	*			
B4	"		*		
Bol Am-B4-1-#-#	"				*
Bol Am-B4-1-#-4-3	"				*
Bol Am-B4-1-#-4-#	"				*
1452-25(S)-#-1-1-f-#-#	"	*	*	*	
MexJ-#-B1-#	"				*
Venz 1-1-2-3-f-#-#-#	Venezuela		*	*	*
Venz 1-B6-#-#	"				*
Venz 1-B6-#-2-1-1	"				*
Venz 1-B6-2-1-1	"				*

APPENDIX V (Cont'd)

Pedigree	Parental Source	Zones in which the lines performed well 1	2	3	4
Eto-2103-#-#-#-#-1-#	Colombia			*	
Eto-B1-202-f-#	"		*	*	
Eto-B1-216-#-#-#(1)	"		*	*	
Eto-B1-245-f-#-#	"		*	*	
Eto-B1-282-f-#	"		*	*	
Eto-B1-2003-f-#-2	"			*	
Eto-B1-2053-f-#-#	"		*	*	
Eto-B1-2109-f	"		*	*	
Eto-B1-2109-f-#-2	"			*	
Eto-B1-2148-f-#	"		*	*	
Eto B1-2173-#-#-#-#	"		*	*	*
Eto B1-PL-#-#-#-#-⊗bulk-#	"		*	*	
Eto PL-9-1-#-5-#	"		*		
Eto PL-13-1-#-#-1-#	"		*	*	
Mayb-395-1-f-#-#-#-2	"			*	
Mayb-395-1-f-#-#-#-#	"			*	
MatSLP-1-5-2-f-1	"			*	
MatSLP-1-5-2-f-#	"		*		
Nar 330-#-23B-1-f-f-#-#	"		*	*	*
Nar 330-#-23B-1-f-#-#-#-#	"			*	*
Nar 330-#-23B-1-#-#-#-#-⊗bulk-#-#-1	"			*	
Nar 330-#-23B-1-#-#-#-#-⊗bulk-#-3-2	"			*	
Nar 330-#-23B-1-#-#-#-#-⊗bulk-#-#-#	"		*	*	*
Nar 330-#-23B-#-#-#-#-⊗bulk-#-#-#	"			*	
Nar 330-72B-2-f-#-#-#-#	"		*	*	*
Nar 330-#-87C-3-f-#-#-#-#	"		*		*
Nar 330-#-#a-3114A-f-#	"			*	
Nar 330-#-#a-3218B-#a-#-#-#-#	"		*	*	
Precoz 115-4-f-f-#-#-#	"		*		
(PTR-1-605-3)-1-2-#-1-f-f-#-#-#	"	*	*	*	*
(RVI(L1xVenz 1-1-2-3)-204-f-#	"		*	*	
(303 Tex x L1)-2-f-f-#-#-#	" -USA		*	*	
A26-4-#-1	Caribbean				*
AdeC-A1-#	"	*			
AdeC-A1-2-#-#-#	"	*			
AdeC-A1-2-#-#-#	"	*			
AdeC-A1-2-#-4-#	"	*	*		
AdeC-A7-#-#	"	*			
AdeC-A19-#	"		*		
AdeC-A19-#-1	"	*			
AdeC-A20-1	"	*	*	*	
AdeC-A20-1-2	"		*		
AdeC-A20-#	"	*	*	*	
AdeC-A26-#-3	"		*		
AdeC-A26-#-#	"	*	*		
AdeC-A29-#-#	"		*	*	
AdeC-A33-4	"		*	*	*
AdeC-A33-4-#	"		*		
AdeC-A33-#-2	"		*		
AdeC-A33-#-#	"	*	*	*	
AdeC-A58-1-#	"		*		
AdeC-A58-1-2	"		*	*	

APPENDIX V (Cont'd)

Pedigree	Parental Source	Zones in which the lines performed well 1	2	3	4
AdeC-A58-2-1	Caribbean-USA	*	*		
AdeC-A89-#	"			*	
AdeC-A116-4-#-#-#	"	*	*	*	*
Venz 1-30-1-#-1-f-#	Venezuela	*	*	*	*
Venz 1-42-f-f-#-#	"	*	*	*	
Venz 1-42-f-#-#-#-#-1	"			*	
Venz 1-42-f-#-#-#-#-2-#	"			*	
Venz 1-267-f-#-#	"		*		
Venz 1-1162A-f-#-#	"	*	*		
Venz 1-1175A-f-#-#	"	*	*		
Venz 1-1219B-#-1-f	"	*	*	*	
Venz 1-1387-f-#	"	*	*	*	*
(Venz 1xVenz400-#)-13-1-#-#	"		*	*	*
(Venz 1x1-2-3 x Col 2-76)-#-1-#-#-#-#	"			*	
(Venz 25xVenz15)-4-1-x (yt.Early Mat) etc-5-2-4-#-#	"		*		
Kenya wh-2(B)-y-#	Kenya		*	*	
Kenya yl	"	*		*	
187-2	USA	*			
CI13A	"			*	
CI21	"		*		
CI21E	"	*	*	*	*
CI27	"			*	
Coker 811-C25	"	*			
Coker 811-C30	"	*			
(Coker 811 x Jull)-B1-1-#	"				*
(Coker 811 x Jull)-B1-#-#	"				*
CYD-2-1	"		*		
CYD-2-2	"		*	*	
Dix18-A1-1-3-f	"	*	*	*	
G715-A1-#-#-#	"		*	*	
G715-A1-2-2-#	"		*	*	*
G715-A2-#	"	*			
G715-A2-2-1-1-1-#	"				*
G715-A2-2-1-1-4-#	"				*
G715-A2-#-1	"	*	*		
G715-A22-1-#-2-#	"				*
G715-A31-1-1-4-#	"				*
G715-A35-#-#-#	"			*	
G715-A35-2	"	*	*		
G715-A36-#-#-#-#	"		*	*	*
G715-A36-2-1	"	*	*		
G715-A49-#	"			*	
G715-A59-#-#	"	*			
G715-A65-#	"	*			
G715-A66-#-2	"			*	
G715-A207-1	"	*	*		
G715-A243-1-1	"			*	
G715-A259-#-#-3	"			*	
G715-A321-#-#	"		*		
G715-A407-#-1	"		*		

APPENDIX V (Cont'd)

Pedigree	Parental source	Zones in which the lines performed well 1	2	3	4
G733-A28-#	USA		*		
G733-A54-1	"	*			
G733-A95-2	"	*			
G733-A96-#-#	"	*	*	*	*
G733-A96-1	"		*		
G733-A96-2	"	*	*		
G733-A96-3	"		*		
G733-A96-#-1	"	*			
G733-A98-1	"		*		
G733-A98-#	"	*	*		
G733-A263-#	"	*			
G733-A263-#-2	"	*	*	*	
G733-A263-#-5	"	*	*		
GT112	"		*		
GT112-A6-1-#-#	"	*	*	*	*
DT112-A9-3-#	"		*	*	*
GT112-A9-4-#-#-#	"		*	*	*
H72(A)-3	"	*			
(Jar x Eto)-B2	USA-Colombia				*
(Jar x Eto)-B3	"-Colombia				*
(Jar x HM1)-B5-2	"-India				*
K150	"	*			
K201	"	*			
Kys	"	*			*
N6	"	*			
N15	"				*
N16	"		*		
Oh43	"	*		*	
OK15	"		*	*	
R76	"		*	*	
SS 111-#-B1-#-2-1	"				*
SS 111-#-B1-#-3-4	"				*
SS 111-#-B1-#-#-2	"				*
Tenn29	"		*	*	
Tx61M	"	*			
Tx203	"	*		*	
Wf9	"	*			*
Ab-6A-1-2-#-#-#	Unknown		*	*	

Note : x Selffing
Sibbing
f #-#-#-#-#

APPENDIX VI

Performance of Experimental Double Cross Hybrids in different zones**

Exptl. Hybrid No.	Zone 1 Yield	Zone 1 %of Local	Zone 2 Yield	Zone 2 % of Local	Zone 3 Yield	Zone 3 % of Local	Zone 4 Yield	Zone 4 % of Local
238	6735	150*	4175	120	3620	110	5574	150*
239	6975	156*	3511	101	3781	115	5640	151*
240	7377	165*	4000	115	4405	134	5705	153*
247	6954	155*	4397	127	4016	123	6104	164*
254	7172	160*	3763	3837	3837	117	5072	137
265	-	-	3472	100	4641	141*	4711	127
266	-	-	4850	140*	3533	108	5196	140
268	-	-	3459	100	4873	149*	4784	128
277	-	-	4932	142*	3665	112	5849	157*
2014	-	-	3526	101	4326	132	4344	117
2024	-	-	2994	86	4708	144*	4277	116
2044	-	-	3751	108	3764	115	4869	131
2064	-	-	3096	89	4237	129	3946	106
2084	-	-	3178	91	4089	125	3965	107
2264	-	-	4871	140*	2923	89	-	-
2384	-	-	5209	150*	-	-	-	-
2394	-	-	5134	148*	-	-	-	-
2015	-	-	4365	126	5309	162*	5021	135
2025	-	-	4173	120	4577	140*	5173	139
2075	-	-	4661	134	5287	151*	5419	146
2085	-	-	-	-	-	-	-	-
2115	-	-	4109	118	4707	144*	4852	131
2135	-	-	2135	128	5121	156*	-	-
2145	-	-	4877	140*	4451	136	-	-
2155	-	-	4391	127	4606	141*	-	-
2165	-	-	4746	137	4894	149*	-	-
2175	-	-	4230	122	4889	149*	-	-
2185	-	-	4626	133	5155	157*	-	-
2195	-	-	4487	129	4956	151*	-	-
2205	-	-	3846	111	4828	148*	-	-
2215	-	-	4408	127	5100	156*	-	-
2225	-	-	4700	135	4940	151*	-	-
2265	-	-	4694	135	4771	146*	-	-
2275	-	-	4460	128	4660	142*	-	-
2305	-	-	4600	132	4217	129	5052	136
2315	-	-	3934	113	4727	144*	-	-
2335	-	-	4230	122	4159	127	5427	146
2345	-	-	4544	131	4775	146*	-	-
2355	-	-	4521	130	3958	121	5461	147
2365	-	-	4368	126	4856	148*	5182	139
2385	-	-	4416	127	4476	137	4959	133
2395	-	-	4534	130	4400	134	5007	135
2425	-	-	4296	124	4627	141*	-	-
2435	-	-	4830	139*	4749	145*	-	-
2445	-	-	4055	117	4336	132	5799	156*
2455	-	-	4304	124	4802	147*	5894	158*
2465	-	-	5421	130	4668	143*	-	-
2475	-	-	4142	119	4724	144*	-	-

-- Contd.

** According to the Progress Report of the Coordinated Maize Breeding Scheme, 1965-67, ICAR, India.

APPENDIX VI (Cont'd)

Exptl. Hybrid No.	Zone 1 Yield	Zone 1 % of Local	Zone 2 Yield	Zone 2 % of Local	Zone 3 Yield	Zone 3 % of Local	Zone 4 Yield	Zone 4 % of Local
445	6918	154	4526	150*	3978	121	5333	143
446	7443	166*	4734	136*	3709	113	5702	153*
448,454	6780	151	4601	132*	3675	112	5553	149*
450	7246	162*	4070	117	3541	108	5615	151
451	6911	154	5232	122	3505	107	5638	152*
453	7538	168*	3392	98	4201	128	5436	146
458	7350	164*	3806	110	4038	123	5402	145
460	7338	164*	3924	113	4442	136	5552	149
461	6958	155	4531	130*	3715	113	5659	152*
462	7277	162*	4427	127	3441	105	5690	153*
464	7460	167*	4557	131*	3777	115	5546	150*
467	7130	159	4448	128	4287	131	5984	161*
470	7441	166*	3873	111	4087	125	5471	147
479	7011	156	4607	134*	3530	108	4843	130
487	-	-	4250	151*	3846	117	6036	162*
490	-	-	4639	134*	4020	123	5264	141
491	-	-	3690	107	4064	124	5845	152*
492	-	-	5015	144*	4029	123	5525	149*
4034	-	-	4802	139*	4265	130	5545	149*
4044	-	-	4727	136*	4456	136	5521	148
4054	-	-	4879	140*	3917	120	5828	157*
4015	-	-	-	-	-	-	6237	168*
4025	-	-	-	-	-	-	6039	162*
4045	-	-	5241	151*	3859	118	5616	151*
4055	-	-	-	-	-	-	5586	150*
Checks								
Local	4478	100	3471	100	3273	100	3718	100
Ganga 3	6328	141	4082	118	3741	114	4836	130
Ganga 101	5783	129	3596	104	4103	125	4607	124
Deccan	6851	153	3631	105	4275	131	5510	148
Ranjit	6842	153	3537	102	4250	130	5316	143
Him.123	7353	164	3494	101	3730	114	4758	128
Ganga Safed 2	5821	130	3897	112	4625	141	4525	122
Hi Starch	6582	147	4251	122	3514	107	4627	124

* The outstanding hybrids in the zone

APPENDIX VII

Code numbers and pedigress of Experimental Double Cross Hybrids.*

Code No.	Pedigree
238	(CM 201 x CM 202) x (CM 103xEto-25(A)-#-1-f-#-⊗bulk-#-#-#)
239	(CM 104 x CM 105) x (Eto-25(A)-#-1-f-#-⊗bulk-#-#-# x CM 202)
240	(CM 104 x CM 103) x (CM 105 x CM 202)
247	(AdeC-A257-#-#-# x CM 111) x (CM 109 x CM 202)
254	(CM 111 x CM 109) x (Eto-81(B)-#-1-f-f-#-# x CM 202)
265	(Cuba 24-#-#-#-#-1-#-#-#-#-#-1-f x G715-A407-#-1)x(G7(B)xKenya yl.)
266	(Cuba 24-#-#-#-#-1-#-#-#-#-1-fxG715-A407-#-1)x(Eto-81-#-#-2-1-#-2-fx Kenya yl)
268	(Cuba 24-#-#-#-#-1-#-#-#-#-1-f-Kenya yl)x(Eto-81-#-#-#-2-#-1-#-2-f x G 715-A407-#-1)
277	(Cuba 24-#-#-#-#-1-#-#-#-#-1-fxVenal-42-#-#-#-1-f-#-#-#)x(CM102 x Kenya yl)
2014	(CM 109 x CM 202) x Amarillo salvadoreno
2024	(CM 300 x CM 400) x Coker 811
2044	(CM 109 x CM 202) x Francisco Flint
2064	(CM 111 x Eto-81(B)-#-1-f-f-#-#)xJarvisxIndian Chief)
2084	(CM 111 x Eto-81(B)-#-1-f-f-#-#)xVijay
2264	(Basi-E46xBasi E27)x(AdeC-A257-#-#-#xCM202)
2384	(Basi-E27 x Basi E-106)x(AdeC-A257-#-#-# x CM 202)
2394	(Basi-E27xBasi E-106)x(CM 109 x CM 202)
2015	(CI 21 x Fla 5B48-1-# x CmsRf#)x(Fla 3H-94-#-# x T 224)
2025	(CI 21 x MP414)x(Fla3H-94-#-#)x(VenalxVenz.400-#)-13-1-f-#-#)
2075	(CI 21 x Fla5B-48-1-#-CmsRf-#)x(Fla3H-94-#-# x CM 105)
2085	(CI 21 x CM 104) x (Fla3H-94-#-# x MP 414)
2115	(CI 21 x Venz 1 x Venz 400-#)-13-1-f-# x (Fla3H94-#-# x CM 105)
2135	(CM 400 x CM 600-133) x (MP 119 x CM 300)
2145	(CI 64 x MP 119) x (KT 41-A25-#-1-2(B)-f) x CM 600-133)
2155	(CM 400 x CI 64) x (MP 119 x GM600-133)
2165	(MP119 x Bl. Theo-186-1-f-#-#-#-#) x CM 300 x CM 600-133
2175	(CM 400 x CI 64) x (MP 119 x CM 300)
2185	(CM 400 x CM 600-133) x (MP 119 x Bl.Theo-186-1-f-#-#-#-#)
2195	(CI 64 x MP 119) x (CM 300 x CM 600-133)
2205	(CM 400 x Bl.Tjeo-186-1-f-#-#-#-#) x (CM 300 x CM600-133)
2215	(CM 400 x T.139) x (CM 300 x CM600-133)
2225	(CM 400 x CI 64) x (CM 300 x CM 600-133)
2265	(CM 400 x T.139) x (MP 110 x CM600-133)
2275	(CM 400 x T.139) x (CM 300 x KT 41-A25-#-1-2(B)-f)
2305	(CM 111 x CM 202) x Vijay
2315	(CM 111 x CM 202) x USA 342
2335	(CM 111 x CM 202) x Comp. III
2345	(CM 111 x CM 202) x TTc Tb DDS Compsite
2355	(CM 111 x CM 202) x Cuba 11J
2365	(CM 111 x CM 202) x Puerto Rico Gr. I
2385	(CM 111 x CM 202) x CM 500
2395	(CM 111 x CM 202) x Antigua Gr. II
2425	(CM 111 x CM 202) x Caribbean Flint composite
2435	(CM 111 x CM 202) x Amarillo de Cuba
2445	(CM 111 x CM 202) x A1
2455	(CM 111 x CM 202) x A2
2465	(CM 111 x CM 2020) x B1(Y)
2475	(CM 111 x CM 2020) x B2

--- Cont'd

* According to the Progress Report of the Coordinated Maize Breeding Scheme, 1965-67, ICAR, India.

APPENDIX VII (Cont'd)

Code No.	Pedigree
445	(CM 205 x CM 202)x(Peru 330-A4-#-#-1 x Peru 330-#-#-327B-f-#-#-#)
446	(CM 202 x G715-A1-#-#-#-#)x(Peru 330A4-#-#-1x(Venz.1xVenz.400-#)-13-1-#-#-#-#
448,454	(CM 202 x G715-A1-#-#-#-#)x(Venz.1xVenz400-#)-13-1-#-#-#-# x (Peru 330-#-#-327B-f-#-#-#)
450	(CM 202 x CM 112)x(Peru330-A4-#-#-1-# x Venz.400-#)-13-1-f)
451	(CM 202 x G715-A1-#-#-#-#)x(CM104x(Venz1xVenz400-#-13-1-f)
453	CM202xG715-A1-#-#-#-#)x(PTR-1-605-3)-1-2-#-1-f-f-#-#-#-# x (Venz 1 x Venz 400-#)-13-1-f)
458	(PTR-1-605-3-1-2-#-1-f-f-#-#-#-# x CM 103)x(CM104 x CM202)
460	(CM 105 x CM 103) x (CM 104 x CM 202)
461	(CM 201 x CM 202)x(Eto-25(A)-#-1-f-#-⊗bulk-#-#-# x CM 104)
462	(CM 201 x CM 202) x (Eto-25(A)-#-1-f-#⊗bulk-#-#-# x CM 106)
464	(CM 103 x CM 202) x (Eto-23(A)-#-1-f-#-⊗bulk-#-#-# x CM 104)
467	(CM 105 x Eto-25(A)-#-1-f-#-⊗bulk-#-#-#)x(CM 201 x CM 202)
470	(CM 105 x CM 106) x (CM 201 x CM 202)
479	(CM 103 x Eto-25(A)-#-1-f-#-⊗bulk-#-#-#-#)x(CM 202 x CM 205)
487	(CM 202 x G715-A1-#-#-#-#)x(CM 104 x CM 112)
490	(CM 104 x Eto-182-1-2-f-f-#-#-#-#-⊗bulk)x(G715-A31-1-#-#-3-#-2-#xCM202)
491	(CM 104 x Nar330-#-23B-1-#-#-#-#-⊗-#-2-2-#)x(G715-A31-1-#-#-2-#-!-#xCM 202)
492	(CM 104 x (JarxEto)-#-B3-#-#)x(G715-A31-1-#-#-3-#-2-#xCM202)
4034	(Nar330-#-23B-1-#-#-#-#-⊗bulk-#-2-2-#-#-#x(JarxEto)-#-B3-#-#)x (G715-A31-1-#-#-3-#-2-# x CM 202)
4044	(CM104(JarxEto)-#-B3-#-#)x(G715-A59-2-#-⊗bulk x CM 202)
4054	(Eto-182-1-2-f-f-#-#-#-#-⊗bulkxNar330-#-23B-1-#-#-#-#-⊗bulk-#-2-2-#-#)x (G715-A31-1-#-#-4-#-2-#xCM202)
4015	(Eto-3-1-f-f- x (Jarvis x Eto)-#-B3-#-#)x(G715-59-2-#-⊗Bulk-#xCM202)
4025	(Eto-182-1-2-f-f-#-#-#-#-xbulk-#x(JarvisxEto*#-B3-#-#)x(G715-59-2-#-⊗bulk-#xCM202)
4045	(Eto-297-f-#-#-6-#-#-#-⊗bulkx(JarvisxEto)-#-B3-#-#)x(G715-59-3-⊗bulk-#xCM202)
4055	(Eto-182-1-2-f-f-#-#-#-#-⊗bulk-#x(Eto-297-f-#-#-6-#-#-#-⊗bulk)x(G715-59-2-#-⊗bulk-# x CM 202)

Note: ⊗ Selfing
Sibbing
f #-#-#-#-#

APPENDIX VIII

Code Numbers of the Parental Indred Lines and Varieties of the Released Hybrids *

CM 100	-	P4'-1(B)-4-#-#-#-#
CM 101	-	P4A(y)-1-3y-#-#
CM 102	-	P5PB5-3-f
CM 103	-	Col 1 x (38-11(lot no. etc)3a7mez)-f-f-#
CM 104	-	A Theo-21(B)-f-#-3-f-#-#
CM 105	-	Peru 330-#-#-329C-1-f-#
CM 106	-	Nar 330-#-23B-1-f-f
CM 107	-	GCL 31
CM 108	-	GCL 33
CM 109	-	Dix18-A1-1-3-f-#
CM 110	-	PH3-A6-"-1-#-#
CM 111	-	Cuba 342-2-2-f-#-#
CM 112	-	Desc 2-229-1-1-f-f-#-#-#
CM 113	-	Eto-190C-4-2-f-f-#
CM 200	-	G715-A36-#-#-#-#
CM 201	-	G715-A1-2-2-#
CM 202	-	CI21E(Derivative of US released inbred line)
CM 203	-	NC7(Derivative of US released inbred line)
CM 204	-	NC13(Derivative of US released inbred line)
CM 205	-	Kys(Derivative of US released inbred line)
CM 300	-	Eto PL-13-1-#-#-1-#
CM 400	-	Tenn29
CM 500	-	Antigua Gr.1
CM 600	-	Rudrapur Local
CM 601	-	Jellicorse

Note: CM Indicates Coordinates Maize, meaning that the particular line was evolved under the All-India Co-ordinated Maize Improvement Scheme.

* According to the Progress Report of the Coordinated Maize Breeding Scheme 1962, 64, 68. ICAR, India.

APPENDIX IX

Pedigrees of the Released Hybrids*

Released February 1961, Hyderabad Meeting

1. Ganga Hybrid Makka 1	-	(CM 101 x CM 102) x (CM 100 x CM 200)
2. Ganga Hybrid Makka 101	-	(CM 103 x CM 104) x (CM 201 x CM 105)
3. Ranjit Hybrid Makka	-	(CM 103 x CM 104) x (CM 202 x CM 106)
4. Deccan Hybrid Makka	-	(CM 104 x CM 105) x (CM 202 x CM 201)

Released February 1962, New Delhi meeting

5. VL 54	-	(CM 107 x CM 108) x (CM 203 x CM 204)

Released April, 1963, New Delhi meeting

6. Ganga Safed Hybrid Makka 2	-	(CM 400 x CM 300) x CM 600
7. Hi-Starch Hybrid Makka	-	(CM 400 x CM 300) x CM 601

Released March 1964, New Delhi meeting

8. Ganga Hybrid Makka 3	-	(CM 109 x CM 110) x (CM 202 x CM 111)
9. Himalayan Hybrid Makka 123	-	(CM 202 x CM 205) x (CM 113 x CM 112)

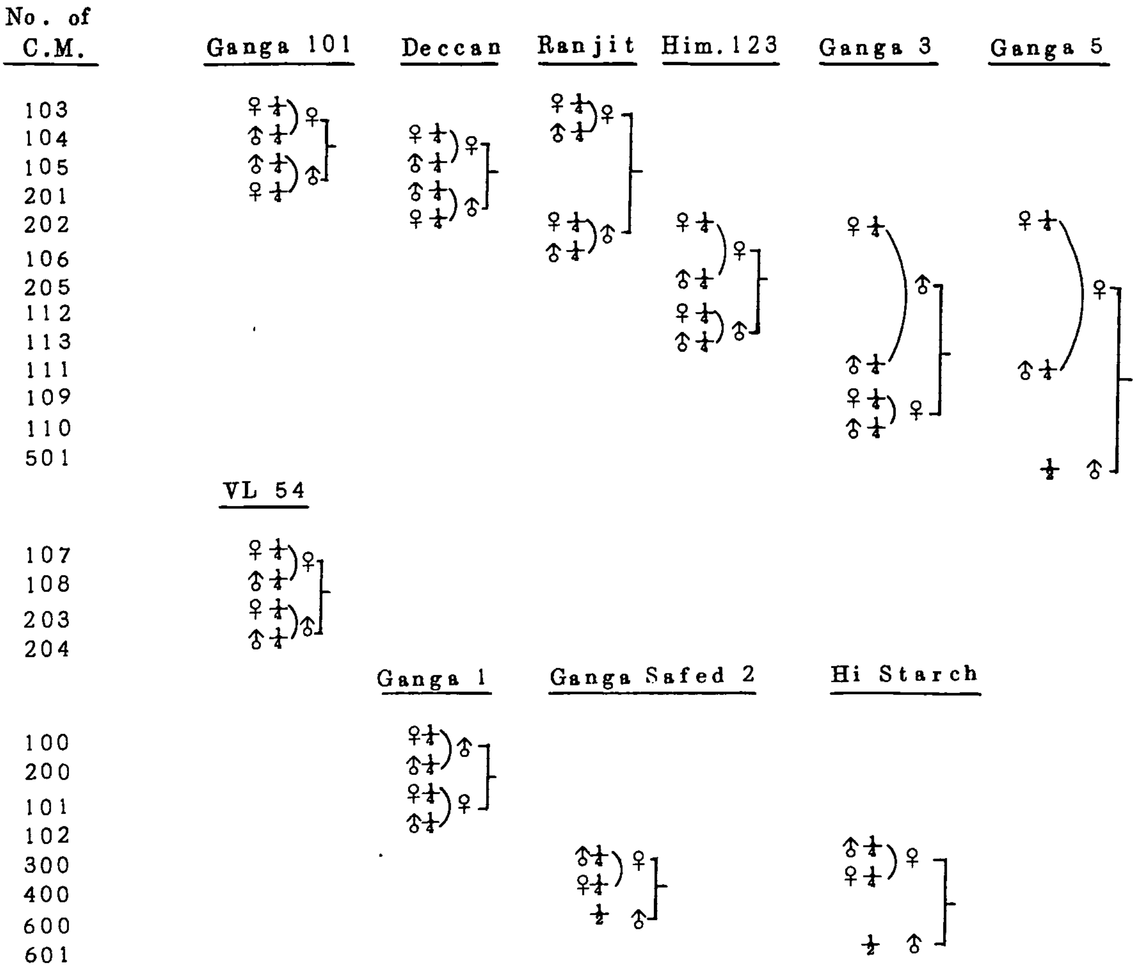
Released May, 1967, Ludhiana meeting

10. Ganga Hybrid Makka 5	-	(CM 202 x CM 111) x CM 500

* According to the Progress Report of the Coordinated Maize Breeding Scheme 1962, 64, 68. ICAR, India.

APPENDIX X

Direction of crossing of released hybrids *



Note: C.M. Coordinated Maize

* Compiled from the Progress Report of the Coordinated Maize Breeding Scheme, 1962, 64, 68. ICAR, India.

APPENDIX XI

State-wise list of Indian Maize Complexes*

State			Charac- ters	Year compo- sited	No. of collec- tion compo- sited	Days to silk	Present gener- ation
Andhra Pradesh	Complex	112	L.Y.F	1964	3	59	C1
		113	L.R.F	1964	3	55	C1
		114		1964	21	53	C1
Assam	Complex	37	E.W.F	1962	4	45	C2
		38	L.W.F	1962	11	57	C2
		39	E.Y.F	1962	16	54	C3
		40	L.Y.F	1962	7	49	C3
		99	L.Y.F	1964	8	52	C1
Bihar	Complex	20	E.W.F	1962	13	57	C2
		21	L.W.F	1962	33	61	C2
		22	E.Y.F	1962	16	54	C3
		23	L.Y.F	1962	41	63	C2
		45	E.W.F	1963	14	47	C2
		46	L.W.F	1963	11	55	C2
		47	E.Y.F	1963	14	47	C2
		49	E.O.F	1963	7	-	C2
		50	L.O.F	1963	3	-	-
		51	E.F.F	1963	2	55	C2
Bombay	Complex	125	E.W.F	1964	2	50	C1
		126	L.W.F	1964	2	52	C1
		127	L.O.F	1964	2	59	C1
		129	L.Y.F	1964	10	52	C1
Gujarat	Complex	115	L.W.F	1964	8	55	C1
		116	L.W.D	1964	3	61	C1
		117	E.O.F	1964	2	50	C1
		118	L.O.F	1964	3	52	C1
		119	L.Y.F	1964	5	55	C1
		141	E.O.F	1965	2	41	P
Himachal Pradesh	"	8	E.W.F	1961	3	57	C2
		9	L.W.F	1961	5	60	C2
		10	L.W.D	1961	3	53	C2
		11	E.O.F	1961	16	47	C3
		12	L.O.F	1961	6	4	C3
		13	L.O.D	1961	3	53	C3
		80	L.W.F	1963	2	53	C2
		81	E.Y.F	1963	2	55	C2
		82	E.O.F	1963	14	47	C2
		83	L.O.F	1963	2	51	C2

---Contd.

* According to the Progress Report of the Coordinated Maize Breeding Scheme, 1965-1968, ICAR, India.

APPENDIX XI(Cont'd)

State		Charac-ters	Year compo-sited	No. of collec-tion compos-ited	Days to silk	Present gener-ation
J&K Complex	1	E.W.F	1961	31	55	C2
	2	L.W.F	1961	6	57	C2
	3	E.W.D	1961	20	51	C2
	4	L.W.D	1961	7	53	C2
	5	E.O.F	1961	30	57	C2
	6	L.O.F	1961	16	55	C3
	70	E.W.F	1963	4	49	C2
	71	L.W.F	1963	5	57	C2
	72	E.Y.F	1963	4	47	C2
	73	L.Y.F	1963	2	57	C2
	74	E.O.F	1963	6	55	C2
	77	L.R.F	1963	3	55	C2
Kerala complex	107	L.W.F	1964	3	59	C1
	108	L.R.F	1964	2	81	C1
Madhya Pradesh complex	24	E.W.F	1962	17	48	C2
	25	L.W.F	1962	35	63	C2
	26	E.Y.F	1962	16	59	C2
	27	L.Y.F	1962	22	61	C2
	52	L.W.F	1963	7	49	C2
	53	E.Y.F	1963	2	-	C2
	54	L.Y.F	1963	6	55	C2
	93	L.W.F	1964	13	55	C1
	95	E.Y.F	1964	2	46	C1
	96	L.Y.F	1964	12	57	C1
	130	E.W.F	1965	3	41	P
	131	L.W.F	1965	12	46-60	P
	132	E.Y.F	1965	4	40-45	P
	133	L.Y.F	1965	6	47-56	P
	134	L.O.F	1965	3	49-51	P
Madras Complex	105	L.Y.F	1964	4	53	C1
Manipur "	43	L.W.F	1962	5	62	C2
	44	L.Y.F	1962	13	62	C2
	102	L.Y.F	1964	2	62	C1
	103	L.R.F	1964	3	51	C1
Mysore "	109	L.W.F	1964	3	51	C1
	111	L.Y.F	1964	4	50	C1
Orissa "	121	L.W.F	1964	4	55	C1
	122	L.O.F	1964	6	55	C1
	124	L.Y.F	1964	21	52	C1

----Contd.

APPENDIX XI(Cont'd)

State		Charac- ters	Year compo- sited	No. of coll- ection compo- sited	Days to silk	Present gener- ation
Rajasthan complex	135	L.W.F	1965	3	56-60	P
	136	L.O.F	1965	2	55-58	P
Tripura Complex	41	L.W.F	1962	2	61	C2
Uttar Pradesh complex	28	E.O.F	1962	29	53	C2
	29	E.Y.F	1962	19	57	C2
	30	E.W.F	1962	4	52	C2
	31	L.W.F	1962	12	55	C2
	32	L.O.F	1962	9	49	C2
	56	E.W.F	1963	13	55	C2
	57	L.W.F	1963	12	51	C2
	58	E.Y.F	1963	10	-	C2
	59	L.Y.F	1963	3	52	C2
	60	E.O.F	1963	17	49	C2
	61	L.O.F	1963	7	51	C2
W.Bengal complex	33	E.W.F	1962	3	49	C2
	34	L.W.F	1962	17	55	C2
	35	E.Y.F	1962	5	53	C3
	36	L.Y.F	1962	7	53	C3
	64	L.W.F	1963	2	55	C2
	65	E.Y.F	1963	7	-	C2
	66	L.Y.F	1963	5	53	C2
	67	E.O.F	1963	3	53	C2
	68	L.O.F	1963	2	53	C2
Punjab complex	14	E.W.F	1962	20	56	C2
	15	L.W.F	1962	12	63	C2
	16	E.Y.F	1962	24	55	C2
	17	L.Y.F	1962	31	61	C2
	18	E.O.F	1962	2	49	C2
	19	L.O.F	1962	17	63	C2
	86	M.W.F	1964	4	51	C1
	87	L.W.F	1964	3	51	C1
	88	E.Y.F	1964	4	47	C1
	89	L.Y.F	1964	11	55	C1
	90	E.O.F	1964	23	44	C1
	91	L.O.F	1964	42	55	C1
	144	L.Y.F	1965	2	56	P

E-Early M-Medium L-Late W-White O-Orange Y-Yellow R-Red F-Flint D-Dent

APPENDIX XII

Master Sheet of Yield Trial*

TRIAL NO. -----   YEAR ----------

LOCATION --------------

Entry No.	Pedigree	Origin of seed	Replication I	II	III	IV
1			5393	5467	5525	5578
2			5394	5459	5522	5552
3			5395	5485	5523	5562
4			5396	5481	5520	5554
5			5397	5471	5521	5584
6			5398	5442	5524	5570
7			5399	5455	5519	5546
8			5400	5463	5507	5579
9			5401	5460	5508	5547
10			5402	5490	5509	5561
11			5403	5482	5506	5558
12			5404	5472	5510	5588
13			5405	5448	5505	5568
14			5406	5449	5511	5543
15			5407	5468	5501	5580
16			5408	5457	5499	5553
17			5409	5489	5504	5565
18			5410	5483	5502	5559
19			5411	5476	5498	5583
20			5412	5446	5503	5574
21			5413	5452	5500	5540
22			5414	5469	5530	5581

* According to information given by Dr. N.L.Dhawan. They used in the scheme.

TRIAL NO. ----   YEAR ----------

LOCATION -----------

Entry No.	Pedigreee	Origin of seed	Replication I	II	III	IV
23			5415	5462	5532	5548
24			5416	5484	5529	5566
25			5417	5478	5531	5557
26			5418	5473	5528	5587
27			5419	5443	5536	5571
28			5420	5454	5527	5541
29			5421	5465	5516	5575
30			5422	5461	5512	5550
31			5423	5486	5513	5567
32			5424	5480	5518	5556
33			5425	5474	5515	5582
34			5426	5444	5517	5569
35			5427	5453	5514	5545
36			5428	5466	5533	5577
37			5429	5458	5537	5549
38			5430	5487	5534	5563
39			5431	5477	5539	5560
40			5432	5470	5538	5586
41			5433	5445	5536	5573
42			5434	5450	5535	5544
43			5435	5464	5491	5576
44			5436	5456	5495	5551
45			5437	5488	5494	5564
46			5438	5479	5498	5555
47			5439	5475	5497	5585
48			5440	5447	5493	5572
49			5441	5451	5492	5542

APPENDIX XIII

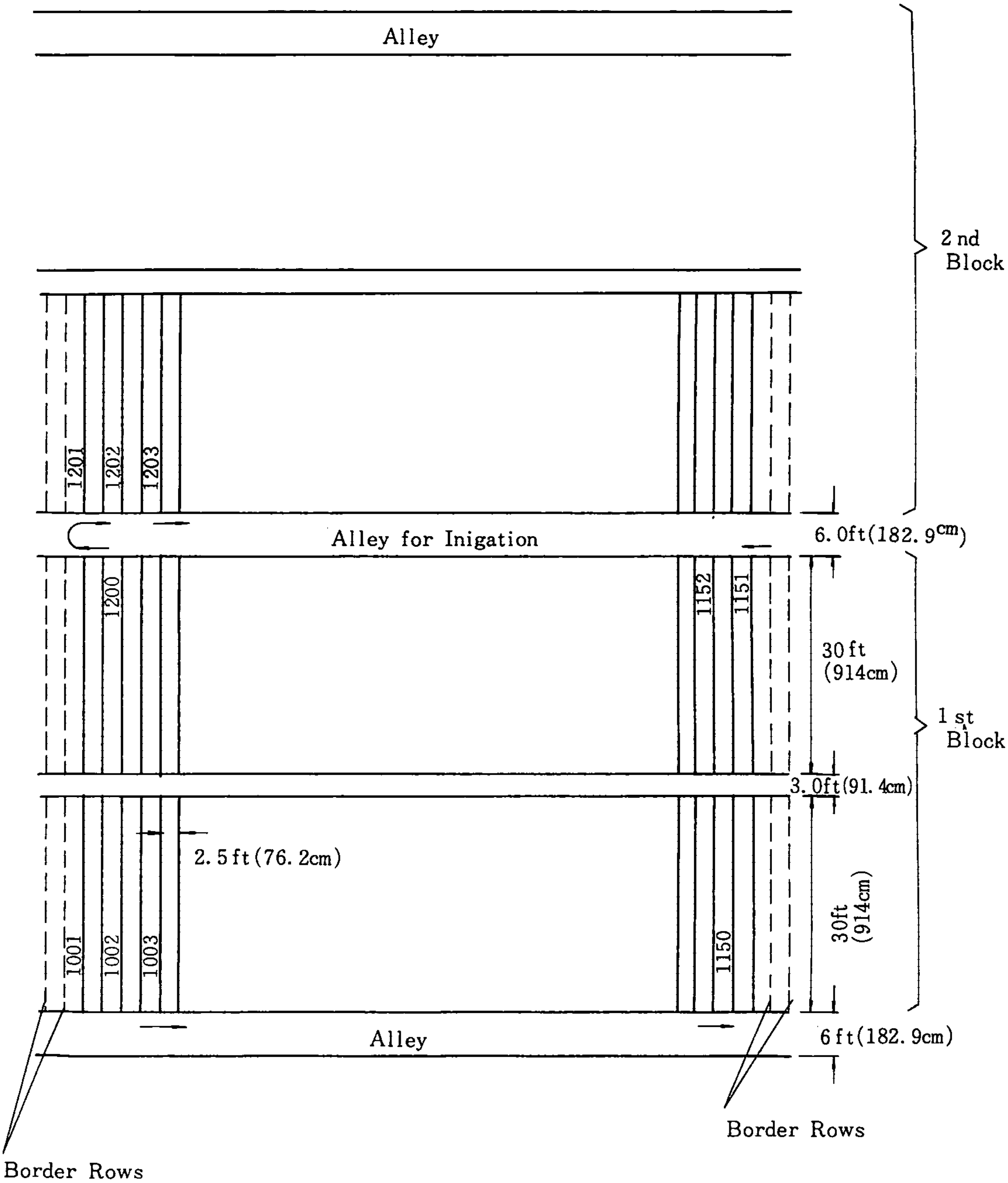
Field data recording sheet *

	1 Days to 75% silk	2 Vigour	3 Plant aspect	4 Insect notes	5 Disease notes	6 Lodging root/ stem	7 Husk cover	8 Ear aspect	9 Fresh Weight	10 Moisture %	11 Effective Stand	12	13	
O	1	2	3	4	5	6	7	8	9	10	11	12	13	Plot No. 8137 7 Entry No.
	1	2	3	4	5	6	7	8	9	10	11	12	13	8138 2
O	1	2	3	4	5	6	7	8	9	10	11	12	13	8139 4
	1	2	3	4	5	6	7	8	9	10	11	12	13	8140 12

* According to the Form given by Dr. N.L.Dhawan.

APPENDIX XIV

Field Lay Out Yield Trials*



* Used on the Yield Trials of the Coordinated Maize Breeding Scheme, in IARI, New Delhi.

APPENDIX XV

List of abbresses of NSC units*

1. National Seeds Corporation Ltd., 1-7-143 Golconds, Cross Road, Musheerabad, Hyderabad 20, ANDHRA PRADESH.

2. National Seeds Corporation Ltd., Hempur (Gaushala) Via Kashipur, District Nainital, UTTAR PRADESH.

3. National Seeds Corporation Ltd., Foundation Seed Unit, Nandikotkur, District Kurnool, ANDHRA PRADESH.

4. National Seeds Corporation Ltd., 67, Malviya Nagar, Bhopal, MADHYA PRADESH

5. National Seeds Corporation Ltd., Narrivari Street, Gandhi Nagar, Vijayavada, ANDHRA PRADESH.

6. National Seeds Corporation Ltd., 217, Dr. Nanjappa Road (Sarojini Street), Coimbatore 18.
7. National Seeds Corporation Ltd., Mama Road, Dharmapeth, Nagpur.

8. National Seeds Corporation Ltd., 851-A-B, Block No. V, Rajaji Nagar, Bangalore 10, MYSORE.

9. National Seeds Corporation Ltd., Malmaddi, Manjunathpur, Near Rayar Math, Dharwar, MYSORE.

10. National Seeds Corporation Ltd., 102, Sector 18A, Chandigarh.

11. National Seeds Corporation Ltd., Durlab Niwas, Prithvi Raji Marg, 'C' Scheme, Jaipur, RAJASTHAN.

12. National Seed Corporation Ltd., 12-C/1/35, Rampur Garden, Civil Lines, Bareilly, UTTAR PRADESH.

13. National Seeds Corporation Ltd., Nageshwar Colony, Boring Road, Patna 1, BIHAR.

14. National Seeds Corporation Ltd., 587, Nanapeth, Laxmi Road, POONA 2.

15. National Seeds Corporation Ltd., P.O. Saproon, Solan, Simla Hills.

16. National Seeds Corporation Ltd., Seed Processing Plant, Borawaki Godown, Near Rly Station, Shrirampur District Ahmednagar, MAHARASHTRA.

* According to NSC, Plans and Progress, 1968, by National Seeds Corporation LTD, New Delhi.