Proceedings of the International Conference for Agricultural Machinery & Process Engineering
October 19-22, 1993, Seoul, Korea

MECHANISATION SYSTEM FOR LARGE SCALE GRAIN MAIZE PRODUCTION IN MALAYSIA

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ABSTRACT

The formulated mechanisation packages for grain maize production have performed to the expected limit generating encouraging imformation. Besides physical fesibility, management factors viz: production operation sequence, operations scheduling and machinery matching with respect to environment can still limit system suitability. A new production operation sequence was introduced to overcome weed problems and limitations of available working days. Proper operations scheduling will improve the initial soil-crop environment for better seedling establishment, and reduce the number of [illegible]. Machinery selection and matching together with proper farm infrastructure have been identified as key factors to reduce capital investment and cost of production
Keywords: grain maize, mechanisation package

INTRODUCTION

The annual importation of over 1 million tonnes of grain maize into the country together with the projected increase in utilisation by the livestock industry indicates the importance of grain maize as a feed crop (Leong 1992). Yet there has been no record of large scale production at present due to low yields and high production costs in Malaysia. In order to reduce the cost of production, MARDI has advocated fully mechanized large scale grain maize cultivation in Malaysia. As the first step, a study was carried out to develop the machinery system for grain maize production. This communication highlights the results of some studies on the development of machinery system for grain maize production.

METHODOLOGY

Project area

The project was located at Ladang Lambor, Perak, Malaysia. The grain maize production was confined to 40 hactare (100 acres). The area was undulating with less than two degree slope and with widesprread depressions. The soil series were from the association of Sitiawan, Sogarma and Holyrood series with peat also present. The texture ranges from clay loam to clay. The production area is in an oil-palm estate, with existing secondary and tertiary drains. However additional in-field drains have been constructed at 30m apart.

Cultural practices

Composite seeds of the varieties Suwan 1 and Suwan 3 were used with seeding rate 20 kg per hectare. Compound fertilizer (15:15:15 NPK) was banded about 5 cm away from the seed rows at the rate of 400 kg per hactare. The planting distance was 25 cm x 75 cm, giving a plant density of 53, 333 plants per hactare. The pre-emergence weedicide used was atrazine at 3 l/hectare. Top dressing of urea was banded at the rate of 60 kg N per hactre 3 weeks after planting. The crop was harvested 105-110 days after planting.

Machinery selection and packaging

Previously developed packages were evaluated to identify the problems encounted during production. Based upon the identified problems, machinery selection was carried out and hence new production packages developed. The package together with development of new inproved implementation techniques were then evaluated.

Contract services provide an alternative system to reduce farm mechanisation costs. In the project undertaken contract services were used for land preparation, crop establishement and crop care operations. These contract services are readily available near the project area. Aquisation of machinery was only made for those services not provided for by the custom operators especially the implements. The developed package was based on the size of the customs operators prime mover (between 73-77 hp) which is easily available.

RESULT AND DISCUSSION

Problem identification

Although the machinery packages (Table 1) developed to date (Chan et. al. 1991) were carefully selected and evaluated but there still exist several problems during implementation. There is the need for some modification and adjustment to improve the packages. The problems faced and identified during implementation were uneven seed establishement, inefficient weed control, limited available working days and high machinery cost. Based on field observation, these problems arise due to the weaknesses of land preparation technique, and management technique. The development of new packages must be capable of solving the above problems by improving land preparation and management techiques. Improving the land preparation technique is not so much a problem, it is merely selecting and combining the implement based on the identified field problems. Improving the management technique is a difficult task. This involve matching the environment with the available machinery packages.

Development of new mechanisation packages

In developing a new mechanisation package it is essential to improve the land preparation technique to provide suitable environment for seeding and seedling establishment (Table 2), and to incorporate effective weed control measures.

Chan et. al. (1991) have developed several mechanisation packages for grain maize production (Table 1, package 3,4,5 and 6). Several machineries such as disc plough, rotovator, precision seeder, sprayer and combine harvester can directly be adopted for the development of the new mechanisation packages. The new mechanisation packages developed (packages 7 and 8) are shown in Table 1.

Table 1: Mechanization system packages in large scale grain maize cultivation

	Machanized grain maize Production packages						
	Previous packages				New packages		
Operations	3	4	5	6	7	8	
Land form	F	F	F	F	F	F	
Field condition					weed	non-weed	
LAND PREPARATION							
Pre-tillage							
Lime spreading (S_L)	x	x	x	x			
Tillage							
Subsoiling (Ss)	x	x	x	x			
Disc ploughing (Dp)	x	x	x	x	xx	xx	
Raking (Sk)					x	x	
Disc harrowing (Dh)	xx		xx	x			
Rotovating (R)		xx		x	x	x	
CROP ESTABLISHEMENT CUM BASAL							
4 row press wheel (Sd)	x						
6 row precision (Sd) planter			x	x	x	x	x
CROP CARE							
Spraying - 6 m boom (Sp)	x	x	x	x			
- 15 m boom (Sp)					x	x	
Top dressing - 4-row (Sp)	x						
- 6-row (Sp)		x	x	x	x	x	
HARVESTING							
Combine - 3-row (H)	x	x	x	x			
- 4-row (H)					x	x	

Dp = Disc plough, 3 dises with 60" diameter
Sk = Universal Rake with 2.85 meter width
R = Rotavater with 1.78 meter
Tektor = 73-77 hp

Table 2: Types of machinery required for packaging base on functional.

Function of the selected implement	Types of implement	Symbol
LAND PREPARATION		
To control weed after barvesting	Disk plough	Dp_1
To clear the dry weed and stuble	Rake	Sk
To improve the depth of ploughing and weed control	Disk plough	Dp_2
To reduce the size of the clods	Rotovater	R
CROP ESTABLISHEMENT CUM BASAL		
Single seed at 25 x 75 cm spacing	Precision planter equiped with fertilizer applicator	Sd
CROP CARE		
To control pre emergence weed	Sprayer-carpet spraying	Sp
Top dressing cum pulverizer	Fertilizer applicator cum pulverizer	C_f
HARVESTING COMBINE	Combine harvester 4-row	H

Matching environment with mechanisation packages

Management techniques are important for successfull grain maize production. The parameters that need to be considered include production operations sequence, operations scheduling and number of machinery required taking into account weed control measures, ease of operation, cost reduction and selecting suitable environment for good establishment and harvesting.

Production operation sequence (POS)

The new production operation sequence introduced was H Dp_1 Sk Dp_2 R Sd Sp C_P H (Fig. 1) as compared with the previous S_L Ss Dp Dh R Sd Sp C_P H and S_L Ss Dp Dh Dh Sd Sp C_P H. The new POS considers harvesting as one component of continous operation during planning and also considering the Dp_1 as weed control measures after harvest. The new POS was improved through increasing the number of available working day for every operation and thus limit the number of machinery required for system operations.

Operations scheduling

Figure 2 shows the improved operations scheduling as compared to the previous packages. The details of operation scheduling is as describe in the appendices.

Table 3: Field performance of the selected machinery.

Parameters	Field Operations							
	Dp_1	Sk	Dp_2	R	Sd	Sp	C_P	H
Average Gross field capacity (ha/hr)	0.16	0.18	0.28	0.64	1.23	4.67	1.89	0.89
Working width (mm)	540	2850	540	1780	1800	15000	4500	3000
Working depth (mm)	22	-	22	12	25.7	-	10	-
Field speed (ms^{-1})	0.45	-	0.95	1.4	1.25	0.80	1.2	0.85
Machine use (h ha^{-1})	6.25	5.56	3.57	1.56	0.81	0.21	0.53	1.12
Labour (man-h ha^{-1})	6.25	5.56	3.57	1.56	2.43	0.21	1.59	3.37
Field efficiency	63.29	35.28	77.8	91.68	66.16	87.86	71.65	83.94

Effect of management technique

The developed management technique can be used as a guide for planning purposes. The success of utilizing this technique depends upon the accuracy of estimated number of weed control days, the required working days and machine capacity (Appendices).

The production operation sequence (Fig.1a) was found to be suitable for the project area. It helps in completing the work ahead of time. The production sequence developed can also be used as a guide to monitor aditional machinery requirement at any time during operation. Fig. 1a and 1b compare the differences between the planned and the actual implementation schedules.

Operation scheduling is the most difficult part. Fig. 1a shows the planned operating schedule implemented and Fig. 1b is the actual operating scheduling. In the planned schedule rotovation, seeding and spraying must be carried out simultenously but in actual implementation some delays accur. The delay in starting some of the operations results in the increased in total working days (Fig. 1a and 1b) and in the number of additional machinery required (Table 5).

Table 5: Estimated and actual amount of machinery used and working days.

	Estimated Number		Actual Number	
Operation	Machinery required*	Days*	Machinery used	Days
LAND PREPARATION				
Disc ploughing	2	29	3	15
Raking	2(2)	25	2	23
Disc ploughing	1	28	2(-1)	19
Rotovating	1	18	1	11
CROP ESTABLISHEMENT CUM BASAL				
Seeding	1	18	1	11
CROP CARE				
Spraying	1	18	1	13
Fertilizing cum Pulveristion	1	18	1	14
HARVESTING				
Combvine harvester	1	18	1	14

* Calculated value, refer to appendices.

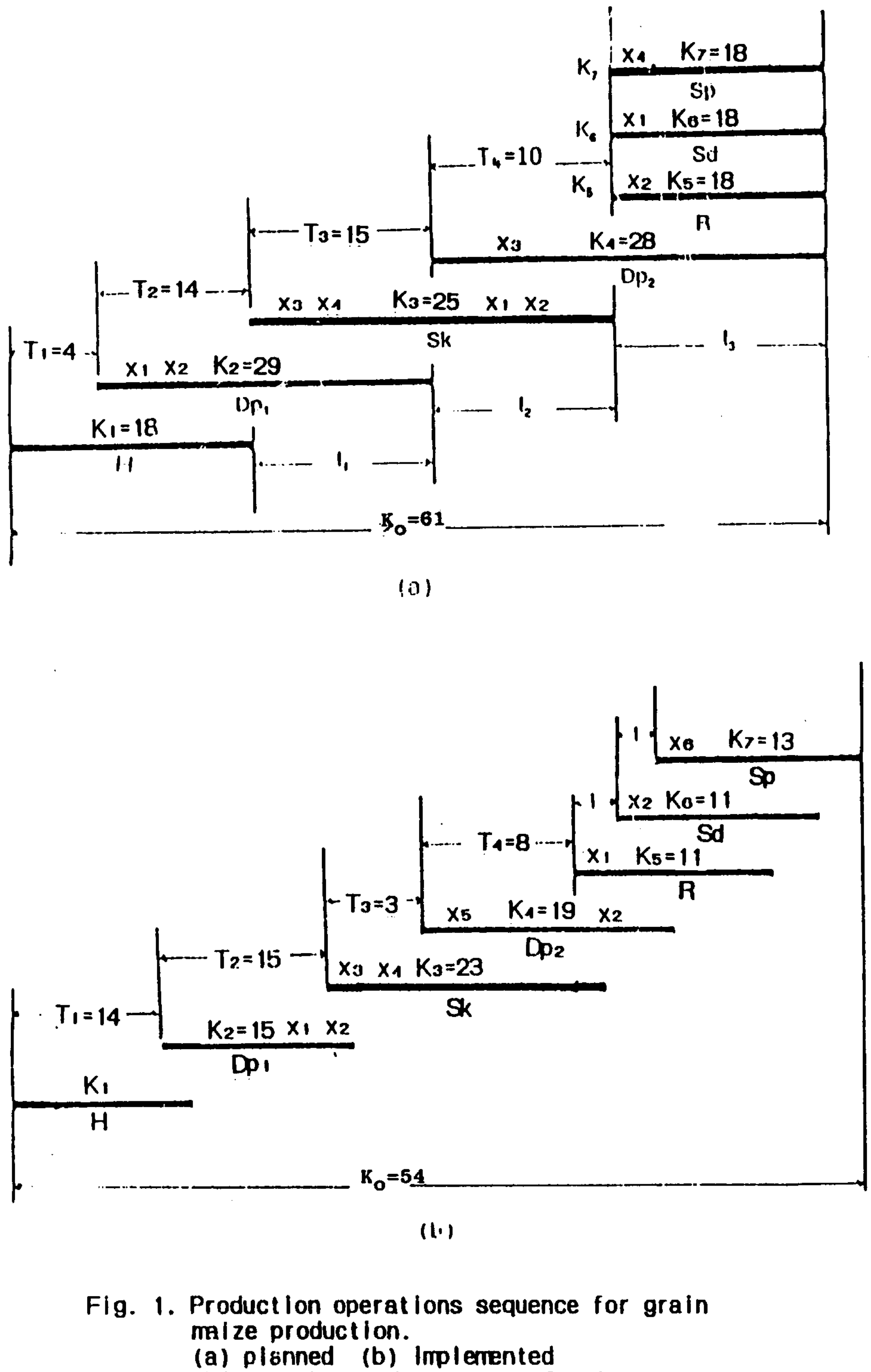

Fig. 1. Production operations sequence for grain maize production.
(a) planned (b) implemented
Xi = number and movement of prime-mover
Ti = number of days before next operation begin
Ki = number of days required for the operation

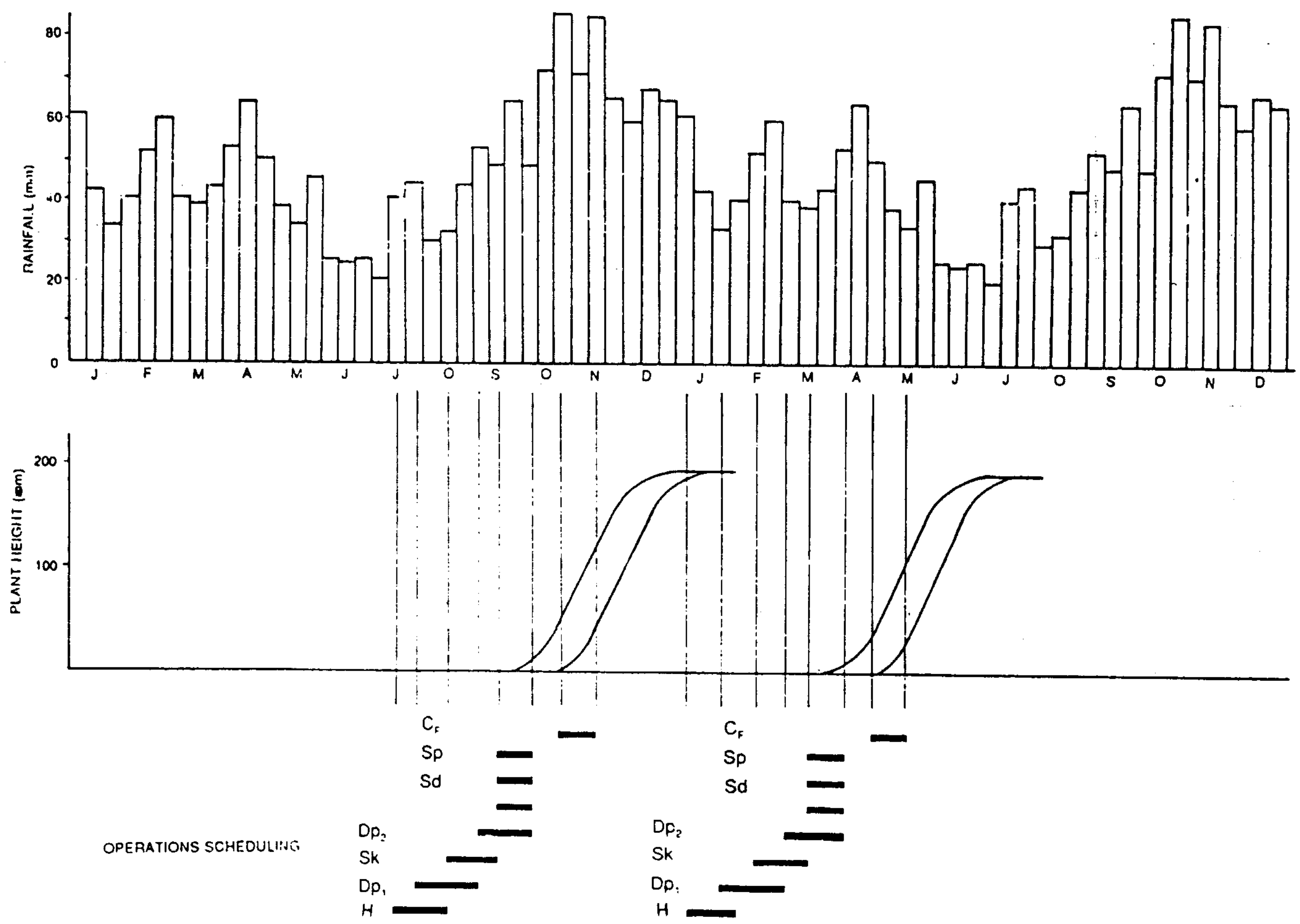

Fig. 2. Operation scheduling planned for grain maize production.

Table 4: Field performance of the selected machinery.

Parameters	Field Operations							
	Ss	Dp_1	Dh_2	R	Sd	Sp	C	H
Average Gross field capacity (hah^{-1})	0.29	0.26	0.45	0.7	0.75	2.85	1.1	0.7
Working width (mm)	750	590	2050	1780	4500	6000	4500	3000
Working depth (mm)	40	23	10	12.5	-	-	-	-
Field speed (ms^{-1})	0.65	0.95	0.85	1.45	0.95	0.75	1.15	0.885
Machine use (hha^{-1})	3.44	3.85	2.22	1.43	1.33	0.35	0.91	1.432
Labour (man-h ha^{-1})	3.44	3.85	2.22	1.43	4.0	0.35	2.73	4.29
Field efficiency (%)	86.5	84	85	92.5	74.5	90	68	73

Source: Chan et. al. (1991)

Effect of land preparation technique

Through observation, the new land preparation technique is able to control weed sufficiently in certain plots. Although the overall expected level of weed control was below the target limit throughout the farm, it is expected that the weed infested area can be reduced over long term of practising this technique. The weed was effectively controlled after ploughing and after crop establishment but not after maturation. After maturation senescence sets in and so the weeds are at competitive advantage leading to heavy weed infestation in the field. There is no suitable technique to control the weeds except through land preparation technique. Therefore the first ploughing is aimed at controlling this weed to reduce weed infestation in the next cropping season.

For efficient seeding the field should be free of dried weeds and stubble (Table 3 and 4). The presence of these material on the soil surface will hinder effective seeding. The process of raking should be carried out to improve the gross field capacity of the seeding machine (Table 3 and 4). It has been observed that the dried weeds and stubble normally get stuck to the fertilizer shank and furrow opener leading to frequent stopping during seeding operation. This reduces the efficiency of machine use.

The newly developed technique also improve the number of plant stand and spacing (Fig. 3 .) as compared to the previous packages of one discking followed by two rounds of harrowing and rotovation (Fig. 3). The accummulation of the dried weeds and stubble affect fertilizer and seed drop as both are dragged along as the machine moves. The process of dragging the fertilizer and seed will affect crop stand uniformity, increased plant spacing and thus reducing number of crop stand per unit area (Fig. 3).

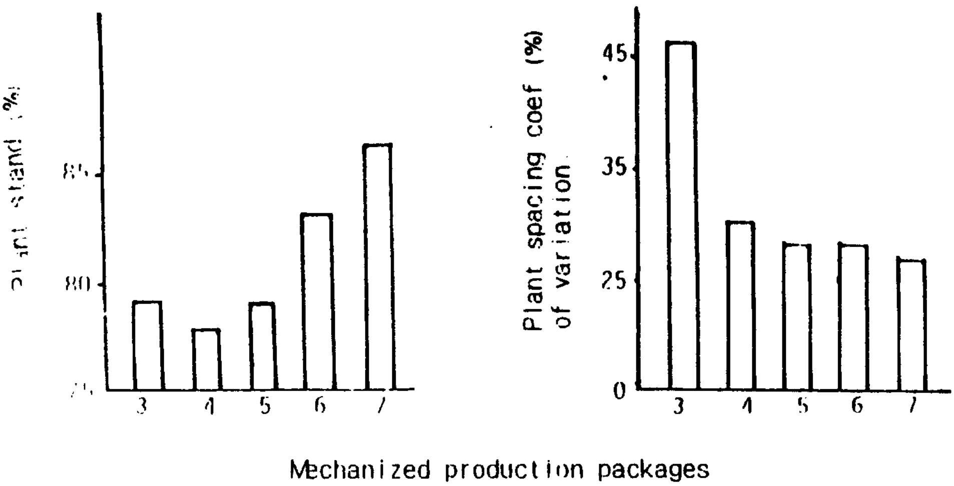

Fig. 3. Effect of land preparation techniques on plant stand and spacing.

Performance of selected machinery

The performance of the selected machinery is summarised in Table 3 while Table 4 summarises the machinery performance evaluated by Chan et. al. (1991). The gross field capacity increases as compared to the previous machinery package, while the field efficiency decreases. This indicated that the existing field size is still small for effective machine mobility eventhough the field conditions have been improved (Table 3 and 4). The plot size should be increased to suit machine suitability particularly in relation to seeding and harvesting requirement. The other obstacle to efficient machine use in the project area is the presence of ditches 30 m apart. Such field layout hinders machine meanuverbility. Furthermore the weeds and stuble reduce machine performance (Table 6).

Table 6: The time component involved in each operation.

	Field Operations							
Time component	Dp	Sk	Dp_2	R	Sd	Sp	C	H
Actual working time (%)	63.29	35.28	77.80	91.63	66.18	87.89	71.66	83.96
Turning time (%)	8.62	7.65	12.69	8.36	21.59	12.11	6.28	16.04
obstacle time (%) (removal of weed and stubble)	26.25							
Adjustment time (%)	1.85		3.85					
idle time (%)		57.07	5.66					
Total time	100	100	100	100	100	100	100	100

Cost, machine and labour use for different packages

Production cost in relation to mechanisation operation and the number of machine and labour use can be estimated from Tables 1, 3, 4 and 7. All the packages show the trend that land preparation and harvesting contributed the highest cost. Therefore cost of production can be reduced if land preparation cost can be minimized as shown by package 8, the lowest cost of all the packages tested. Package 7, specifically developed for controlling weed, is one of the highest machine cost per hectare. The cost of controlling weeds is about 50% of the land preparation cost while land preparation contributes 47% to the total cost (Table 7, packages 7 and 8).

Package 8 had the lowest machine use hour per hactre while package 7 is one of the highest (Table 3). The same is true for man hours per hectare. The highest machine and labour use is for the tillage operation and raking for weed control (Table 3).

Machinery selection and matching for the prime-mover is most critical to reduce cost (Table 7). Studies in the project area indicated that different packages incur different machinery cost per hactare. The cost of machine per hactare ranges from RM525.49 - RM703.08. It is difficult to further reduce the cost per hectare. This is due to the fact that even with minimum operations requirement for mechanized grain maize production (package 8), there is no further reduction can be made with respect to machinery cost/ha.

Table 7: Operating cost per hacter base on the custom hire service.

Operation	Operating cost per hactre (RM/h)					
	Previous Packages				New Packages	
	3	4	5	6	7	8
LAND PREPARATION						
Pre-Tillage						
Lime spreading (S_L)	8.27	8.27	8.27	8.27		
Tillage						
Subsoiling (Ss)	80.20	80.20	80.20	80.20		
Disc ploughing (Dp)	66.69	66.69	66.69	66.69	2(80.00)	80.00
Raking (Sk)					80.49	80.49
Disc harrowing (Dh)	2(49.84)		2(49.84)			
Rotovating (R)		2(93.86)		93.86	80.00	80.00
CROP ESTABLISHEMENT CUM BASAL						
4 rows press wheel	48.05					
6 rows precision (Sd) planter		61.18	61.18		67.50	67.50
CROP CARE						
Spraying (Sp)						
- 6 m boom	18.43	18.43	18.43	18.43	28.67	28.67
- 15 m boom						
Top dressing						
- 4 - row (C_f)	31.08					
- 6 - row		28.50	28.50	28.50	54.0	54.00
HARVESTING						
Combine (H)						
- 3 - row (H)	312.09	312.90	312.50	312.50		
- 4 - row					215.30	215.30
	664.49	763.08	675.04	719.06	685.96	525.49

CONCLUSION

Mechanisation of farm operation for grain maize production can satisfactorily be achieved, therefore the possibility of large scale grain maize production in Malaysia. The results of mechanisation packaging in Ladang Lambor can be extended for adoption in other suitable areas provided that due emphasis and consideration be given especially with respect to management and land preparation technique to suit locational requirement.

ACKNOWLEDGEMENTS

The authors wish to thank the Director General of MARDI for his support in carrying out this research. Special thanks is extended to members of the Grain Maize Project Task Force, Ladang Lambor, Malaysia for making this study possible. Special thank is also extended to Mr. Said Osman, Mr. Hashim Aziz and Mr. Abd. Rasad Matsom for their technical assistance in project implementation and to Ms. Fadhilah bt. Ismail for tayping the manuscript.

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APPENDIX 1: Estimation of required working days

The estimation of required working days is based upon 3 parameters.

1. Weed control scheduling.

Operations	Implements	Function of the implement	Days (T) General	Days (T) Lambor
LAND PREPARATION				
Disc ploughing	Dp_1	To cpntrol weed after harvest - long term effect	0-7	4
Raking	Sk	To clear the surface from dry weed and stubble	7-14	14
Disc ploughing	Dp_1	To increase depth and further improve weed control	7-21	15
Rotovating	R	To breakdown further the clod size	7-14	10
CROP ESTABLISHMENT CUM BASAL APPLICATOR				
Seeding	Sd	Precise seed placement	0-1	
CROP CARE				
Spraying	Sp	To control pre-emergence weed	0-1	
Fertilizing and pulverizing	C_f	To apply top-dressing and loosening the soil	21-30	
HARVESTING				
Combine	H	To harvest the crop	100-115	

2.Production operation sequence and machinery requirement (Fig. 1).

3 Assumed ratio of 1:1 for planting and harvesting.

The relationship established for estimation of required working days is as follows:-

$$K_0 = T_1 + T_2 + T_3 + T_4 + K_5$$
$$K_1 = T_1 + T_2$$
$$K_2 = T_2 + T_3$$
$$K_3 = T_3 + T_4$$
$$K_4 = T_4 + K_5$$
$$K_5 = K_1$$

Calculated required working days.

K	Calculated required working days (K)		
	Minimum (days)	Special case for Lambor	Maximun (days)
K_1	7	18	21
K_2	14	29	35
K_3	14	25	35
K_4	14	28	35
K_5	7	18	21
K_0	28	61	77

APPENDIX 2: Estimated required machinery working capacity (qi)

The estimated machinery capacity can be calculated from the average farm size (hectare), estimated available working day and estimated non-productive days which include travelling looses, rainy day, holiday, breakdown of machinery and contractor problems. For the purpose of the calculation, 40% of the estimated required working days are non-productive .

Estimated required machinery working capacity.

	Estimated required machinery working capacity (h/hr)		
qi	Minimum	Lambor	Maximum
q_1	1.22	0.47	0.41
q_2	0.61	0.29	0.24
q_3	0.61	0.34	0.24
q_4	0.61	0.27	0.24
q_5	1.22	0.47	0.41

APPENDIX 3: Estimated number of machinery required

Estimated number of machinery required for every operation was calculated base on the lowest machinery capacity performance data tested by Chan et. al. (1991).

Estimated number of machinery required.

	Estimated the number of machinery for every operations (No)		
Operation	Maximum Number	Lambor	Minimum Number
H	3	1	1
Dp_1	3	2	2
Sk	3	2	2
Dp_2	3	1	1
R	3	1	1