MAIZE (Zea Mays L.) AN INTERCROP FOR SMALLHOLDERS

RUBBER RESEARCH INSTITUTE OF MALAYSIA

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This report is based on both experimental and pilot project results secured over the last few years by the R.R.I.M., and compiled by a team consisting of:

Cheng Yu Wei
Chee Yan Kuan
B.S. Rao
Mohd. Yusof Azaldin
Lim Sow Ching
Ti Teow Chuan
Mohd. Ghazali bin Mohd. Noor
E. Pushparajah
Soong Ngin Kwi
K. Sivanadyan
P.D. Abraham, Alternate
Haji Ani bin Arope, Co-ordinator

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PREFACE

This report gives an account of the work done by the Rubber Research Institute of Malaysia on the production of hybrid maize varieties and the growing of maize mainly as an intercrop in rubber smallholdings. It also provides a general review of work done in growing maize in Malaysia, an analysis of the supply and demand position and the economic benefits of growing maize locally as well as the details of techniques to be employed for the introduction of hybrid and synthetic varieties of maize as an intercrop with rubber. The aim is to provide an alternative source of income for the smallholders during the immaturity period of rubber, thus, alleviating their hardship and providing maximum utilisation of their available land. This report indicates that maize appears to be a suitable intercrop both as a viable crop and one which would save considerable foreign exchange by substituting for import thus, benefitting both the farmer and the nation.

This report was a team effort of the many research workers involved in the project. In addition, special acknowledgement is made to Encik S. Subramaniam for help rendered in the preparation of Chapter V, Encik Foo Kah Yoon for assistance with the editing, Encik Hoh Lian Yong for the graphic work and Cik Aziah binti Othman, Puan Margaret Lau and Encik Yusup bin Abdullah for various processing assistance rendered.

Haji Ani bin Arope
Director
Rubber Research Institute of Malaysia

SYNOPSIS

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Rubber trees currently take about six to seven years to mature from planting in new areas or in replanting of old stands before the participants begin to benefit from them. During this period, the farmers are without an alternative income. Intercropping with cash crops under immature rubber offers the quickest means of providing adequate income and maximising the use of land. Maize is a suitable choice for intercropping and in addition, allows for import substitution.

The world supply and demand position of maize is reviewed in this report. It is shown that Malaysia is an importer of unmilled maize and maize in the form of animal feeds. In 1972, maize was grown in Peninsular Malaysia in 2411 hectares. It is estimated that in order for Malaysia to be self-sufficient at least 65 000 ha with one crop per year should be grown with maize.

This report presents a general review on work done with maize in Malaysia. Special emphasis is given on the recent achievements in R.R.I.M.'s work on the use of suitable varieties of synthetic and hybrid maize as intercrop under rubber.

Economic analysis shows that with average yields of 3.1 tonnes per hectare of dried grains and at a farmgate price of $400 per tonne, net returns of $230 and $570 per hectare can be obtained from the first and second crops respectively. In terms of family returns, this amounts to $518 and $699 per hectare respectively or $1217 per year for two crops. With higher yields obtainable under good management, greater returns can be realised.

A detailed account of hybrid seed production as well as the techniques and procedures required to be involved in commercial implementation of intercropping maize under rubber is given in this report.

This report also considers that there is sufficient technical and economic justifications for intercropping rubber with maize and that the objectives can be achieved with an integrated and co-ordinated approach.

CONTENTS

CHAPTER		PAGE

CHAPTER		PAGE
	Control of Diseases	63
	Seed Rots and Seedling Diseases . . .	63
	Leaf Rusts and Leaf Blight	64
	Crop Rotation	64
	Harvesting and Drying	64
VII	POLICY IMPLICATIONS AND RECOMMENDATIONS . . .	65
	REFERENCES	67

LIST OF TABLES

TABLE		PAGE

LIST OF FIGURES

LIST OF PLATES

CHAPTER I

INTRODUCTION

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INTRODUCTION

Need for Intercropping

During the immature phase of the rubber trees, the smallholder is left without an alternative source of income. The introduction of selective intercropping on replanted smallholdings with economically, viable, short-term crops grown under proper management is a method which not only will give the smallholders extra income during the period of immaturity but also will benefit the growth of the rubber trees because of better maintenance in the smallholdings.

Conventional intercropping on replanted smallholdings where conditions are suitable, is practised by progressive smallholders. In many cases, the operators are not smallholders. They lease the land from the smallholders for intercropping. These operators have to maintain the replanted holdings in good condition for the benefit of the smallholders in order to get the approval for replanting grants and they collect the proceeds from the sale of the crops grown as intercrops. The smallholders, although aware of the advantages and profits obtained for intercropping by the operators, have not been able to carry out intercropping themselves. The reasons are due to a number of factors such as lack of good planting materials, technical knowhow of cultivation and the usage of fertilisers.

Thus, the Rubber Research Institute of Malaysia (R.R.I.M.) felt there was an urgent need to undertake research on intercropping in order to determine the most efficient and profitable use of land in the interrows of rubber trees.

Unproductive Area under Immature Rubber

Presently during the first three years of growth of the rubber trees in smallholdings, about four-fifths of the soil areas mostly in the interrows, are left unexploited. The R.R.I.M. intended to exploit this unused area by growing short-term cash crops with the view of producing income from a given area of land to the smallholders. In addition to creating diversification of agriculture without using new areas or losing existing areas under rubber to other crops, Chee[1] has shown in an economic production trial with nine smallholders that by intercropping with maize under rubber, smallholders can obtain an income of $773.29 without hired labour and $706.29 with hired labour per hectare.

Beneficial Effect of Intercropping

Work at R.R.I.M.[2] and by Cheng and Mohd. Noor[3] have shown that intercropping on a rotation basis with grain and legume crops, e.g. maize, soyabean or groundnut did not adversely affect the growth of the rubber trees. On the other hand, with a legume to legume rotation (ground-soyabean), the growth rate of the rubber trees was improved.

Choice of Crops

In a survey of imports of food crops and the practice of intercropping in 2500 smallholdings in Peninsular Malaysia, Lim[4]

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[1] Chee, Y.K. (1974) Intercropping with groundnut and maize on rubber smallholdings. Proc. Rubb. Res. Inst. Malaysia Plrs' Conf. Kuala Lumpur 1974.

[2] Rubber Research Institute of Malaysia (1973) Intercropping with annual crops in immature rubber. Plrs' Bull. Rubb. Res. Inst. Malaysia No.126, 85.

[3] Cheng, Y.W. and Mohd. Noor Wahab (1973) Studies of intercropping in immature rubber on smallholdings. Rubb. Res. Inst. Malaya (Internal paper).

[4] Lim, S.C. (1969) An agro-economic study of intercrops in rubber holdings. Econs Plnn. Div. Rep. No.6, Rubb. Res. Inst. Malaya.

showed that 50% of the smallholdings had bananas while 7% had tapioca, groundnut and maize as intercrops. Among the other short-term food crops that could be grown as intercrops, groundnut, soya-bean and maize were found to be suitable. These offer considerable opportunity for import substitution and they are non-competitive with the growth of rubber trees under good management. Tapioca has a good export market but was shown to be competitive with the growth of rubber and hence unsuitable. Bananas had limited market outlet.

Maize, as one of the main crops selected for investigation, is mainly used locally for animal feeds. Limited quantities of fresh cobs are used for human consumption. Maize is also processed for use as cooking oil. The production of maize for animal feeds locally has been very limited. Nearly all the required grains for the animal industry have been imported mainly from neighbouring countries such as Thailand and Indonesia. Thus, the growing of maize on a sufficient scale offers the opportunity for import substitution.

Objectives of Report

The objectives of this report are to provide:

- A review of the world supply and demand position of maize.
- A general review of work done in growing maize in Malaysia especially as an intercrop under rubber.
- An economic analysis of the benefits that this crop can accrue to the farmer and the nation.
- A method to produce hybrid maize seeds.
- The relevant information and details of techniques to grow the crops commercially in smallholdings.

CHAPTER II

WORLD SUPPLY AND DEMAND POSITION OF MAIZE

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Maize Products

Maize is one of the most important sources of food for feeding beef cattle, hogs and lambs. In addition to this, it provides invaluable roughage for dairy and beef cattle. Its use in dairy rations is indispensable, being a high and important nutritional proportion of the concentrate mixture.

Having a high carbohydrate content (70.4%) maize too may be channelled for human consumption in the form of cornflakes and maize meal.

Besides the two uses mentioned above, maize has also been utilised for the manufacture of certain industrial products like alcohol, maize starch and maize oil. The stalks of the maize plant can be turned into paper and cardboard, while the cobs are used in the production of chemicals, plastics, methanol and tar.

With the predictable growth of the livestock industry in this country, especially poultry farming and cattle raising, and with the appallingly low local production of maize, the need to expand Malaysia's maize production has become an urgency. Although tapioca could possibly substitute maize as feeds, it has certain disadvantages. Tapioca has a lower fat and protein contents (0.5% and 2.5% respectively as compared to 3.9% and 9.4% for maize) which must be met with further substitution by other feeds that contain a larger proportion of two nutrients mentioned above, than found in maize. Thus, to be an efficient substitute for maize from the economic point of view, the price of tapioca has to be substantially lower than that of maize. This has been calculated to be 20%. Even when the price of tapioca has fallen to this level, feedmiller producers would still be reluctant to substitute tapioca for maize as the change in the contents of their product mixtures may disrupt the feeding habits of the animal. Undoubtedly, maize as an animal feed is second to none in Malaysia.

World Production

Table 1 highlights the area under maize, the production trend and the yield by countries. The countries are consciously selected for the purpose of comparing the output trend of the major producers as well as for comparing the extreme yield levels among producing countries.

Total hectarage under maize changes little between 1972 and 1973. All of the most important producers are shown in Table 1, with the exception of South Africa, experienced an increase in planted hectarage, although on a small scale. South Africa suffers a reduction of more than 29% of planted area under maize.

World production of maize (unmilled equivalent) increased by more than 10 million tonnes between 1972 and 1973, an increase of 3.2%. Again, all major producers experienced an increase in production with the exception of South Africa. South Africa's output fell by 55% during this period, caused partly by the reduction in planted hectarage and the fall in the yield level. The substantial increase in Argentina's production of 65% was mainly attributed to the impressive improvement of yield level per hectare as well as the expansion of the planted hectarage under maize. France features well too as a potentially important producer. Although her planted area under maize increased by a mere 3.5%, she recorded an impressive 30% increase in production, placing herself in the position of the fourth most important producer of maize in the world. This momentous increase in output was achieved with the improvement in the yield level by 25%, which in 1973 ranked second only to the United States. The United States is still the leading producer, with 144 million tonnes in 1973. Although the increase (in percentages) in production that she recorded from 1972 to 1973 was far from impressive, in terms of the volume of output and planted hectarage her record is unsurpassed. The fall in yield level she experienced in 1973 did not affect her position as the world's most important producer of maize.

TABLE 1

AREA, PRODUCTION AND YIELD OF MAIZE BY COUNTRIES (1972-3)

AREA

Country	1972 Mill. ha	1972 % total	1973 Mill. ha	1973 % total	% increase in hectarage
United States	23.2	21.5	24.9	22.7	7.3
China	10.5	9.7	10.6	9.7	0.9
Brazil	10.3	9.5	10.4	9.5	1.0
S. Africa	5.6	5.2	4.0	3.6	-29.2
Argentina	3.1	2.9	3.7	3.3	16.4
Philippines	2.6	2.4	2.7	2.5	3.0
France	1.9	1.7	2.0	1.8	3.5
Hungary	1.4	1.3	1.5	1.4	6.2
World total	108.0	-	109.7	-	1.5

PRODUCTION (unmilled)

Country	1972 Mill. ha	1972 % total	1973 Mill. ha	1973 % total	% increase in hectarage
United States	141.0	44.6	144.2	46.0	2.2
China	28.6	9.4	29.8	9.5	4.2
Brazil	14.0	4.6	15.3	4.9	10.0
S. Africa	9.6	3.2	4.3	1.4	-55.3
Argentina	5.9	1.9	9.7	3.1	64.7
Philippines	2.1	0.7	2.2	0.7	4.0
France	8.2	2.7	10.7	3.4	30.3
Hungary	5.6	1.8	6.0	1.9	8.0
World total	302.9	-	313.6	-	-

YIELD

Country	1972 Tonnes/ha	1973 Tonnes/ha	% increase
United States	6.1	5.6	-8.2
China	2.7	2.8	3.7
Brazil	1.4	1.5	7.1
S. Africa	1.6	1.1	-31.3
Argentina	1.9	2.6	36.8
Philippines	0.8	0.8	0.0
France	4.4	5.5	25.0
Hungary	4.0	4.0	0.0

Source: Food and Agriculture Organisation (1973) Monthly Bulletin of Agricultural Economics and Statistics, Vol.22, November 1973, Rome: F.A.O.

International Trade

World export of maize did not undergo any substantial amount of fluctuation in terms of tonnage (see Table 2), from 1970 onwards. The United States had been the leading exporter since the mid-1960's. Her leading position was greatly strengthened in 1972, registering an export figure 70% higher than that of 1971. This helped to improve her already impressive share of the world export of 44.6% in 1971 to 86.2% in 1972. No other exporting countries could possibly equal such an achievement, at least in the near future. Mexico, which was once an important exporter virtually dropped out in obscurity in the seventies.

In 1971 European importers imported about 76% of the world's export of maize. However, the single most important importer undoubtedly is Japan, consuming about one-third of the world's export in 1972. She has held this position since 1970 (see Table 3).

The world trade in maize in the 1970's has been remarkably stable as compared to the trade of other food products like groundnut. This may be attributed to two factors; the absence of a suitably economical substitute for maize as animal feed and, the stable

TABLE 2

MAJOR NET EXPORTER (MILLION TONNES, UNMILLED)

Countries	1965	1970	1971	1972
United States	15.2	14.4	12.9	22.4
France	0.6	2.5	4.1	3.5
S. Africa	0.3	1.2	1.5	3.2
Thailand	0.8	1.4	1.8	3.2
Mexico	1.3	0.3	0.3	0.6
World's total	-	27.2	28.9	26.0[a]

[a]10 months' figure.

Source: Food and Agriculture Organisation (1973) Monthly Bulletin of Agricultural Economics and Statistics, Vol.22, November 1973, Rome: F.A.O.

TABLE 3

MAJOR NET IMPORTERS (MILLION TONNES, UNMILLED)

Countries	1965	1970	1971	1972
Japan	3.4	6.0	5.0	6.0
Italy	5.2	4.2	4.5	4.8
Fed. Rep. of Germany	2.3	2.6	3.3	3.3
United Kingdom	3.3	3.1	3.0	3.1
Europe's total	18.2	17.4	19.2	n.a.
World's total	23.8	25.4	25.1	18.2[a]

[a]10 months' trade figure only.

Source: Food and Agriculture Organisation (1973) Monthly Bulletin of Agricultural Economics and Statistics, Vol.22. November 1973, Rome: F.A.O.

prices that maize enjoy. Table 4 shows that prices of maize fluctuates little between 1970 to 1972, ranging from the annual average figure of £27 to £30 per tonne. The annual price of the United States No.3 for 1972 was in fact lower than that for 1970. Prices, however, rose sharply in the later part of 1973.

TABLE 4

AVERAGE PRICES OF MAIZE, NEAREST FORWARD SHIPMENT C.I.F. (£/TONNE)

Average price from	U.S. No.3 Yellow, C.i.f. Liverpool			
	1970	1971	1972	1973
January to June	28.4	31.1	24.5	37.9
July to December	31.7	25.7	31.1	58.2
Annual average	30.1	28.4	27.8	48.1

Average price from	U.K.: Nearest forward shipment: Argentina, C.i.f. U.K.		
	1970	1971	1972
January to June	28.5	31.1	28.7
July to December	33.3	28.4	-
Annual average	30.9	29.8	28.7

Source: Food and Agriculture Organisation (1973) Monthly Bulletin of Agricultural Economics and Statistics, Vol.20, February 1971, Vol.21, January 1972 and Vol.23, January 1974, Rome: F.A.O.

Domestic Situation

In 1972, the total area under maize in Peninsular Malaysia was recorded to be 2411 hectares. This compared rather unfavourably to 3078 hectares in 1970, let alone to the hectarage of other beverages and food crops. Maize ranked the tenth in hectarage under this category of crops. In view of the rise in the importance of the livestock industry in this country, the current local production of maize is far from satisfactory. This is arguably so in that most of the maize required for feedmills had to be imported.

Table 5 shows that in 1965, Peninsular Malaysia imported 76.6 thousand tonnes (unmilled equivalent) of maize. By the end of 1971 this figure had more than doubled to 188.5 thousand tonnes, a compounded growth rate estimated to be more than 10%. The imported

TABLE 5

IMPORT OF MAIZE AND MAIZE PRODUCTS INTO PENINSULAR MALAYSIA
1965 AND 1971 (UNMILLED EQUIVALENT)

Products of maize	1965		1971	
	'000 tonnes	$ million	'000 tonnes	$ million
Unmilled	39.5	8.3	111.1	22.2
Meal and flour	4.7	1.1	2.1	0.5
Animal feed	24.4	5.0	71.2	13.3
Flake	3.9	1.3	0.8	0.2
Others	-	-	1.1	0.2
Total	76.6	15.8	188.5	36.4

Source: Department of Statistics (1965-71) External Trade, Dept. of Statist. Malaysia.

Conversion rate to unmilled equivalent:

Meal and flour (x) - 66%

Flake (Y) - 70%

Others (z) - $\frac{z}{2}(x) + \frac{z}{2}(Y)$

maize in 1971 was valued at $36.4 million as compared to $15.8 million in 1965. Unmilled maize and maize in the form of animal feed accounted for 98% of the total import in 1971. This imported product recorded a compounded growth rate of 17% from 1965 - 71.

Thailand is the largest exporter of unmilled maize to Peninsular Malaysia. In 1971, she exported 68.3 thousand tonnes, accounting for more than 60% of Malaysia's total import of unmilled maize (see Table 6). On the whole, imports of maize and maize products from Thailand in 1971 came close to $27 million of which unmilled maize accounted for $13.9 million.

Prospects for Local Production

Most of the unmilled maize imported into this country is processed into animal feed. Indeed, import of unmilled maize has

TABLE 6

IMPORT OF UNMILLED MAIZE INTO PENINSULAR MALAYSIA 1965 AND 1971

Country	1965		1971	
	'000 tonnes	$ '000	'000 tonnes	$ '000
Thailand	33.7	6 969	68.3	13 981
Sumatra	-	-	36.5	6 883
Burma	0.4	106	2.9	634
Cambodia	3.4	731	2.0	362
Vietnam Rep.	1.8	436	0.1	10
Others	0.2	46	1.3	293
Total	39.5	8 288	111.1	23 163

Source: Department of Statistics (1965-75) External Trade, Dept. of Statist. Malaysia.

increased in the 1970's to meet the demand of the rapidly expanding livestock industry that unfortunately could not be met with by local production. In view of the rapid expansion of the country's animal husbandry, and the additional prospect of saving invaluable foreign exchanges, a policy of expanding local maize production through a substantial increase in both the planted hectarage as well as the yield level should be quite appropriate and timely.

Table 7 shows that considering the volume of local production as well as the net import, and basing on the yield level of 3.1 tonnes per hectare, it is estimated that just to satisfy the local demand for maize and maize products, an area of not less than 65 000 hectares (in sole crop equivalent) should be planted under maize in Peninsular Malaysia.

TABLE 7

GROSS SUPPLY OF MAIZE

Year	Sole crop equivalent (hectares)	Local production[a] (tonnes)	Net imports[b] (tonnes)	Total (tonnes)	Equivalent hectarage[c]
1970	3 078	9 540	188 444	197 985	63 866
1971	1 787	5 539	188 477	194 017	62 586

[a]Estimation of local production at assumed yield of 3.1 tonnes/ha.

[b]In unmilled equivalent.

[c]Estimation of equivalent hectarage required at assumed yield of 3.1 tonnes/ha.

CHAPTER III

REVIEW OF WORK

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REVIEW OF WORK

Maize (Zea mays L.) is a popular crop commonly grown by smallholders in Peninsular Malaysia either as a monocrop or as an intercrop under rubber. In Peninsular Malaysia maize cultivation is particularly important in the states of Trengganu, Pahang, Kelantan, Kedah and Perak. There are numerous varieties of maize which display diversity of forms and qualities. Phang[5] reported that the popular varieties grown by the smallholders are the Flint varieties (Zea mays Var. indurata). Those belonging to this group are the local Flint, Metro and Guatemala varieties. The varieties of sweet corn are not considered in this review.

Varieties

In general there has been a limited number of varieties of maize grown in Peninsular Malaysia. The popular Local Flint Variety is generally considered to be of native origin. Metro, a synthetic variety of Indonesian origin which is higher yielding than the Local Flint, has been used by smallholders for many years until it was replaced by the Guatemala variety. These varieties have shown decline with time, which have been attributed to be mainly caused by the degeneration of the varieties in growth, vigour, plant height, ear size and yield[6]. Lim[7] conducted varietal trials with maize at the Lundang Station in Kelantan and

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[5]Phang, C. (1973) Review of maize in Malaysia. Department of Agriculture Conference Paper No.2. Kuala Lumpur

[6]Cheng, Y.W. (1974a) Comparative studies on the existing varieties of maize in Malaysia. Rubb. Res. Inst. Malaysia (Internal paper).

[7]Lim, H.J. (1969) Research and investigation on maize and sorghum in Kelantan. Proceedings of the Malaysian Maize and Sorghum Co-ordination and Improvement Workshop, Paper I. Dept. of Agri., Malaysia.

the results of the promising varieties are given in Table 8. The five introduced varieties were superior in yield to Metro. In view of the need of maize for profitable intercropping in rubber smallholdings, attempts to develop locally adapted high yielding maize by the introduction of varieties from other countries were made by R.R.I.M. from 1968. Cheng[8] compared three Australian hybrids in the R.R.I.M. Experiment Station in Sungei Buloh. The results given in Table 9 show that only one of the Australian hybrids gave higher yield than Metro and was only marginally superior.

TABLE 8

COMPARISON OF SOME PROMISING MAIZE VARIETIES IN KELANTAN

Varieties	Clean grain yield (kg/ha)	
	1968	1969
Doeto - 1	6 162.1	3 989.6
Guatemala Caribbean Syn.	6 145.3	4 885.3
UPCA Var. 1	5 921.1	5 148.8
Puerto Rico Gr. 1-1	5 559.0	5 287.8
Antiqua 2D-1	5 004.1	5 290.0
Local Metro	3 729.6	4 720.5

TABLE 9

COMPARISON OF AUSTRALIAN HYBRIDS OF MAIZE

Varieties	Yield dry grain (kg/ha)
GH 128	2 530.1
GM 211	2 676.95
QK 37	3 350.67
Metro	3 263.23

[8]Cheng, Y.W. (1969) Improving the performance of catch crops in Malaysia. Crop Diversification in Malaysia (Blencowe, E.K. and Blencowe, J.W. ed.), Kuala Lumpur: The Incorporated Society of Planters.

In 1971, the R.R.I.M. commenced breeding work with maize at the R.R.I.M. Experiment Station[9]. Several single cross hybrids and synthetic varieties were developed and compared in the trials on smallholdings and at the R.R.I.M. Experiment Station, Sungei Buloh. The more promising varieties were compared with those supplied by Malaysian Agriculture Research and Development Institute (M.A.R.D.I.). The results given in Table 10 show that R.R.I.M. varieties were all superior than those supplied by M.A.R.D.I. The highest yielding was the Sungei Buloh Hybrid No.2 followed by Sungei Buloh Nos.4 and 5. The Sungei Buloh Synthetic variety also gave fairly high yields. Cheng[10] comments that Sungei Buloh Hybrid No.2 is recommended for grain production. It is also a stable and superior variety than Guatemala and comparatively tolerant to lodging and drought. Sungei Buloh No.4 can be used for fresh cob as well as grain production but was subject to slight lodging. The Sungei Buloh Synthetic variety was early maturing and can be used for late planting in a crop season.

Spacing

Goh[11] compared three spacings with variety Metro. The results (Table 11) from his trial indicate that the optimum planting distance was 61.0 x 22.9 centimetres. Whereas Cheng[12] found that for intercropping and with hybrid maize varieties, a spacing of 90 x 23 cm with one plant per point was optimum. This planting density will provide for 47 840 plants per intercropped hectare. He comments that with higher densities the plants would become susceptible to lodging and produce small cobs resulting in poorer yield.

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[9]Cheng, Y.W. (1974) Op. cit.

[10]Cheng, Y.W. (1974) Ibid.

[11]Goh, P.E. (1969) Maize and sorghum - prospective intercrops in Malaysian plantations. Crop Diversification in Malaysia (Blencowe, E.K. and Blencowe, J.W. ed.), Kuala Lumpur: The Incorporated Society of Planters.

[12]Cheng, Y.W. (1974b) Growing maize as an intercrop in rubber. Rubb. Res. Inst. Malaysia. (Internal paper).

TABLE 10

THE PERFORMANCE OF EXISTING VARIETIES OF MAIZE

Variety	Source	Days to		Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear weight at harvest (gm)	Shelling (%)	% moisture at harvest (%)	Grain yield 15% moisture (kg/ha)	Yield % of Guatemala (%)
		Tasell-ing	Silk-ing								
Sungei Buloh Hybrid No.2	R.R.I.M.	57	60	263	137	20.7	192	80.0	25.7	5 420	200
Sungei Buloh Hybrid No.5	R.R.I.M.	60	63	277	148	22.5	202	74.3	26.6	5 225	192
Sungei Buloh Hybrid No.4	R.R.I.M.	57	62	285	144	21.5	191	75.6	24.5	5 202	192
Sungei Buloh Synthetic Variety	R.R.I.M.	52	55	274	140	20.0	167	78.9	21.5	4 952	179
Sungei Buloh Hybrid No.1	R.R.I.M.	56	61	270	128	22.4	165	77.0	23.6	4 348	160
Sungei Buloh Hybrid No.3	R.R.I.M.	58	64	257	126	20.5	160	73.0	26.9	3 682	136
Cupurico x Flint Compuesto	M.A.R.D.I.	57	62	261	126	19.1	154	72.6	26.1	3 972	146
Improved Metro	M.A.R.D.I.	57	61	275	147	17.7	140	73.5	23.4	3 337	123

TABLE 10

THE PERFORMANCE OF EXISTING VARIETIES OF MAIZE (Contd)

Variety	Source	Days to		Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear weight at harvest (gm)	Shelling (%)	% moisture at harvest (%)	Grain yield 15% moisture (kg/ha)	Yield % of Guatemala (%)
		Tasell-ing	Silk-ing								
UPCA Variety No.1	M.A.R.D.I.	58	62	283	144	17.2	139	74.8	25.5	3 474	128
Bogor Comp. No.2	M.A.R.D.I.	55	60	273	143	17.8	136	74.7	24.3	3 367	124
MARDI Comp. No.1	M.A.R.D.I.	59	63	271	144	19.7	137	71.9	25.6	2 976	109
Guatemala		58	62	281	151	18.2	121	72.0	24.3	2 715	100

TABLE 11

YIELD OF METRO MAIZE IN TWO SPACING TRIALS (KG/HA)

Between row spacing (cm)	Trial (1)			Trial (2)		
	Within row spacing (cm)					
	22.9	30.5	45.7	22.9	30.5	45.7
30.5	2 006.59	2 578.30	3 217.27	2 914.6	3 508.73	3 351.79
61.0	3 228.48	3 105.17	2 555.88	3 508.73	3 217.27	2 925.81
91.4	2 387.73	2 320.47	2 073.85	3 015.43	2 589.51	1 905.70

Weed Control in Maize

Effect of Weeds on Crop

Woo and Pushparajah[13] showed that when weed regeneration was rapid, reduction in the yield of maize was about 25% (Table 12).

TABLE 12

EFFECT OF WEEDING ON YIELD OF MAIZE

Treatment	Yield of grains (kg/ha) Variety: Metro	Yield as percent of control
No weeding	2 010	100
Weeding at 2nd week	2 525	126
Weeding at 2nd and 4th week	2 580	128
Regular weeding	2 570	128

The results show that weeds that have regenerated by the second week of establishment of maize is critical. In this treatment at the fourth week a top dressing of N was applied along the rows and the soil ridged. This could have had some effect on controlling weeds

[13]Woo, Y.K. and Pushparajah, E. (1973) Weed control in groundnuts, soyabeans and maize. Proc. 3rd ASIAN Pacific Weed Control Conf. Kuala Lumpur 1971.

regenerating after the second week.

Chemical Control

As hand weeding is both intensive and expensive, chemical methods of control were also assessed. Woo and Pushparajah[14] found that various chemicals were effective (Table 13).

TABLE 13

EFFECT OF PRE-EMERGENT HERBICIDES ON WEED REGENERATION AND YIELD OF MAIZE

Treatment	Weeds at 4 weeks (%)			Yield of grains (kg/ha)	Yield as percent of control
	Grass and sedges	Dicots	Total		
Control	49	24	73	2 000	100
Handweeded at 2 weeks	5	8	13	2 520	126
Handweeded at 2nd and 4th week	7	6	13	2 580	129
Atrazine 1 kg a.i./ha	10	2	12	2 940	147
Planavin 1 kg a.i./ha	10	2	12	2 880	144
Alachlor (Lasso) 1 kg a.i./ha	1	24	25	2 710	136

Though atrazine was found to be the most effective chemical, because of its long residual effects and possible adverse interaction with a succeeding legume crop, it is generally not recommended (Woo and Pushparajah[15]). Of the other chemicals, Alachlor was recommended because of its effectiveness against grasses and sedges, these being generally more difficult to eradicate by hand. Further, Alachlor has a short residual effect (Woo[16]) and it does not even when used

[14] Woo, Y.K. and Pushparajah, E. (1973) Ibid.

[15] Woo, Y.K. and Pushparajah, E. (1973) Ibid.

[16] Woo, Y.K. (1973) Rate of breakdown and residual toxicity of sodium chlorate and alachlor in soil. Proc. 3rd ASIAN Pacific Weed Control Conf. Kuala Lumpur 1971.

at the above or higher rates, adversely affect legume crops of soyabean or groundnut.

Cultural Control

Pushparajah[17] found that within four weeks of tilling the soil, especially in the interrows of young rubber, about 50% of the ground was covered by weeds such as Eleusine indica, Cyperus sp. and Borreria latifolia. By increasing the time interval between ploughing and the final harrowing of the soil to about four weeks, a large percentage of the regenerating weeds can be eradicated. This would ensure that subsequent weed regeneration is minimal and can be readily controlled by chemicals.

Soil Suitability

Maize plant has a coarse fibrous root system which spreads widely and penetrates deeply. Because of such rooting habit this crop grows well in adequately drained medium textured soil, such as sandy clay loam, loam and clay loam or well aggregated clay soils. Very sandy and heavy clay soils are generally not suitable. For a soil to be suitable, it must have besides adequate nutrients, physical properties that are favourable for root development and anchorage of the crop. The following soil characteristics have to be taken into consideration for determining the suitability of soils:

- Soil profile
- Texture of the surface soil
- The slopes of thê land
- Other agronomic important factors, such as drainage, acidity, nutrient level and erosion.

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[17]Pushparajah, E. (1971) Weed control in rubber cultivation. Crop Protection in Malaysia (Wastie, R.L. and Wood, B.J. ed.), p.38. Kuala Lumpur: The Incorporated Society of Planters.

Using the index system of Guha and Soong[18] for the classification of soil suitability, each soil characteristic will be rated on the basis of its influence on the growth and yield of the crops. The most favourable or ideal condition of each factor is rated as 100%- as conditions become less favourable - the percentage value is decreased appropriately. The percentage rating values for the various factors are then combined together to give a single value, indicating the suitability of the soil. For example, a soil belonging to the Rengam series and having sandy clay loam texture, more than 130 cm deep, on 0 - 3% slope will be rated as follows:

			Rating value (%)
FACTOR A:	Profile more than 130 cm deep		100
FACTOR B:	Sandy clay loam texture		100
FACTOR C:	0 - 3% slope		100
FACTOR D:	Nutrient level	85	
	Acidity	90	

Suitability index = 100 x 100 x 100 x 85 x 90 = 77%

On the basis of the above system of rating the following soils are rated on their suitability for cultivation of maize.

If the slope factor is taken into consideration, then the value in Table 14 has to be multiplied by the values given in Table 15. For example, Serdang series soil has a rating of 77% when it is on level terrain, but if it occurs on hilly terrain then the rating becomes 31%. The rating becomes 15% if the soil occurs on steep terrains.

On the basis of the index value, the soils can be graded into five soil suitability classes as follows:

Class I (excellent) - soils with index values between 80 and 100%

Class II (good) - soils with index values between 60 and 79%

[18]Guha, M.M. and Soong, N.K. (1969) Suitability and prospects of rubber growing soils for intercropping. Crop Diversification in Malaysia (Blencowe, E.K. and Blencowe, J.W. ed.), Kuala Lumpur: The Incorporated Society of Planters.

Class III (fair) - soils with index values between 40 and 59%

Class IV (poor) - soils with index values between 20 and 39%

Class V (very poor) - soils with index values below 20%

Therefore, soils with index values below 40% is generally considered to be not suitable for planting of maize because of too many limitations.

TABLE 14

SUITABILITY INDICES OF MALAYSIAN SOILS FOR MAIZE

Soil series	Soil texture	Soil depth to parent material/ laterites/ water table (cm)	Suitability index (on 0-3% slope)
1. Kuantan) 2. Segamat) 3. Prang)	Clay (well aggregated)	130	90
4. Selangor	Clay to silty clay	130 - 50 150	35 25
5. Serdang	Sandy loam	130	77
6. Holyrood) 7. Tampoi) 8. Ulu Tiram)	Loamy sand	130	50
9. Harimau 10. Klau	Sandy clay loam to sandy clay	130	72
11. Jerangau) 12. Rengam) 13. Senai)	Sandy clay loam to clay loam	130 50 - 130 50	72 58 36
14. Munchong	Clay to clay loam	130	77
15. Bungor	Sandy clay loam	130	73
16. Malacca	Clay loam	50 - 75 25 - 50	46 31
17. Sg. Buloh	Loamy coarse sand	130	38
18. Batu Anam) 19. Durian)	Silty clay	50 - 75	22
20. Sogomana	Silty clay	130	32
21. Sitiawan	Silty clay	130	45

TABLE 15

RATINGS ACCORDING TO SLOPE FACTOR

Terrain class	Percent rating
Nearly level (0 - 3%)	100
Gently undulating (3 - 8%)	95
Rolling (8 - 16%)	85
Hilly (16 - 30%)	40
Steep (30 - 45%)	20
Very steep (45% and over)	10

The advantage of the rating system described above is that it is able to pin-point the factors that are causing the low rating for the soils. Holyrood, Tampoi and Ulu Tiram series soils have low rating mainly because of their low moisture retention characteristics and poor inherent fertility. These two factors can, however, be easily overcome by proper agro-management practices such as frequent irrigation and proper adjustment of fertilisers. Therefore, these three soils can be considered to be suitable for cultivation of maize. The limiting factor in Selangor series is drainage and acidity. To overcome both these factors they may require great economic outlays such as installation of an efficient drainage system and heavy liming. The returns obtained from the crop may not justify such expenditure.

There are other limiting soil factors which are not easily overcome by agro-management practices. Shallowness of soil depth is one and very poor moisture retention is the other. Soils of Malacca series are very shallow and have very little soil depth for root development of the crop. Cultivation of such soils also causes erosional hazard. Soils of the Sungei Buloh series are so sandy in texture that they retain very little available water for plant growth and leaching losses of nitrients in such soils are very serious. Very frequent irrigation and heavy fertilisation may help only to a certain extent.

Agro-management Practices on Soils Used for Maize Cultivation

Even though a soil may have a high suitability rating, once under cultivation, proper agro-management practices must be implemented to ensure that its fertility and productivity are maintained. Several of such practices deserve to be mentioned here.

(a) Cultivation at the right soil moisture. To prevent deterioration of soil structure, tillage and mechanical cultivation should be carried out when the soil is at the right moisture content. Table 16 gives the optimum moisture content at which some Peninsular Malaysian soils could be mechanically worked. These figures are valid only when light machinery with small loading pressures is used. If heavy machinery is to be used, the soil has to be worked at drier condition (2 to 5% by weight, depending on soil machinery used).

TABLE 16
OPTIMUM MOISTURE CONTENTS FOR MECHANICAL WORKING OF PENINSULAR MALAYSIAN SOILS

Soil series	Optimum moisture content (% W/W)
1. Kuantan, Segamat and Prang	28 - 30
2. Selangor, Sitiawan and Sogomana	24 - 26
3. Serdang, Tampoi, Holyrood, Ulu Tiram and Sg. Buloh	10 - 13
4. Jerangau, Rengam, Munchong, Senai and Bungor	16 - 18
5. Batu Anam and Durian	22 - 24
6. Klau and Harimau	14 - 16
7. Malacca	18 - 20

As a rule of thumb, mechanical cultivation should not be carried out immediately after heavy rain. For sandy soils of the Serdang, Tampoi, Holyrood, Ulu Tiram and Sungei Buloh series, cultivation can be carried out 24 to 48 hours after a heavy rain. For medium soils of the Jerangau, Rengam, Munchong, Senai and Bungor series, cultivation should be carried out four to five days after a heavy downpour.

(b) Contour tillage and terracing. The use of contour tillage and terracing is necessary for reducing soil erosion. This is particularly important for sedentary soils that are highly erodible, such as Serdang, Rengam, Tampoi, Harimau and other light textured soils. Contour tillage on 2 to 8% slopes can reduce soil loss to half when compared to tillage up and down the hills, when slopes exceed 8% terracing for ridging should be carried out. This conservation measure can reduce soil loss by more than 20%. In addition, water losses can be reduced by 12 to 20%.

(c) Frequency of fertiliser application. Sivanadyan[19] and Soong[20] have shown that leaching losses of nutrients, such as nitrogen and potassium in a sandy soil like Serdang series can be 30 to 40% of the applied fertilisers. In more clayey soils, like Munchong series, the magnitude of leaching was less than 10%. Since leaching of nutrients is so pronounced on sandy soils, it is necessary to increase the frequency of fertiliser application. This will reduce leaching losses and enhance uptake of nutrients by the plants. All those soils with sandy, loamy sand and sandy loam texture require this practice; the frequency should be increased as the sand content of the soil increases.

Fertiliser Application

In tropical countries, the rate of fertiliser application is about 90 - 125 kg N, 45 - 80 kg P_2O_5 and 30 - 60 kg K_2O per hectare[21]. In Malaysia, earlier work done in intensively cultivated farms[22] shows that in addition to farmyard and other

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[19] Sivanadyan, K. (1972) Lysimeter studies on the efficiency of some potassium and nitrogenous fertilisers on two common soils in West Malaysia. Proc. Second ASEAN Soil Conf. 1972, Djakarta (in press).

[20] Soong, N.K. (1973) Effects of nitrogenous fertilisers on growth of rubber seedlings and leaching losses of nutrients. J. Rubb. Res. Inst. Malaya, 23(5), 356.

[21] Jan G. de Geus (1973) Fertiliser guide for tropics and subtropics. 2nd edition. Zurich: Centre d' Etude del'Azote.

[22] Ministry of Agriculture, Federation of Malaya (1961) Maize. Agricultural leaflet No.45.

organic manures used, 65 kg N, 80 kg P_2O_5 and about 160 kg K_2O are needed. As the soil fertility status in rubber areas are different from intensively cultivated farmland, limited work on use of fertilisers for maize in such areas have been carried out in R.R.I.M.[23].

Nitrogen

Responses to nitrogen on its own were seen on the contrasting three soils examined by Pushparajah and Wong[24].

Results are shown in Table 17. Yield increases of 16 to 67% were obtained by doubling the N applied. In the experiment on Serdang series, soil application of N at the third level depressed yields.

TABLE 17
RESPONSE TO NITROGEN

	Soil series and yield (kg/ha)		
	Selangor	Colluvium of Serdang	Rengam
Level 1 of N	380	943	497
Level 2 of N	633	1 064	683
Level 3 of N	-	947	779
Level 2 as % of Level 1	167	116	137

Note: On Selangor unit level of N was 50 kg/ha and in the other two areas, unit level was 65 kg/ha.

[23]Pushparajah, E. and Wong Phui Weng (1970) Cultivation of groundnuts and maize as intercrops in rubber. Crop Diversification in Malaysia (Blencowe, E.K. and Blencowe, J.W. ed.), Kuala Lumpur: The Incorporated Society of Planters.

[24]Pushparajah, E. and Wong Phui Weng (1970) Ibid.

Phosphorus

Pushparajah and Wong[25] showed that even though rock phosphate was equally as efficient as soluble P for rubber, for maize, the latter was superior (Table 18).

TABLE 18

EFFECT OF PHOSPHATES ON DRY WEIGHT OF MAIZE PLANTS (KG/HA)

	Ploughed	Placed 5 cm below seeds	Mean
45 kg P_2O_5/ha (double super)	547	638	592
90 kg P_2O_5/ha (double super)	645	930	787
130 kg P_2O_5/ha C.I.R.P.	242	379	295
260 kg P_2O_5/ha C.I.R.P.	508	517	512
Nil P applied	-	-	91

Even though higher amounts of P were applied by C.I.R.P., the effectiveness was inferior to that of soluble P. For both forms of P, banding the fertilisers below the seeds was superior. In this trial, at the time of silking and tasselling a severe drought adversely affected cob formation and hence only yields of total plant dry weights are given.

In assessing the phosphate needs of maize, it was apparent that fairly good responses were obtained even on Selangor series soil, a soil where Hevea does not show response to P[26]. The nil P treatment gave a yield of 368 kg per hectare, while the P treatment gave a yield of 647 kg or a response. Absence of N or P or K led to crop failures on inland soils in the assessment of response to P on inland soils, nil P plots were not tested. The results showed that increasing the level of P_2O_5 applied from 55 kg to 110 kg was beneficial (Table 19).

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[25] Pushparajah, E. and Wong Phui Weng (1970) Op. cit.

[26] Pushparajah, E. (1964) Response of immature Hevea to fertilisers in three experiments sited on alluvial soils of the West Coast of Malaya. Rubb. Res. Inst. Malaya Res. Arch. Docum. No.32.

TABLE 19

RESPONSE TO P ON INLAND SOILS

Level	Treatment	Soil series and yield (kg/ha) Colluvium of Serdang	Rengam
1	55 kg P_2O_5/ha (soluble P)	761	517
2	110 kg P_2O_5/ha	1 252	849
	Level 2 as % of Level 1	164	164

A yield increase of about 64% was observed.

Potassium and Magnesium

As for P on Selangor series, even though rubber does not respond to K, a yield increase of 70% was obtained in maize to application of about 75 kg of K_2O per hectare. Among the inland soils, the response to K was higher on Rengam series than on the colluvium of Serdang series (Table 20).

TABLE 20

RESPONSE TO POTASSIUM

Level	Treatment	Soil series and yield (kg/ha) Colluvium of Serdang	Rengam
1	55 kg K_2O/ha	1 055	566
2	110 kg K_2O/ha	915	800
	Level 2 as % of Level 1	87	141

In fact in the colluvium of Serdang, a yield depression was obtained by increasing the level of K applied. This was attributed to the antagonistic effect of severe Mg deficiency observed[27]. Even on the trial on Rengam series, mild symptoms of

[27]Pushparajah, E. and Wong Phui Weng (1970) Op. cit.

Mg deficiency was observed and this could have suppressed the yield response to increased K.

Combined Applications of NPK

Good responses were obtained to combined applications of NPK using metro variety (Table 21).

TABLE 21

YIELD INCREASES TO NPK APPLICATIONS

	Soil series and yield (kg/ha)		
	Selangor	Colluvium of Serdang	Rengam
Nil fertilisers	112	155	65
NPK*	1 092	1 495	1 254
Yield as % of control			

*N on Selangor = 90 kg on others 120 kg/ha

P_2O_5 on Selangor = 75 kg on others 55 kg/ha

K_2O on Selangor = 55 kg on others 110 kg/ha

Where no fertilisers were applied, the crop was a virtual failure. However, in the two trials on inland soils, the lack of Mg may have adversely affected the response to NPK applications.

Liming

As most of the soils under rubber has a pH of 4.5 to 5.0, the value of liming was investigated[28]. In the initial trial, they showed that application of 560 kg per hectare of dolomitic lime gave an extra yield of 628 kg per hectare, or a yield of 1570 kg compared to the no liming treatment yield of 942 kilogram.

In a subsequent trial using metro variety, it was seen that even with a soil pH of 5, responses to increasing amounts of liming were obtained (Table 22).

[28]Pushparajah, E. and Wong Phui Weng (1970) Op. cit.

TABLE 22

INFLUENCE OF LIMING ON YIELD

Treatment[a]		Yield kg/ha
Mag. lime	620 kg/ha	2 139
	1240 kg/ha	2 807
	1860 kg/ha	3 146
	2480 kg/ha	3 393

[a]Other fertilisers applied in kg/ha was N = 105, P_2O_5 = 110, K_2O = 60.

By increasing the level of liming from 620 kg to 1240 kg an extra yield of 668 per hectare was obtained.

In the above applications, the lime was applied broadcast. Later Cheng[29] showed that by applying the lime only in the surface 5 cm of soil, 560 kg of Mag. lime could give the same effect as the higher rates used by Pushparajah and Wong.

Diseases and Pests of Maize

Seed Rots and Seedling Diseases

Maize seedlings normally are resistant to most parasitic diseases under the conditions that favour germination and early growth. But in wet soils a germinating maize kernel may be attacked by fungal parasites that caused the seed to decay and weaken the seedlings. Seed decay can be brought about by seed-borne fungi, viz. species of Diplodia, Giberella, Penicillium and Aspergillus, and many others of lesser importance[30,31].

[29]Cheng, Y.W. (1974) Op. cit.

[30]Stapley, J.H. and Gayner, F.C.H. (1969) Pests and Diseases. In World Crop Protection, Vol.1: London Iliffe Books Ltd.

[31]United States Department of Agriculture (1953) Plant diseases. The Yearbook of Agriculture, 337. The U.S. Government Printing Office, Washington D.C.

Soil-inhabiting fungi, however, are the most common cause of seed rots and seedling diseases. Various species of Pythium are the main cause of such diseases[32] although other fungi viz. Helminthosporium, Fusarium, Sclerotium and Corticium, which are all of lesser importance, can also occur. All these diseases can be controlled by seed dressing with Captan or Thiram.

Leaf Rusts

Two principal rusts attacking maize are caused by Puccinia polysora and Puccinia sorghi. Both have been considered serious and of economic importance in this country[33,34] commonly occurring in all the maize growing areas, where high rainfall and temperature along with high humidity favour establishment of the disease[35]. Maize rust attack is symptomised by the numerous small pustules that develop on the leaf which eventually dries up. Heavy infection may result in heavy loss of crop because of reduced cob formation[36] (Plate 1).

Although many of the locally grown varieties are susceptible to rust, the disease appears rather late and is therefore unlikely to reduce the yield of vegetable by very much[37]. Nevertheless, the use of resistant varieties should be adopted in order that such disease can be avoided.

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[32] Rubber Research Institute of Malaya (1971) Disease problems of intercrops. Plrs' Bull. Rubb. Res. Inst. Malaya No.112, 62.

[33] Singh, K.G. (1973) A checklist of host and diseases in Peninsular Malaysia. Division of Agric. Bull. No.132, 66. Ministry of Agriculture and Fisheries, Malaysia.

[34] Ministry of Agriculture and Fisheries (1972) Maize. Agricultural Leaflet No.45, 4.

[35] Lee, B.S. and Verghese, G. (1972) Susceptibility of maize (Zea mays L.) varieties to Malayan isolates of Puccinia polysora Undrew. Mal. Agr. Res. 1(1), 31.

[36] Frahlich, G. and Rodewald, W. (1970) Pests and diseases of tropical crops and their control. Pergamon Press.

[37] Graham, K.M. and Yap, T.C. (1973) Chinta: a new tropical sweet corn. The Planter, No.49, 188. Kuala Lumpur.

Plate 1. Leaf rust by Puccinia sp.

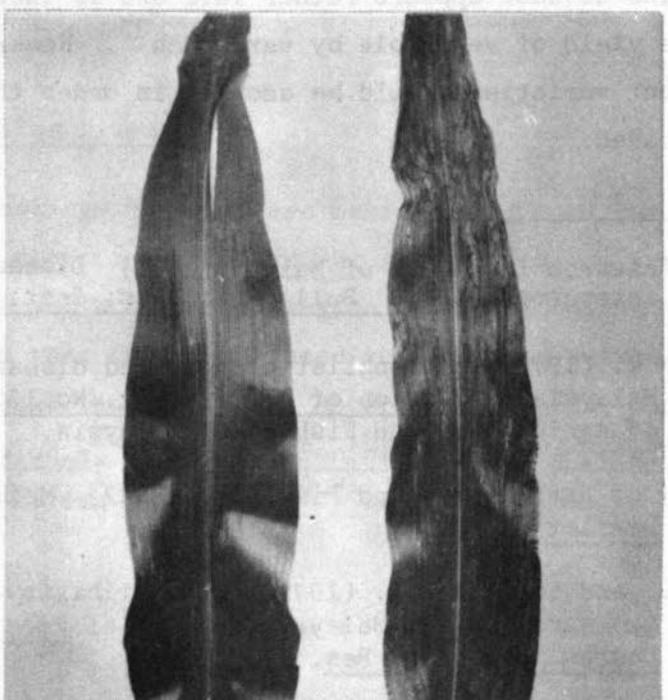

Plate 2. Leaf blight by Helminthosporium sp.

Leaf Blight

Although the disease is not present in epiphytotic proportion in Malaysia, it is present in nearly all maize plantings[38]. Of the two causal fungi - Helminthosporium maydis and H. turcicum, the former is more common.

A heavy infection before tasselling can cause severe damage while in less favourable weather conditions, only minor damage may result. Consequently, a loss ranging from a trace to as much as 50% may occur[39]. Effective leaf area reduction resulting in yield loss occurs where infection by either of the two causal fungi produces numerous large elliptical and greenish to yellowish brown spots on the leaves (Plate 2). In severe cases the spots may cover the whole leaf, thus killing the entire leaf which can eventually serve as a source of inoculum[40].

Although Goh[41] has shown that the incidence of H. turcicum can be reduced by weekly spraying of 0.25% Perenox, to date, no economic chemical control is recommended for maize rust. The most satisfactory control is to obtain resistant varieties[42,43].

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[38]Liew, K.W. and Graham, K.M. (1972) Effects of leaf infection by Helminthosporium maydis on grain yield of maize. Mal. Agr. Res. 1(1), 24.

[39]Roberts, A.L. (1953) Some of the leaf blight of corn. U.S.D.A. Year Book of Agriculture, 380. U.S.D.A. Washington, D.C.

[40]Hanna, A.D. (1969) Crop disease review, maize. PANS, Vol.15(1), 31.

[41]Goh, P.E. (1969) Maize and sorghum research. Past, present and future in West Malaysia. The Proceedings of the Malaysian Maize and Sorghum Coordination and Improvement Workshop. Fed. Expt. Stn. Serdang (Goh Pek Eam ed.), 56. Selangor.

[42]Goh, S.L. and Goh, P.E. (1969) Brief notes on maize and sorghum diseases in West Malaysia. The Proceedings of the Malaysian Maize and Sorghum Coordination and Improvement Workshop. Fed. Expt. Stn. Serdang (Goh Pek Eam ed.), 54. Selangor.

[43]Yap, T.C. and Graham, K.M. (1972) Performance of sweet corn varieties (Zea mays L.) under local conditions. Mal. Agr. Res. 1(1), 1.

Other Diseases

Although the following diseases have been recorded locally[44], they are considered of minor importance since their occasional occurrence has been somewhat negligible and scattered.

Leaf blights caused by: Corticium solani, Curvularia leonensis, Khuskia oryzae, Leptosphaerulian trifolii.

Leaf spots caused by: Curvularia sp., Phyllosticta zeae, Cochliobolus heterostrophus.

Flower moulds caused by: Cochliobolus heterostrophus, Cladosporium sp., Curvularia pallescens, Fusarium equiseti.

Stalk rots caused by: Erwinia carotovora f. sp. zeae Pythium aphamidermatium

Smut caused by: Ustilago maydis

No economic chemical control has been recommended for all of the diseases as listed above.

Pests of Maize

Maize is a favourite host of a large number of pests, as may as thirty-five having been recorded in Malaysia alone[45]. Most of them have a number of other host plants as well, particularly among graminaceous crops, occasionally becoming a localised problem on maize. The commonest and the most important pests however are two species of caterpillars - Pyralid Ostrinia salentialis and a Noctuid Heliothes obsoleta. An aphid Rhopalosiphum maidis is also common, but causes only minor damage. Planting in areas infested with

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[44] Goh, S.L. and Goh, P.E. (1969) Op. cit.

[45] Yunus, A. and Ho, T.H. (1969) The biology and chemical control of the maize stem borer Ostrinia salentialis. Malay. Agric. J. 47, 109.

cockchafer grubs can result in heavy mortality of seedlings. Rats may become troublesome when the cobs are fully formed.

Commonly known as maize stalk borer, O. salentialis (Plates 3a and 3b) feeds on almost all parts of the plant: in the early stages, externally on the leaf whorls, thereafter internally within the stem or inside the ears, sometimes also in the tassel and silk. Plants get attacked about four weeks after germination, the greatest damage caused when a number of caterpillars bore into the stem of the same plant before the cobs are formed. Later attacks on the stem are known to have little effect on yield, but then the cobs get infested. In a life cycle of four weeks, the caterpillar stage lasts about eighteen days. The European corn borer Ostrinia nubilalis is generally controlled by spraying DDT, gamma BHC, carbaryl or endrin at intervals of seven to ten days from the fourth week onwards. Good control of O. salientialis have been reported in Malaysia with 0.1% gamma BHC or dieldrin applied high volume four times at fortnightly intervals[46]. Trials with medium low-volume spraying (200 litre per hectare) with mist-blowers using 0.4% carbaryl, 0.4% trichlorphon, 0.175% endosulfan sprayed five times brought about only partial control of the pest, while high-volume spraying (400 - 600 litre per hectare) of 0.1% carbaryl, 0.05% gardona, 0.05% dieldrin or 0.05 fenitrothion sprayed at ten-day intervals gave only partial control[47]. He also showed that granular formulation of 5% endosulfan, 2% endrin, 10% diazinon and 5% gardona applied directly into the leaf whorls only twice, at four and seven weeks, gave satisfactory control. Granules of gamma BHC were found to be phytotoxic to young leaves. The amount of granules required for the two applications are 12 and 18 kg respectively per hectare. Although this method of treatment is attractive from the point of view of better control and lesser number of applications required, there is no suitable equipment known that will deliver the granules directly into the whorls. This is now done manually by shaking a

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[46] Yunus, A. and Ho, T.H. (1969) Op. cit.

[47] Rao, B.S. (1970) Pest problems of intercropping in plantations. Crop Diversification in Malaysia (Blencowe, E.K. and Blencowe, J.W. ed.), Kuala Lumpur: The Incorporated Society of Planters.

Plate 3a. Stalk-borer Ostrinia salentialis - external symptoms.

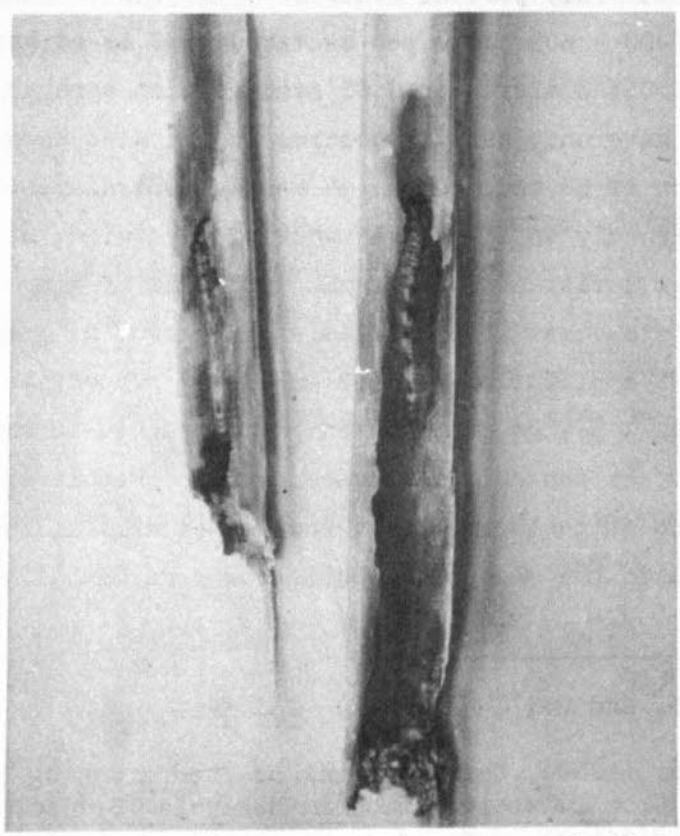

Plate 3b. Stalk-borer Ostrinia salentialis - internal damage.

large-sized talcum powder tin containing the granules, the perforated end facing downwards over the whorls. Further, the treatment affords protection only against the pest feeding in the stem, not in the cobs.

The second serious caterpillar pest, H. obsoleta (Plate 4), is commonly known as corn earworm. Like the stalk borer it is polyphagous; on maize it feeds on the ripening grains within the developing cobs. The corn earworm is controlled by spraying 0.2% DDT directly on the newly formed cobs, followed by a second application two weeks later[48].

Plate 4. Corn earworm Heliothes obsolera.

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[48]Rao, B.S. (1970) Op. cit.

CHAPTER IV

ECONOMICS OF PRODUCTION

CHAPTER IV

ECONOMICS OF PRODUCTION

The substantial local demand for maize as a component in animal feedstuffs and to a lesser extent as fresh cobs suggests an attractive potential for the crop. In addition, since maize is popularly cultivated in rural areas as a supplementary food crop, most rubber smallholders are likely to be familiar with the crop. Returns to maize production is however influenced in practice by a number of economic variables, namely cost, yield and price of the marketed product. Towards providing an indication of profitability in intercropping maize this section examines the effect of differences in these variables on returns. A breakeven analysis is also performed to indicate the extent to which profitability alters under extreme conditions.

Assumptions

A range of yields and prices commonly encountered locally are employed in the exercise. Yield levels are assumed to range from 25 000 to 45 000 cobs per hectare which, in terms of dried grains, is estimated to be 2200 - 4000 kg grains per hectare. In practice, big and small cobs are usually produced in the ratio of 3 : 1. The price ranges of big and small cobs are assumed to be 8 - 10 ct and 5 - 6 ct per cob respectively while six grain price levels of \$250, \$300, \$350, \$400, \$450 and \$500 per tonne are used.

Establishment, maintenance, harvesting and drying costs are based on R.R.I.M. field experience with the crop on smallholdings. Two levels of establishment costs are evident since cost of land preparation in the first intercrop on newplanting/replantings has been found to be higher than areas intercropped previously. Current prices are employed to value the inputs of fertilisers, herbicides and pesticides.

Labour requirements estimated for all operations, except land preparation which is normally done by contract, provide an indication of the hectarage that can be maintained by a smallholder if family labour only is employed. However, unemployed or under-employed labour outside the family can be hired for the various operations at varying levels. It is useful, therefore, to budget for a situation in which labour is totally hired so as to indicate the lowest level of profitability.

Maize is assumed to be sold either as cobs for direct consumption or as grains to feedmills. The former outlet is, however, limited in scope at any one time in a given locality. As such, where large-scale production is intended the product must necessarily be sold as dried grains. In the exercise farmgate price for cobs and ex-factory prices for grains are employed.

Costs and returns are computed on the basis of per sole crop hectare. In terms of intercropped area (per rubber hectare), the equivalent results will be 70% of the sole crop area, assuming a planting distance of 30 by 9 ft for rubber.

Results

Cost of Production

Table 23 depicts a detail breakdown of material and labour costs. As noted earlier, cost of land preparation incurred in the first crop ($198 per hectare) is substantially higher than that in the second crop ($49.4 per hectare). Amongst the inputs, the cost of fertiliser is the most significant accounting for 40 and 45% of total grain production costs in the first and second crop respectively. It is, however, essential to ensure that such a level of fertilisation is carried out to attain the postulated yield levels. Total labour cost is estimated to be $284 - $288 per hectare which will accrue to the smallholder if he provides all the labour requirements. Total material costs inclusive of land preparation is considerably higher totalling $748 and $567 per hectare in the first and second crop respectively. It should however be noted that costs have been estimated on the high side and that in practice variation is also likely to occur between localities especially in respect to land

TABLE 23

ITEMISED COST OF MAIZE PRODUCTION (PER CROP HECTARE)

Item	First crop		Second crop	
	Amount	Man-day[a]	Amount	Man-day
	$		$	
Land preparation[b]	198.0	0	49.4	0
Planting materials:				
Seeds 13.5 kg @ $1.50/kg	20.2	0	20.2	0
Seed dressing 56 gm Thiram @ $9.90/kg	0.6	0	0.6	0
Planting labour	(78.1)[c]	25.2	(78.1)	25.2
Fertilisers:				
Magnesium limestone 500 kg/ha	20.7	-	20.7	-
Sulphate of Ammonia 550 kg/ha	209.0	-	209.0	-
Double Super Phosphate[d]	131.0	-	98.3	-
Muriate of Potash 120 kg/ha	39.6	-	39.6	-
Kieserite 20 kg/ha	8.2	-	8.2	-
Manuring labour	(65.7)	21.2	(62.3)	20.1
Weed control:				
Materials 3.5 litre Lasso @ $11 per litre	38.5	0	38.5	0
Spraying labour	(7.7)	2.5	(7.7)	2.5
Pest and disease control:				
Materials[e]	39.4	0	39.4	0
Labour	(21.7)	7.0	(21.7)	7.0
Harvesting[f] 1350 cobs/manday	(80.3)	25.9	(80.3)	25.9
Total costs (cob production)	958.7	81.8	774.0	80.7
Shelling[g]:				
Fuel 19.4 litre petrol @ $0.61 per litre	11.8	0	11.8	0
Labour	(26.5)	8.5	(26.5)	8.5
Drying (Mechanical)[g]:				
Fuel 27.3 litre kerosene @ $0.18 per litre	4.9	0	4.9	0
Labour	(8.1)	2.6	(8.1)	2.6
Total costs (grain production)	1 010.0	92.9	825.3	91.8

[a]Eight hour day.

[b]First crop requires two ploughs and two harrows. Two rotovation rounds are sufficient for the second crop.

[c]Figures in brackets refer to estimated family labour cost assuming a hired rate of $3.10 per manday.

[d]200 kg/ha and 150 kg/ha for first and second crop respectively.

[e]As recommended in text.

[f]Assuming an average yield of 35 000 cobs/ha which is equivalent to 3100 kg grains/ha.

[g]Direct costs only.

preparation and hired labour.

Gross Revenue

Maize can either be marketed as cobs for direct consumption or as dried grains mainly for animal feeds. The former outlet is however limited in any one locality, but it can be tapped the gross revenue is extremely high. For example, assuming that big and small cobs, which are normally produced in the ratio of 3 : 1, are sold at an average farmgate price of 9 and 5 ct respectively, the gross revenue at the yield levels assumed (25 000 - 45 000 cobs per hectare) will range from $2000 to $3600 per hectare. It is, however, more realistic to aim for the dried grain market especially if large scale production is carried out. In such a case, at the postulated prices ($250 - $500 per tonne) and yield levels (2.2 - 4.0 tonne grains per hectare) the gross revenue is expected to range from $550 to $2000 per hectare.

Profitability

Profitability in maize production is assessed in terms of both net revenue and family returns, in order to reflect the respective situations where hired workers and family labour are used exclusively. Where a combination of hired and family labour is employed the performance can be inferred from the results.

It is clear from the estimated cost and gross revenue of fresh cob production that profitability is very high even at the lowest yield and price level assumed. The limited market also suggests that only a small area in any one locality can take advantage of this attractive outlet. In view of this profitability of fresh cob production is not discussed further although relevant data has been presented earlier.

(i) Net revenue from grain production. Table 24 depicts the net revenue at various yield and price levels when maize is cultivated as a first and second crop. As expected net revenue from the first crop is lower due mainly to higher land preparation and fertiliser costs. Combinations of yield and price which give positive net revenue are shown below the line indicated in the table. With

TABLE 24

ESTIMATED NET REVENUE FROM MAIZE AT DIFFERENT YIELD AND PRICE LEVELS ($ PER CROP HECTARE)

Price $/t	Yield (t/ha)				
	2.20	2.65	3.10	3.55	4.00
First crop					
250	-421.8	-328.4	-235.0	-141.3	-47.5
300	-311.8	-195.9	-80.0	-36.2	152.5
350	-201.8	-63.4	75.0	213.7	352.5
400	-91.8	69.1	230.0	391.2	552.5
450	18.2	201.6	385.0	568.7	752.5
500	128.2	334.1	540.0	746.2	952.5
Second crop					
250	-237.1	-143.7	-50.3	43.4	137.2
300	-127.1	-11.2	104.7	220.9	337.2
350	-17.1	121.3	259.7	398.4	537.2
400	202.9	386.3	569.7	753.4	937.2
500	312.9	518.8	724.7	930.9	1 137.2

higher levels of these variables a corresponding increase in net revenue is registered indicating the potential of maize production under such conditions.

(ii) Expected family earnings from grain production. Table 25 depicts the estimated family earnings from maize production in which total labour requirement is provided by the smallholder. The table reveals that cash costs are not recovered only in three combinations of yield and price in the first crop. The increase in positive family returns that can be obtained at higher yield and price levels indicates that maize grain production can be a profitable proposition. In this connection, it should be noted that to attain higher earnings effort should be directed primarily to improving yield which unlike price is more amenable to control by the smallholder.

TABLE 25

EXPECTED FAMILY EARNINGS FROM MAIZE AT DIFFERENT YIELD AND PRICE LEVELS ($ PER CROP HECTARE)

Price $/t	Yield (t/ha)				
	2.20	2.65	3.10	3.55	4.00
First crop					
250	-167.0	-57.1	53.1	163.1	273.2
300	-57.0	75.4	208.1	340.6	473.2
350	53.0	207.9	363.1	518.1	673.2
400	163.0	340.4	518.1	695.6	873.2
450	273.0	472.9	673.1	873.1	1 073.2
500	383.0	605.4	828.1	1 050.6	1 273.2
Second crop					
250	14.3	124.3	234.4	344.4	454.5
300	124.3	256.8	389.4	521.9	654.5
350	234.3	389.3	544.4	699.4	854.5
400	344.3	521.8	699.4	876.9	1 054.5
450	454.3	654.3	854.4	1 054.4	1 254.5
500	564.3	786.8	1 009.4	1 231.9	1 454.5

Breakeven Yields

This section illustrates the grain yield level that must be attained in order to recover production costs in the first and second crops. Figure 1 depicts the breakeven yield curves constructed for situations where (a) labour is totally hired and (b) family labour is used. As could be expected the curves show a progressive increase in breakeven yield with reduced prices. Assuming an average price of $350 per tonne the breakeven yield in situation (a) in the first and second crops are 2.9 and 2.4 tonnes per hectare respectively (denoted by y_1 and y_2), while the corresponding breakeven yields for situation (b) are 2.1 and 1.5 tonnes per hectare (denoted by y_3 and y_4). Generally the figure provides a useful indication of profitability since any combination of yield and price above the respective breakeven yield curves will generate positive net revenue or family earnings and *vice versa*.

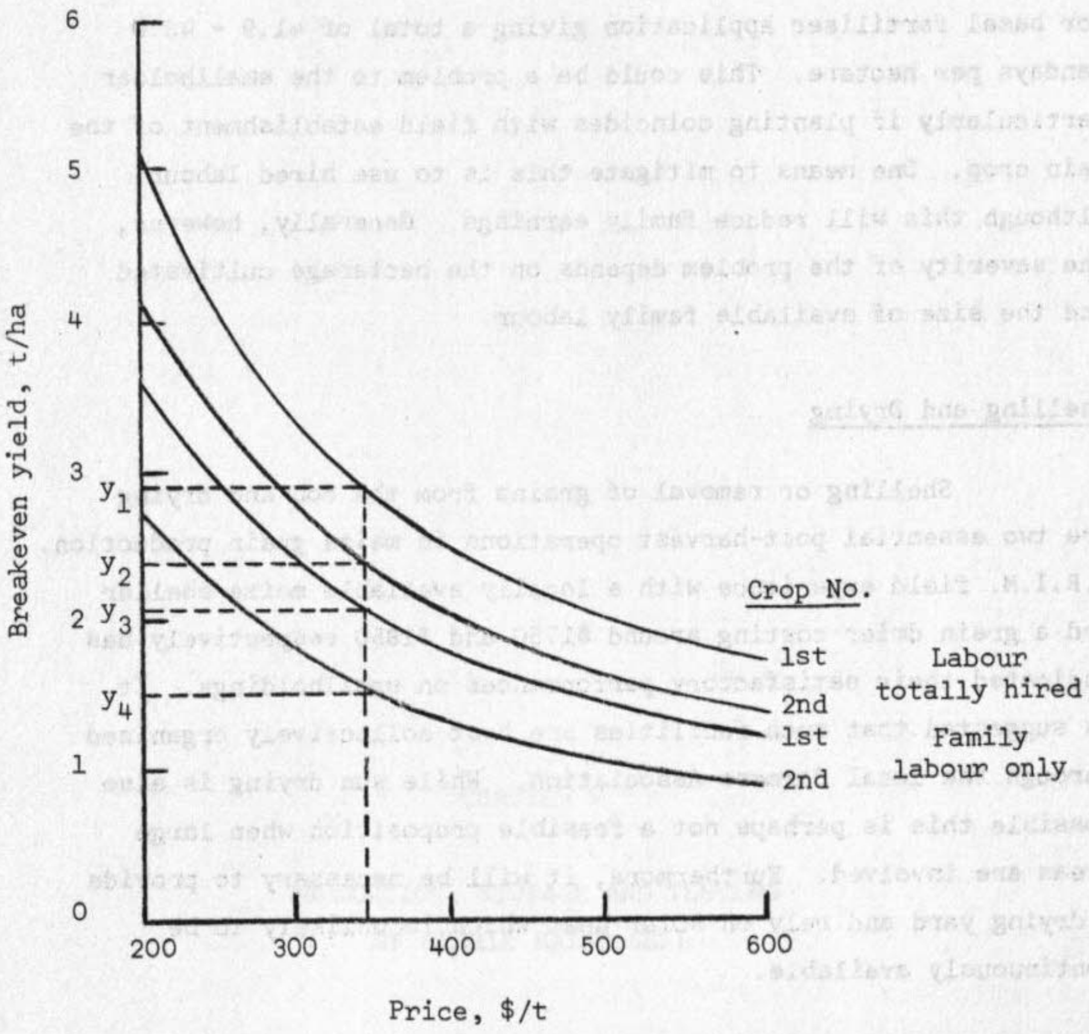

Figure 1. Breakeven yield at various price and yield levels in maize grain production.

Other Considerations

In planning a maize intercropping programme it is essential to take into account a number of related considerations which have an important bearing on field implementation. These include the availability of labour during initial establishment, shelling and drying facilities and marketing of the crop.

Labour Requirements

Nearly half of the total labour requirements is accounted for by operations during planting. This includes 25.2 mandays per hectare for lining and sowing, 2.5 mandays per hectare for pre-emergence herbicide spraying and 14.2 - 15.3 mandays per hectare for basal fertiliser application giving a total of 41.9 - 43.0 mandays per hectare. This could be a problem to the smallholder particularly if planting coincides with field establishment of the main crop. One means to mitigate this is to use hired labour although this will reduce family earnings. Generally, however, the severity of the problem depends on the hectarage cultivated and the size of available family labour.

Shelling and Drying

Shelling or removal of grains from the cob and drying are two essential post-harvest operations in maize grain production. R.R.I.M. field experience with a locally available maize sheller and a grain drier costing around $1750 and $1850 respectively has indicated their satisfactory performances on smallholdings. It is suggested that such facilities are best collectively organised through the local Farmers Association. While sun drying is also possible this is perhaps not a feasible proposition when large areas are involved. Furthermore, it will be necessary to provide a drying yard and rely on solar heat which is unlikely to be continuously available.

Marketing

The local maize grain market is the animal feed industry. Since most feedmills are large volume buyers, smallholders should arrange to sell in bulk either with the aid of the local Farmer Association or through collective sales. In such an arrangement price negotiations and transport of grains to the feedmill will be facilitated while the opportunity to negotiate with alternative buyers will aid the smallholder in securing competitive prices.

CHAPTER V

PRODUCTION, STORAGE AND TESTING OF HYBRID MAIZE SEED

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OF HYBRID MAIZE SEED

Hybrid maize is required for high yields. In Malaysia, the R.R.I.M. can be considered to be the first organisation to have bred hybrid maize suited for local condition. Some of these hybrids have yielded well above 5000 kg per hectare under rain-fed conditions.

Method of Breeding Hybrid Maize

The following stages are involved in the breeding of hybrid maize:

1. Development of inbred lines (pure) by controlled self-pollination of open pollinated varieties of maize.

2. Determination of the specific combination of inbred lines that will give the most desirable progeny.

3. The best combinations of the inbred lines are repeated on a large scale for commercial hybrid seed production.

The above stages are elaborated below.

Development of Inbred Lines

The ear of an open pollinated maize plant is fertilised with the pollen from the same plant. The seeds resulting from this are grown in the field. This first generation progeny is of reduced vigour and low yield. The heterozygosity is reduced to 50 %. The plants possessing the desirable agronomic characters are selected and selfed again. The heterozygosity is further reduced in each successive generation as shown in Table 26. The process of inbreeding and selection is continued until the desirable agronomic

TABLE 26

RATE OF INCREASE OF HOMOZYGOSITY AND DECREASE OF HETEROZYGOSITY DURING REPEATED INBREEDING OF AN OPEN POLLINATED PLANT

Generation selfed	Heterozygosity (%)	Homozygosity (%)
0	100	0
1	50	50
2	25	75
3	12	88
4	6	94
5	3	97
6	1	99

characters are established. This usually takes about six generations when the homozygosity is increased to about 99%. After this, heritable characters can be considered to have been fixed and the inbred lines or biotypes could be maintained by selfing without any further segregation in the progeny or reduction in vigour.

Technique of Selfing

The ear of the plant selected for selfing is covered with a small paper bag. This will prevent any rogue pollen from reaching the silks. When the silks come out of the husks the bag is removed and pollen obtained from the tassel of the same plant is dusted on the silks. After dusting the ear is covered with the paper bag. The technique of selfing used in R.R.I.M. production of inbred lines are illustrated in Plates 5 to 10.

Determination of the Specific Combinations of Inbred Lines

The inbred lines are crossed in all possible single-cross combinations. The progeny are then tested in a comparative trial and the best combinations noted. The inbred lines possessing high specific combining ability are multiplied further for use in commercial seed production. Choice of inbred line as pollinator (male parent) will depend on which inbred produces the most supply of pollen. Similarly, the choice of inbred as seeder (female parent)

Plate 5. The tassel is covered with a paper bag in order to collect pollen from the plant.

Plate 6. Paper bag is fastened with a stapler.

Plate 7. The ear shoot is cut back to encourage emergence of silks.

Plate 8. After the ear shoot is cut back, it is covered with a paper bag.

Plate 9. Pollen collected in the tassel bag is dusted over the silks of the ear.

Plate 10. The tassel bag is pulled down over the ear shoot and fastened with a stapler.

will depend on which inbred produces the best ear and seed characteristics.

There are two popular types of commercial hybrid seeds, viz. single-cross and double-cross hybrids.

Single-cross hybrid. A single-cross hybrid is the first generation progeny of two inbred lines which are known to possess high specific combining ability. However, it has a narrow environmental adaptability. A superior single-cross retains the vigour and productiveness that are lost during inbreeding and will be more vigorous and productive than the original open pollinated parent from which the inbreds are derived. Not all combinations will produce superior single-crosses. Whether two particular inbreds will combine to produce a high yielding single-cross will depend upon the extent to which favourable genes for yield from one inbred supplement those contributed by the second inbred. The increase in vigour and productiveness of a single-cross is a phenomenon called hybrid vigour.

Double-cross hybrid. This type of hybrid seeds are produced by crossing two promising single-cross varieties. It combines in one hybrid the gene combinations of four different parents. The double-cross hybrid usually yield more seeds than single-cross hybrids. Moreover, they have a wider environmental adaptability.

Commercial Hybrid Seed Production

The proven hybrid maize seeds have to be produced separately every year for the smallholders. Seeds obtained directly from the field planted with hybrid maize should not be used as they would yield about 15 - 20% less.

For successful production of pure hybrid seed on a commercial scale, the field should be in an isolated site or be about 220 metres away from other maize growing areas which do not have frequent dry winds. The steps required for hybrid seed production are shown in Figure 2.

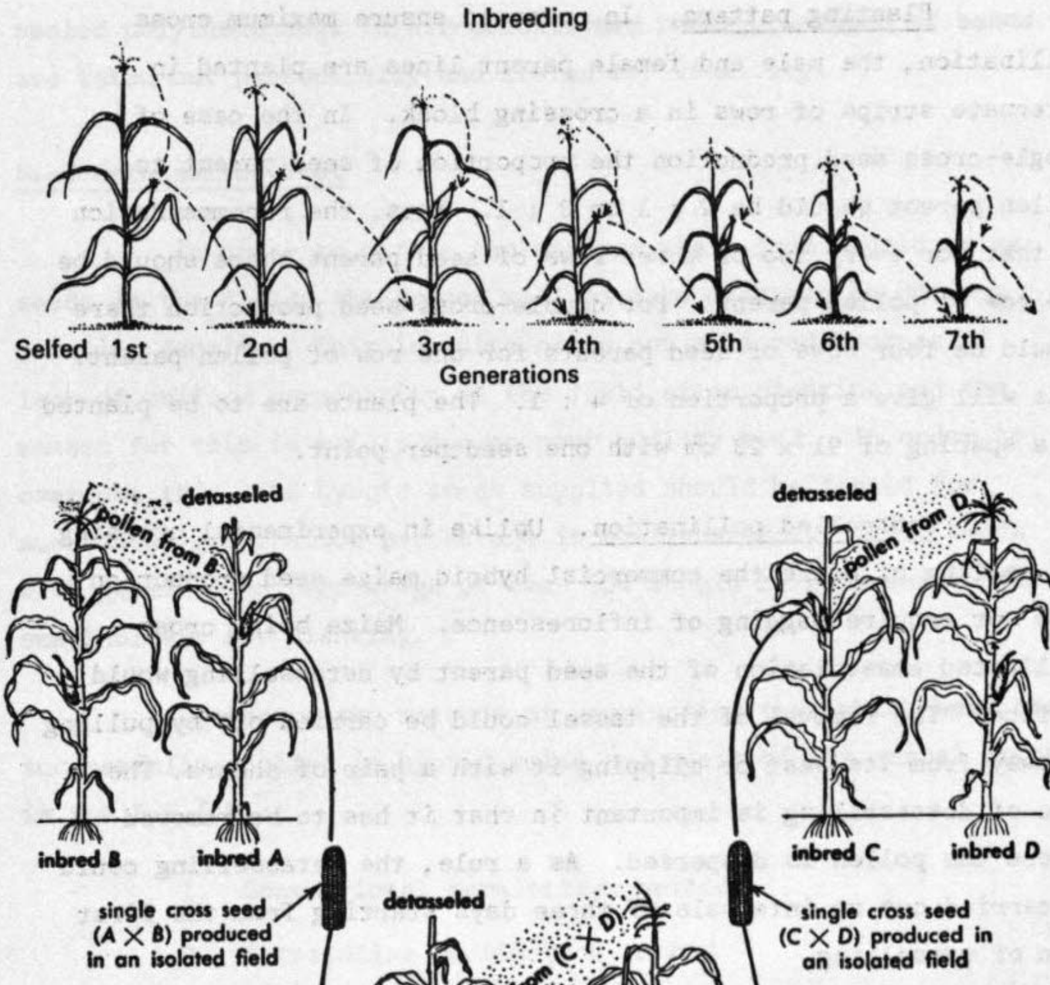

Figure 2. Method of producing single-crosses and double-crosses of hybrid by detasseling procedure.

Planting pattern. In order to ensure maximum cross pollination, the male and female parent lines are planted in alternate strips of rows in a crossing block. In the case of single-cross seed production the proportion of seed parent to pollen parent should be 2 : 1 or 3 : 1. Thus, the recommendation is that for every two or three rows of seed parent there should be one row of pollen parent. For double-cross seed production there should be four rows of seed parents for one row of pollen parent. This will give a proportion of 4 : 1. The plants are to be planted at a spacing of 91 x 23 cm with one seed per point.

Controlled pollination. Unlike in experimental crossing and selfing of maize the commercial hybrid maize seed production does not require bagging of inflorescence. Maize being cross-pollinated emasculation of the seed parent by detasselling would suffice. The removal of the tassel could be carried out by pulling it away from its seat or clipping it with a pair of shears. The time of detasselling is important in that it has to be removed before the pollen is dispersed. As a rule, the detasselling could be carried out at intervals of three days starting from the first sign of tasselling.

In some countries in order to avoid the process of emasculation of the seed parent, the plant breeders have developed male sterile lines which are used as seed parents.

Harvesting and drying. The seeds with ear is harvested when the moisture is 35%, usually after ninety-five days from planting. They are then dehusked, desilked and cleaned of other debris. The ears are then dried either in the sun or in artificial drier until they reach a moisture level of about 10%. The ears are then shelled by machinery to separate the grain from the cob. They are then sorted by discarding all damaged and small seeds.

Storage. The seeds to be stored are dried to a moisture of about 8% and treated with Thiram 75 fungicide and Lindane 20 insecticide at the rate of 100 g of each chemical for 25 kg of seeds. The seeds are then packed in polythene bags and stored in cold rooms where a temperature of 40 - 50°F and relative humidity of about 55% is maintained. Alternatively, they can be stored in sealed polythene bags in air-conditioned rooms. Samples of seeds are taken out periodically and tested for viability.

Seed Germination Test

In order to obtain the maximum yield from hybrid maize seeds in the field, the grower will have to maintain an optimum planting density. This is quite often not achieved because of lack of uniform germination in the field after planting and the reason for this is mainly due to poor quality seed. In order to overcome this, the hybrid seeds supplied should be tested for successful germination percentage in the laboratory. Only seeds with germination percentage of over 90% should be released to the smallholders for planting.

There are two methods of germination test which have been successfully applied in hybrid maize and seeds of the annual crops in the R.R.I.M.:

1. Conventional germination method
2. Tetrazolium germination method

Conventional germination method. A random sample of seed is removed from the lot to be distributed to the smallholders. The seeds are then spread on any moisture absorbent material such as cotton cloth, blotting paper or even newsprint paper. The seeds are then covered with the similar material and the seeds are in moist condition by spraying water on the absorbent material. The sample size for a test of this type is 400 seeds per lot and it should be replicated four times using 100 seeds for each replication. The test is carried out in the laboratory under ambient temperature. The first germination count made after four days and the final count after a week. The result is expressed as a percentage of successful germination.

Tetrazolium germination method. This method is employed when the result of the viability test is required immediately. The seeds are first conditioned by soaking for four to six hours in water. After the seeds have imbibed sufficient water and softened, they are sectioned longitudinally and medially with a razor to expose the embryo. The sectioned seeds are immersed immediately in a 0.5% solution of Tetrazolium salt (2.3.4. triphenyl tetrazolium chloride). Tetrazolium salt is oxidation reduction indicator and the development of a non-diffusible red colour in the tissue is the result of reduction of the chemical by enzymatic action. The seeds are kept in the dark in the oven where the temperature maintained at 30°C to 40°C for thirty minutes to one hour. The embryos of viable seeds are stained bright red within this period. After staining, the tetrazolium solution is drained off and the seeds are washed in water and evaluated for viability. The seeds in which the embryo displayed clearly defined unstained parts are rated as non-viable.

R.R.I.M. Hybrid Maize Varieties

Single-cross hybrids produced by R.R.I.M. In the R.R.I.M., the following single-cross hybrids illustrated in Plates 11 to 14 have been produced from the inbred lines SB No.11, SB 93, SB 151, SB 532 and SB 658. In the crossing of the inbred lines the number mentioned first is always the seeder parent and the second inbred line number the pollinator parent.

Varieties	Inbred lines	Yield kg/ha
Sungei Buloh Hybrid No.2	532 x 11	5 420
Sungei Buloh Hybrid No.5	658 x 532	5 225
Sungei Buloh Hybrid No.4	93 x 532	5 202
Sungei Buloh Hybrid No.1	151 x 532	4 348

One hectare of single-cross hybrid will produce between 1100 kg to 1200 kg of seeds which can be planted in 65 - 70 hectares.

Double-cross hybrids produced by R.R.I.M. The following double-cross hybrids have been produced from the same inbred lines No.SB 11, SB 93, SB 151, SB 532 and SB 658.

Varieties	Inbred lines	Yield kg/ha
Sungei Buloh No.11	(93 x 532) x (151 x 658)	4 906
Sungei Buloh No.12	(532 x 11) x (151 x 658)	5 176

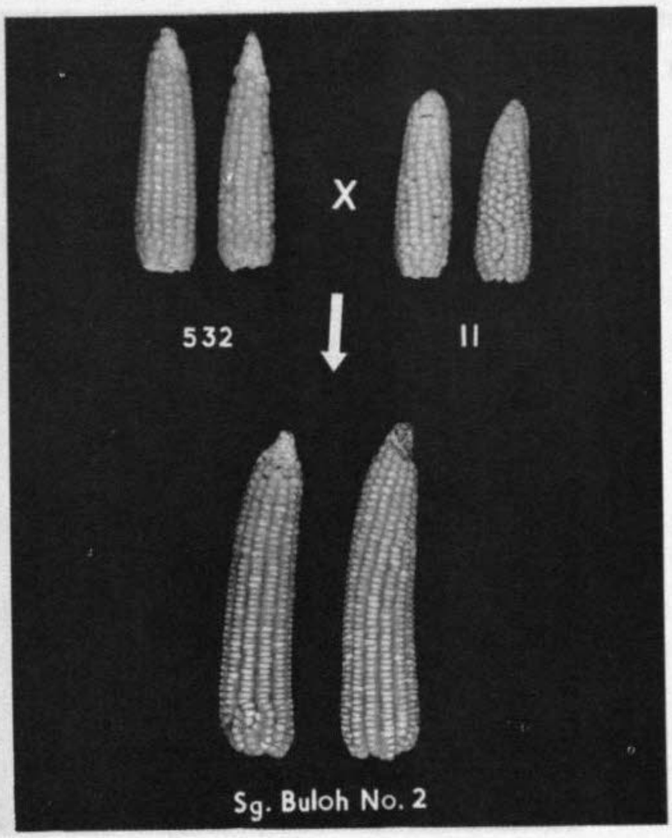

Plate 11. Sungei Buloh Hybrid No.2 and its inbred parents.

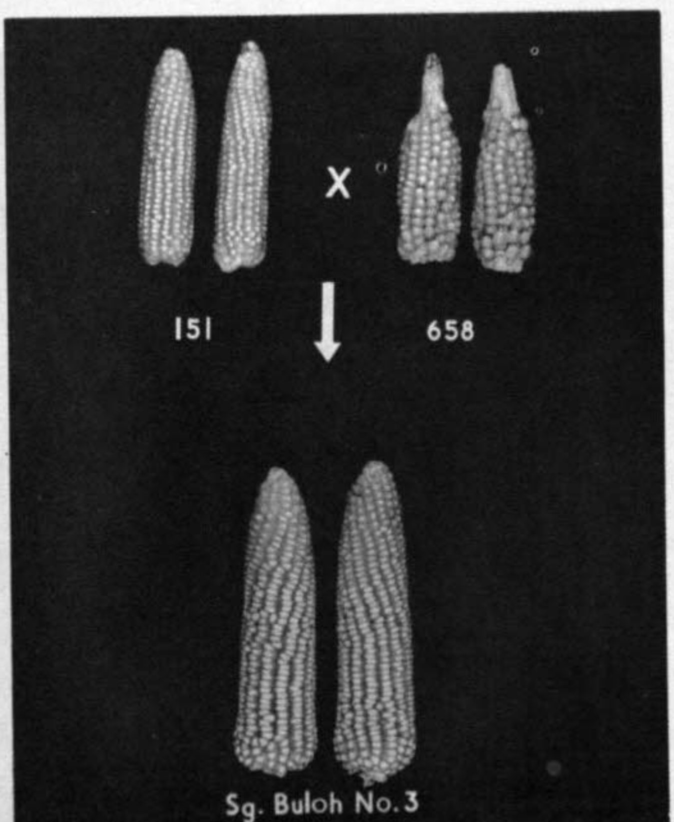

Plate 12. Sungei Buloh Hybrid No.3 and its inbred parents.

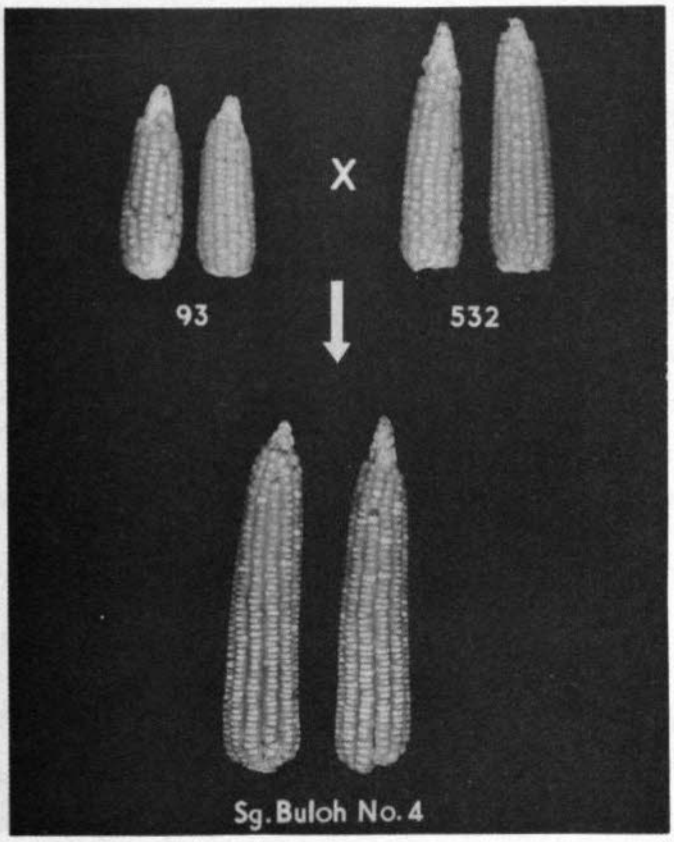

Plate 13. Sungei Buloh Hybrid No.4 and its inbred parents.

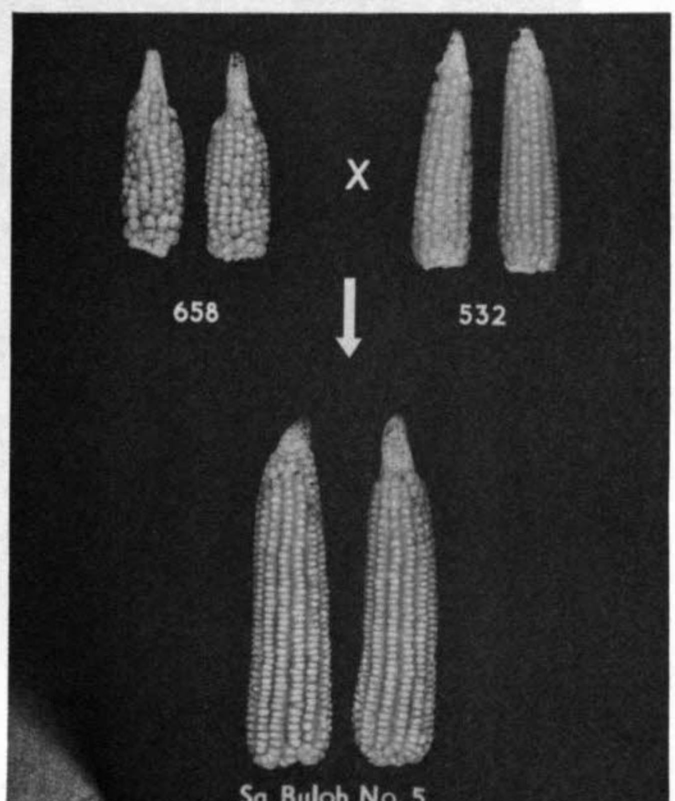

Plate 14. Sungei Buloh Hybrid No.5 and its inbred parents.

One hectare of double-cross hybrid will produce between 1800 kg to 2000 kg of seeds which will be sufficient to plant 106 to 115 hectares in the field.

CHAPTER VI

TECHNIQUES

CHAPTER VI

TECHNIQUES

Planting Season

The date of planting should coincide with the local rainfall pattern of an area to ensure that there is sufficient moisture for germination and during the tasselling and silking stage of the maize plant. In general for most parts of Peninsular Malaysia, two crops of maize can be grown in a year. However, it is preferable to grow maize in rotation with a legume crop. The first cropping season is from late March to early July and the second from late August to early January. Rainfall distribution in a given location should be referred to as a guidance. The mean rainfall in the last few years recorded by the nearest meteorological station would meet this requirement.

Soil Preparation

All old stumps, if present, should be removed and the resulting cavities filled to facilitate cultivation. The surface trash should be buried and a good drainage network constructed to ensure that excess water does not cause water-logging. Cultivation of the soil should be planned so that it occurs on the onset of the rainy season. As a guide, cultivation can commence about two days and three to four days after the last rain for light and heavier soils respectively. The soil should be ploughed to a depth of about 20 to 30 cm and brought to a fine tilth. For the first cropping, this usually requires two rounds each of ploughing and rotovation. While for the second and subsequent crops either one round each of ploughing and rotovation or only two rounds of rotation are required depending on the structure of the soil and condition of the field.

Where the soil is undulating, i.e. on slopes of 5 to 8%, contour tilling should be implemented. This would reduce soil erosion losses by half compared to tilling up and down the slope. If slopes of more than 8% are cultivated then terracing is necessary. Intercropping with maize is generally not recommended on slopes of greater than 8%.

About eight to ten days' interval should be allowed between the ploughings, first and second rotovation in order to reduce weed regeneration. This would ensure a period of about four weeks between ploughing and the final harrowing. Prior to the second rotovation, magnesium limestone at the rate of 560 kg per hectare should be broadcast and shallow rotovation to a depth of 5 cm to incorporate the lime should be carried out.

Planting Distance between Rubber and Maize

The spacings adopted for rubber trees have to be a compromise between reducing inter-tree competition of the rubber and to provide maximum space for the intercrops. Further, as the tree grows, its roots would extend outwards into the interrow areas where the intercrop is grown. Therefore, with the advancement of growth, the maize planting would have to move further away from the rubber trees.

In addition, with growth of the rubber trees, the canopy would cause a shading effect on the maize plants. This shading effect can be minimised if the rubber rows are aligned in an East to West direction. However, with branching formation of the tree, the shading becomes more intensive and usually by the beginning of the third year of field budding, intercropping with maize may not be economical.

The recommended distance between the rows of rubber and maize are given in Table 26. The distance the maize seeds are planted away from the rubber rows has been arrived at to ensure that no damage occurs to the roots of the rubber trees.

Planting Distance of Maize

Maize seeds should be sown at a planting distance of 91 x 23 cm with one seed per point. This density gives 47 840 plants per intercropped hectare.

TABLE 27

PLANTING DISTANCE BETWEEN RUBBER AND MAIZE

Stand of rubber per ha (per acre)	Distance between trees m (ft)	Distance of maize from tree row m (ft)		Effective area available for maize per rubber area (%)	
		1st yr.	2nd yr.	1st yr.	2nd yr.
445 (180)	2.4 x 9.1 (8 x 30)	1.4 (4.5)	1.7 (5)	70	64

Weed Control

At the time of sowing seeds in the ground, the area should be free of weeds if cultivation of soil is done as shown earlier. Should germinating seedlings be present then spray out existing vegetation with paraquat as a solution of paraquat (3.5 litres of Gramoxone 200 g a.i./litre) in 280 litres of water. Immediately after sowing the seeds, spray with a solution of 1.6 litres alachlor (lasso; 479 g a.i./litre) in 225 litres of water as a pre-emergence weed control measure.

The spraying of rubber tree rows to control weeds on the tree rows should be done prior to the establishment of the intercrop. Subsequent chemical weed control may be done after harvesting the intercrop or if the seeds have regenerated rapidly, chemical weeding can be done with carefully directed spraying of weeds in rubber tree rows.

Fertiliser Application

The fertilisers to be applied, their rates and method of application are given in Table 27. In addition to lime the fertilisers required are nitrogen, phosphorus, potassium and where necessary magnesium. The soil along the rows should be ridged after the second application of fertilisers.

TABLE 28

RATE AND TIMING OF FERTILISERS

	kg/ha	Timing	Placement
Magnesium limestone	560	Full rate at second rotovation	Rotovate to depth of 5 cm of soil
N	112 - 135	Half rate at planting Half rate at 3 - 4 weeks as top dressing	Along rows cover with soil
P_2O_5	70 - 80 (soluble P)	Full rate at planting	Along rows cover with soil
K_2O	65 - 80	Half rate at planting Half rate at 3 - 4 weeks as top dressing	Along rows cover with soil
M_gO	5 - 10	Full rate at planting	Along rows cover with soil

Establishment of Maize

Pre-treatment of Seeds

About 17 kg of good viable seeds will be required for each crop hectare. Germination tests should be conducted shortly before seed dressing and planting. Only seeds with germination percentage of over 90% should be used. Seed dressing with suitable fungicides will be necessary prior to planting. The recommended treatment is 100 g of thiram 75 or captan for 25 kg of seeds.

Control of Pests

Insect Pests

Although a large number of pests are known to attack maize, control measures are recommended to be undertaken only when the population of any one of them has increased to the extent of posing a threat of significant loss to the crop. Such severe infestations are mostly localised, and regular examination of the field at weekly intervals should help to locate them early enough for effective control to be obtained by one or two rounds of chemical treatment. Where such regular checking is difficult, as in many situations in smallholdings, routine spraying of the crop with insecticides at regular intervals can be justified as a prophylactic measure; this can be achieved without adding heavily to the cost of production. Areas with a history of cockchafer infestations should be avoided for planting maize, rather than treating the soil against them prior to planting.

Control of Caterpillars

Commonly known as maize stalk-borer *Ostrinia salientalis* feed on almost all parts of the plant. Satisfactory control can be achieved with high volume spraying of Dipterex SP 95 or Sevin 85 WB at a rate of 1 gram in 400 to 500 cm^3 of water. The spraying may begin from the third week after sowing, followed by three rounds of routine spraying given at the fifth, the seventh and the ninth week. An additional round of spraying should be made in between any two sprayings when damage inside the leaf shoots are observed. The corn worm and other caterpillars can also be controlled by similar spraying of Dipterex or Sevin. Alternatively, the corn earworm can be controlled by spraying 0.2% DDT directly on the newly formed cobs, followed by a second application two weeks later.

Control of Aphid

The aphid can be controlled by a single application of 0.04% dimethoate (Rogor 40 1 m per litre), should its population build up to cause any significant damage.

Other Pests

When the cobs develop, particularly just before the time for harvesting, rats should be controlled with warfarin baits.

Control of Diseases

Seed Rots and Seedling Diseases

Soil inhabiting fungi, are the most common cause of seed rots and seedling diseases. Seed dressing with thiram 75 or captan have been found to control these diseases.

Leaf Rusts and Leaf Blight

Two principal rusts attacking maize caused by *Puccinia polysora* and *Puccinia sorghi* are commonly occurring in maize growing areas with high rainfall, temperature and humidity. Leaf blight mainly caused by *Helminthosporium maydis* is not present in epiphytotic proportions in Malaysia. These diseases can be avoided by growing resistant varieties.

Crop Rotation

Crop rotation has been used with success in maize where resistant varieties have not been developed. A rotational system designed for disease control must at the same time comply with other good agricultural practices. Crop rotation should be practised hand-in-hand with field sanitation, proper manuring and drainage, use of good planting materials and proper seed treatments. Crop rotation sequence from legumes to cereals (*e.g.* groundnut to maize) would be an appropriate combination. This will result in the advantages of maintaining soil fertility as well as reducing pests and diseases.

Harvesting and Drying

The time of harvesting maize varies according to varietal differences and the use of the crop. In general, as fresh cobs, it may be harvested after sixty-five days or more after planting. If it is for grains, harvesting is done after the grains have matured and reached the hardening stage.

Harvesting can be done either by hand or by machinery. Shelling of maize should be made with maize sheller for the grain contains about 25% moisture. Shelled maize should be dried to reduce the moisture to about 15% before packing. In case the maize is to be used for seed production, shelling should be done when the seed contains 13 - 14% moisture and dried up to 10% moisture before packing for storage. In order to achieve this, the grains should be thoroughly dried in the sun for five to seven days. Alternatively the whole operation of drying grains can be done within a day if a mechanical drier is used.

CHAPTER VII

POLICY IMPLICATIONS AND RECOMMENDATIONS

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In this report there is sufficient evidence to show that intercropping of young immature rubber with maize will provide an avenue of income to the smallholders during the unproductive phase of the rubber trees. This will also lead to more efficient utilisation of land and it will no longer be a deterrent to the smallholder to replant low-yielding old rubber trees which may currently be his main source of income. In addition, intercropping will provide additional job opportunities in the rural sector; maize cultivation being relatively labour intensive especially during planting and harvesting periods.

The work reported herein represents a review of local work on maize as a sole crop and intercrop under immature rubber. Based on agronomic considerations it is demonstrated that maize is a suitable intercrop. More importantly, however, the cost-benefit analysis indicates that local maize production can be a profitable farm enterprise.. This is likely to provide a strong incentive for smallholders to intercrop their immature rubber with this crop. An expanded local hectarage under maize will serve to conserve foreign exchange through import substitution and could perhaps eventually contribute to net export earnings.

It is, therefore, proposed that the implementing authority consider the following recommendations:

- Maize should be grown preferably in rotation with groundnut or soyabean in soil areas with a suitability rating of 60% or more in new plantings or replantings of less than three years old and in locations where there is a market for the crop.

- In the next planting season, the organisation to implement this project should establish a nursery to multiply suitable varieties of maize. Based on the varieties tested, Sungei Buloh Synthetic is recommended for large scale planting. If facilities are available to produce hybrid maize seeds, then Sungei Buloh Hybrids Nos.2, 4 and 5 are recommended.

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