DEVELOPMENT AND EVALUATION OF WATERMELON PRODUCTION MECHANISATION TECHNOLOGY PACKAGE

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ABSTRACT

Watermelon is one of the most exported Malaysian fruits, mainly to Singapore Hong Kong and the United Arab Emirates. Watermelon crops take about 60 to 75 days to produce, from seedling transplant until harvest. The key to maintaining a consistent supply of watermelons is continuous production without any failure. However, a recent challenge has arisen due to a shortage in the labour workforce, resulting in a slowdown and occasional disruptions in watermelon production. Mechanisation technologies have emerged as the preferred solution to address labour-related challenges. The primary objectives of this study were to develop and evaluate a mechanisation technology package tailored for watermelon production. The package includes mechanisation for land preparation, seedling preparation, planting, crop maintenance, and harvesting. There are a total of 12 technologies in the package. Integrating mechanisation technologies can reduce labour requirements by approximately 73.6 %, providing additional income to farmers through savings in labour costs. Moreover, mechanisation facilitates faster fieldwork, allowing farmers to expand their cultivation acreage more easily within the same time frame as conventional methods.

Keywords: Watermelon production, Labor challenge, Field mechanisation.

INTRODUCTION

Watermelon is a popular fruit among Malaysians because of its taste and affordable price. Watermelons had the highest weight-based exports out of Malaysia of the 14 fruits studied in 2020, with 45,324.3 tonnes or 45,324,300 kg or 45 million kg sent out, mainly to Singapore Hong Kong and the United Arab Emirates. (Anon,2020). Kelantan, Pahang, Terengganu, and Johor are the top 4 states that produce watermelon in Malaysia, with production areas of 2588, 1579, 1345, and 1311 ha, respectively (Anon,

2020). Watermelon crops take roughly 60 to 75 days to grow from seedling transplant until they are ready to be harvested (Anon,2004). Conventional watermelon production within a short time frame requires a lot of manual labour (Kumar,2018). The key to maintaining a consistent supply of watermelons is continuous production without any failure. Agricultural products and food production have recently faced challenges due to a labour shortage (Dardak, 2020). As a result, the industry has had to deal with frequent disruptions and slowdowns, especially after COVID-19 hit. These issues have created a ripple effect throughout the supply chain, impacting everything from farmers to distributors and retailers(Villamarin Rodriguez & Pranay Kumar, 2021). The shortage has forced producers to adjust their strategies, making meeting demand and maintaining consistent quality standards more challenging. Mechanisation technologies have proven to be the most effective solution to labour-related challenges (FAO,2023). The main focus of this research project was to develop and assess a comprehensive mechanisation package that could be specifically tailored to meet the requirements of watermelon cultivation. The package was developed to include a range of mechanised activities, such as land preparation, seedling preparation, planting, crop maintenance, and harvesting. The ultimate goal of this initiative was to enhance the efficiency and effectiveness of watermelon production and to support farmers in achieving higher yields and greater profitability.

MATERIALS AND METHODS

Determination of machinery requirements and specifications

The development of the technology package began with an analysis of all activities involved in watermelon production. There are 4 main activities of watermelon production; land preparation, planting, crop maintenance, and harvesting. Each activity was subdivided into sub-activities based on field surveys and observation. The survey result was used to determine the machine's requirements and specifications. The activities that were difficult to mechanize were isolated and maintained as manual practices. Every manual activity in the mechanised production line is not included in the calculation of the total labour requirement. The values were cancelled out by the manual production practices. The machine specifications were developed by considering the factors of ease of use, suitability for local conditions, and affordability.

Development of technology package

The technologies for the package were initially developed through the careful selection and modification of suitable existing machinery available in the market. The machine that satisfied the required specifications was selected and acquired. However, those specifications that encountered challenges in locating a suitable machine or high cost to acquire were locally developed and fabricated. During the development process, each machine was individually tested and modified until it achieved the required needs before being tested as a package.

Test and evaluation

The technology package was tested and evaluated in MARDI Bachok Station Kelantan, a MARDI station with BRIS-type soil. Bachok is well-known for being one of the main areas that produce watermelons in Kelantan.
The developed mechanisation technology package was evaluated based on its field capacity and labour requirement. All of the agronomy practices used were identical to those used by the farmers in the area where the seedlings were planted space at 0.5 m intervals and well maintained until the harvesting stage at 65 days for machine evaluation and data collection. The standard fertilization rate practised is 70-80g per plant. All the activities were implemented fully mechanised using the developed mechanisation package except those activities that were difficult to mechanise were manually conducted as same as conventional practice. The experiment was conducted in two planting seasons.
The tests result was compared to conventional practice to evaluate the potential of the usage. The usage of mechanisation was expected to reduce the labour required. The reduction percentage was calculated based on the below equation

$$\text{Percentage of reduction in labour requirement (\%)} = \frac{(conventional - mechanised)}{|conventional|} \times 100$$

The field capacity was calculated based on theoretical capacity, the potential capacity that might achieved in ideal conditions. The equation used as below

$$TFC = \frac{W \times S}{C}$$

Where, TFC = theoretical field capacity, W = the width between-row spacing (m), *S* = the average forward speed (km/h) and *C* = constant, *10*

RESULTS AND DISCUSSION

Watermelon production activities

Based on the survey, the four main watermelon production activities, land preparation, planting, crop maintenance, and harvesting, are divided into sub-activities listed in Table 1.0. Sub-activities in *italic* font are challenging to mechanise, meaning they still work as manual operations. There are 5 activities involved in seedling transplanting. Out of these, only the seedling placing activity needs to be done manually. Pollination is an important activity to ensure watermelon crops produce fruits, especially seedless watermelons (Wijesinghe et al., 2020). This activity involves searching, selecting and manually pollinating

male flowers to female flowers, making it difficult to mechanize. Besides that, branch management also needs to be implemented manually because the activity involves selecting, cutting and arranging. Brand management is important to ensure the crop produces quality fruits.

Table 1. Watermelon production in-field activities

Main Activity	Land preparation	Planting	Crop Maintenance	Harvesting
Sub-activity	1. Tillage a. Plough b. Harrow c. Rotary tillage 2. Bed forming 3. Liming 4. Organic fertilising 5. NPK fertilising 6. Plastic mulching laying	1. Seedling preparation 2. Seedling transplanting a. Carrying seedling b. Punching hole *c. Placing seedling* d. Planting e. Covering hole	1. Weed control 2. Pest and disease control 3. Fertilizing *4. Pollination* *5. Branch management* 6. Irrigation control	*1. Picking* *2. Lifting* 3. Loading *4.* Transporting 5. Waste management

Technology Package

The package comprises 12 technologies: 5 for land preparation, 2 for planting, 3 for crop maintenance, and 2 for harvesting, as shown in Table 2 below. All the machines and implements listed in the table are adaptions of existing machines except 3 machines, namely the weeding implement, harvesting aid trailer, and in-field waste management implement. These 3 machines were locally designed and developed. Tillage implements comprising disc ploughs, harrow discs, and rotavators are the standard agricultural implements used in land preparation. Organic fertiliser in the market is available in two forms: raw and processed. The processed organic fertiliser can be applied using the same implement for liming. Spraying implements and drones are used for pest and disease control. Drone is used when the soil surface is fully covered by crops, which means there is no way for a tractor to go in. The harvesting aid trailer was designed to have a long conveyor boom to help the operator speed up the process of harvesting.

Table 2. List of machine technologies in the package based on activity

Land Preparation	Planting	Crop maintenance	Harvesting
1. Tillage Implements 2. Liming implement 3. Organic fertiliser spreading implement 4. Granular fertiliser spreading implement 5. Plastic mulching and drip tape layer implement	1. Seedling Machine 2. Transplanting implement	1. Spraying implement 2. Spraying Drone 3. Weeding implements cum fertiliser applicator	1. Harvesting Aid Trailer 2. In-field waste management implement

Machine performance

Table 3.0 shows the performance of mechanised activities of watermelon production focusing on field capacity and labour requirements. All activities were tested in the field except seed sowing which was conducted under a shed. Seed sowing is the preparation of watermelon seedlings in the trays. 1 hectare requires approximately 5000 to 6000 seedlings. The machine managed to sow 6240 seeds in one hour of operation with a labour requirement was 1 man.hour/ha meanwhile manual operation need about 24 man.hour/ha. This gave about a 95.8 % decrease in labour requirements.

Nowadays, most tillage operations are conducted using mechanisation as also in conventional production which measured the labour requirement of 1.28 man-ha/ha. Organic fertilizer is needed as a soil nutrient enrichment and improvement. Manual organic spreading works require about 13.99 man-ha/ha. Mechanised spreading decreases by almost 62% of labour requirements to 5.29 man-ha/ha using organic fertilizer spreading implement. Mechanised spread not only fast by also resulting the uniform distribution of the organic fertilizer.

In local watermelon production practice, NPK fertilizer is given as early as before plastic laying. Watermelon needs about 80 to 100 g per plant NPK fertilizer. The use of fertilizer-spreading machine helps farmers to speed up their operations with a labour requirement of 1.94 man-ha/ha which decreases almost 87% of manual operation from 14 man-ha/ha. The installation of plastic mulch requires a lot of labour and needs to be carried out carefully to reduce damage. The use of mechanization greatly helps this activity by only requiring 3.03 man-ha/ha compared to manual operations that require up to 16 man-ha/ha.

The activity of tranplanting watermelon seedlings involves 5 steps as discussed above. This process can be accelerated by the use of planting machines where the use of labour is reduced from 23.8 man-h/ha to 7.91 man-h/ha. Table 1 lists the six activities involved in watermelon crop maintenance. Two important operations in crop maintenance are spraying and mechanical

activities like fertilizer spreading and mechanical weeding. Mechanized spraying operations are divided into two types: tractor-mounted and drone. Drones are used after the field surface is fully covered by the crop.. Both operations resulted in a tremendous reduction in labor requirements, from 8 man-hours per hectare for manual operation to 0.5 man-hours per hectare for tractor-mounted and 1.16 man-hours per hectare for drone operation.

Harvesting operation was the highest labour requirement which needed about 4 labourers, 1 as tractor driver and another 3 as the machine operator to manually pick and load on the harvesting aid trailer conveyor. In conventional practice by using a standard trailer, 6 labourers are needed that give the same field capacity as the trailer with conveyor. Watermelon mechanised production activities require about 68.71 man-h/ha or 10 man-day/ha for working hours of 7 hours per day. According to a study by Kumar et al (2018), the traditional method or conventional practice of growing watermelon requires an average of 117 man-days of labour per ha. The amount of labour needed depends on the size of the land used, which is determined by factors such as climate, soil conditions, and the ideal seeding rate per hectare. By comparing the value, mechanised production saves about 73.6 % of labour requirements.

Table 3.0 Performance of mechanised watermelon production activity

Mechanised Activity	**Field capacity (ha/h)**	**Number of Labour**	**Labour requirement (man-ha/ha)**	**Labour requirement (conventional) (man-ha/ha)**
Tillage	0.782	1	1.28	1.28
Seed sowing	1	1	1.00	24
Organic spreading	0.189	1	5.29	13.99
NPK spreading	0.516	1	1.94	14
Plastic mulch laying	0.33	1	3.03	16
Planting	0.253	2	7.91	23.8
Spraying (Tractor)	2	1	0.50	8
Spraying (Drone)	0.86	1	1.16	
Weeding and fertilising	0.28	1	3.57	34
Harvesting	0.11	4	36.36	72
In-field waste management	0.3	2	6.67	54
Total			68.71	261.07

CONCLUSION

The field mechanisation technology package for watermelon production consists of twelve technologies divided into four main mechanisation activities; land preparation, planting, crop maintenance and harvesting. The use of this technology package can reduce almost 73.6% of labour requirements compared to the conventional practice of manual operation. Moreover, mechanisation facilitates faster fieldwork, allowing farmers to expand their cultivation acreage more easily within the same time frame as conventional methods. Further research shall focus on multi-locational tests for different types of soil such as mineral soil and other than BRIS soil to see the real potential of the package usage.

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