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Communiversity initiative via Knowledge Transfer Project (KTP-RIGS): A Socio-economic Transformative Journey of B40 Bentong Ginger Farmers at Kampung Tok Muda Haji Muhammad Karak

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ABSTRACT
Kampung Tok Muda Haji Muhammad (KTMHB) is a village located near Karak town in the Bentong District of Pahang. One of the main crops cultivated by farmers on the mountain slopes of Gunung Karak is Bentong ginger. However, in recent years, Bentong ginger production has faced major challenges due to soilborne diseases and the limited availability of planting materials. In addition, flash floods that occurred in December 2021 and January 2022 destroyed many agricultural fields. These factors have adversely affected the socio-economic well-being of the B40 villagers, who are dependent on agriculture as their primary source of income. Consequently, the community sought the involvement of researchers from the Department of Plant Science (DOPS), Kulliyyah of Science, International Islamic University Malaysia (IIUM), to provide knowledge on modern and sustainable agricultural practices. As an initiative to support the affected community, three strategies were implemented in collaboration with Koperasi Tok Muda Karak Berhad. First, to address the shortage of Bentong ginger planting materials, preliminary research was conducted to develop an optimised tissue culture technique. This technique successfully produced true-to-type, sustainable, cost-effective, and disease-free Bentong ginger plantlets, which can serve as future planting materials for KTMHB farmers. Second, to overcome the limitation of fertile and disease-free agricultural land, a fertigation technique was optimised as an innovative cultivation method for Bentong ginger. Hands-on fertigation workshops were conducted at the planting site to train farmers in proper fertigation practices aimed at producing healthy rhizomes. Third, to generate additional income for the B40 community, a fertigation system for Golden Melon was established on vacant land at Madrasah Tahfiz al-Qur'an, KTMHB. Tahfiz teachers and local community members were trained in fertigation techniques to produce Golden melons as a cash crop. Currently, these fertigation systems are utilised for the cultivation of Bentong ginger and Golden Melon. The income generated contributes to sustaining the community and alleviating poverty, including supporting the operation of the tahfiz for underprivileged students. The socio-economic well-being of the B40 farming community of KTMHB will continue to be monitored.

Keywords: Halia Bentong, melon, zero poverty, tissue culture, fertigation, B40.

Introduction

Bentong ginger (*Zingiber officinale* var. *Bentong*) is a unique variety cultivated in the highlands of Bentong, Pahang, owing to the fertile soil and cooler highland climate. Its high market demand is attributed to the rhizome's strong aroma, spicier taste, higher pungency, and less fibrous pulp compared with other Malaysian ginger varieties. In addition, Bentong ginger contains higher levels of gingerol, shogaol, and essential oil compounds, contributing to its pharmaceutical value (Sundram et al., 2019). In 2015, Bentong ginger was recognised as one of Pahang's Geographical Indications by the Agriculture Bureau of Pahang (Jahiddin, 2020).

The B40 farming community refers to the lower-income group within the agricultural sector, typically representing households in the bottom 40% of the national income bracket (Economic Planning Unit (EPU), 2023). At Kampung Tok Muda Haji Muhammad (KTMHB),

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this community is highly dependent on agricultural activities, particularly Bentong ginger cultivation. However, in recent years, this dependency has increasingly affected their livelihoods due to challenges such as low proliferation rates, limited availability of planting materials, declining soil fertility, and soil-borne diseases, which have constrained Bentong ginger production (Sundram et al., 2019).

In this context, tissue culture represents a promising approach to address the shortage of quality planting materials. Tissue culture is a technique used to produce large numbers of clonal, disease-free, and high-quality planting materials under controlled conditions. Previous studies have demonstrated successful in vitro propagation of Bentong ginger, including shoot multiplication, root development, and microrhizome formation, supporting its potential as a sustainable propagation method for this crop (Sundram et al., 2019; Zahid et al., 2021a, 2021b).

In parallel, Golden melon (*Cucumis melo*) has been identified as a nutritionally rich fruit containing vitamin E, vitamin C, carotenes, and potassium. Under National Agriculture and Agro-food Policy 2021–2030, melon production has been recognised for its export potential. Nevertheless, current melon production in Malaysia remains insufficient to meet local demand. This shortfall is largely attributed to limitations such as inadequate knowledge of modern agricultural practices, high fertilizer costs, unpredictable weather conditions, and pest and disease pressures (Masdek and Muhammad, 2016).

Modern fertigation techniques offer a practical solution to several agronomic challenges encountered in the production of both Bentong ginger and Golden melon. Fertigation integrates fertilization and irrigation through the precise delivery of water and nutrients directly to the plant root zone, thereby optimizing resource use while reducing dependence on fertile soil and minimizing disease risks. This system is relatively simple, flexible, and can be automated to improve crop productivity and management efficiency (Shahid et al., 2009; Yasser and Mohamad, 2016). Importantly, fertigation also presents strong potential as an income-generating strategy for B40 farming communities by enabling sustainable crop production on limited or marginal land.

Therefore, this study aims to address the key production and socio-economic challenges faced by B40 farming community of KTMHB through three integrated strategies: (i) development of a preliminary tissue culture approach to ensure a sustainable supply of disease-free Bentong ginger planting materials as mentioned in materials and methods section: (ii) implementation of fertigation techniques for Bentong ginger to overcome soil-related constraints and improve crop management; and (iii) introduction of Golden melon fertigation as an alternative cash crop to diversify income sources. The techniques used to implement these strategies are outlined as results. Collectively, these strategies seek to enhance agricultural sustainability, strengthen farmers' technical skills, and contribute to the long-term socio-economic well-being of the KTMHB B40 community.

Methodology

Strategy 1: *Preliminary research on optimizing surface sterilization techniques and culture medium for Bentong ginger in vitro culture*

Young rhizomes shoot bud explants were initially surface sterilised by first treating with fungicide carbendazim (30 minutes), 50% sodium hypochlorite (10 or 12 minutes), 70% ethanol (8 or 10 minutes) and 0.2% mercuric chloride solution (8 or 10 minutes) were used. The explants were rinsed with sterile distilled water in between each step and prior to culturing on media. In order to identify optimised media and PGR that could induce shoots & roots, the shoot bud explants were cultured on Murashige and Skoog media (MS) fortified with 30g sucrose, 8g gel rite and different concentrations of BAP

either alone or in combination with NAA (Table 1). Medium without addition of BAP and NAA served as control. After two weeks of initiation, the explants were subcultured biweekly onto fresh medium to replenish nutrients and maintain optimal growth. The number of developed shoots, roots and leaves per explants were assessed monthly for 8 weeks.

Strategy 2: *Establishment of Bentong ginger fertigation*

Fertigation is one of the methods taught to Bentong ginger B40 farmers of KTHMB as part of educating and engaging with the community on modern agricultural practices. The project was divided into four different methods to engage with the community: (1) Workshop seminars, (2) Setting up the rain shelter and fertigation system together with the participants, (3) Preparing and planting the Bentong ginger seeds together with the participants and (4) Continuous monitoring on the progress. The method of ginger fertigation as outlined in manual by Yasser and Mohamad, (2016) with minor modifications was used as guideline to educate the participants involved

Table 1: Effects of BAP and NAA on micropropagation of Bentong ginger

Treatment (MS medium + BAP + NAA)	Weeks	Length of longest shoot (cm)	No. of shootlets	Length of longest leaf (cm)	No. of leaves	Length of longest root (cm)	No. of roots
T_1 (2.0 mg/l BAP)	4	0.0	0.0	0.0	0.0	0.4	1.0
	8	0.9	2.0	0.0	0.0	2.0	4.0
T_2 (3.0 mg/l BAP)	4	0.0	0.0	0.0	0.0	0.4	1.0
	8	1.0	2.0	0.0	0.0	2.4	5.0
T_3 (2.0 mg/l BAP + 1.0 mg/l NAA)	4	0.0	0.0	0.0	0.0	0.3	1.0
	8	0.6	1.0	0.5	2.0	2.8	5.0
T_4 (3.0 mg/l BAP + 1.0 mg/l NAA)	4	1.0	1.0	0.0	0.0	0.6	3.0
	8	2.0	2.0	1.2	4.0	2.5	7.0

Strategy 3: *Establishment of Golden melon fertigation*

In order to generate additional income, golden melon fertigation technique was also taught to the B40 farmers as next strategy in educating the community. As many participants has basic knowledge on fertigation, this engagement project was initially started with workshop on fertigation of golden melon. Next, hands-on fertigation workshops were undertaken. These workshops were divided into 3 growing seasons: (1) first growing season (70% demonstrated by DOPS researchers), (2) second growing season (50% demonstrated by DOPS researchers and 50% hands-on undertaken by participants) and (3) Third growing season (100% hands-on done by participants). This engagement project was continuously observed and monitored by DOPS researchers. Every season involved seed sowing, polybag preparation, setting up and maintaining fertigation system, pesticides and fungicide application, and finally harvesting and selling the Golden melon. The method as outlined in manual by Shahid et al., 2009 with some modification as was used as reference in setting up and running the fertigation. Survey was conducted among participants, before the beginning of the workshop and at the end of third growing season using questionnaires. This survey was conducted to understand the outcome of this engagement project.

Results and Discussion

Strategy 1: *Preliminary research on optimizing surface sterilization techniques and culture medium for Bentong ginger in vitro culture*

As the explants are underground part of the plant, the *in vitro* establishment of clean culture is difficult due to the presence of soil-borne microbes in these living materials (Sundram et al., 2019). The most effective surface sterilisation technique, with 30% survival rate was step-by-step treatment with fungicide carbendazim for 30 minutes followed by 50% sodium hypochlorite for 10 minutes, 70% of ethanol for 10 minutes and 0.2% mercury chloride for 8 minutes. As the explants are underground part of the plant, the *in vitro* establishment of clean culture is difficult due to the presence of soil-borne microbes in these living materials (Sundram et. al, 2019).

The effect of BAP and NAA on Bentong ginger *in vitro* cultures is presented in Table 1. Two shoots per explant cultures were formed in all treatments after 8 weeks. However, the length of the shoots varied, with T4 produced longest shoot of 2cm after 8 weeks of culture. Meanwhile only T3 and T4 produced leaves in 8 weeks old *in vitro* plantlets. T4 initiated 4 leaves in the culture with longest leaf measuring 4.0cm at week 8. All treatments induced roots with T4 producing highest number of roots (7 roots) including the longest root of 2.5cm at week 8. Thus, in this study MS medium fortified with 3.0 mg/L BAP and 1.0 mg/L NAA is the best medium for *in vitro* regeneration of Bentong ginger plantlets (Figure 1). Currently, there are no published data on effects of combinations of BAP and NAA on *in vitro* regeneration of Bentong ginger plant. As mentioned in introduction, Zahid et al., 2021b successfully induced shootlets in MS medium supplemented 10 µM zeatin and *in vitro* roots in MS medium with 7.5 µM NAA. However, zeatin is an expensive PGR and Zahid et al. 2021b reported two different regeneration mediums for rooting and shooting, which is time consuming. The combination of cytokinin BAP with auxin NAA is essential to produce higher number of multiple shoots in domestic ginger. BAP stimulates cell division and elongation more actively in the presence of auxins while NAA auxins is essential in lateral root initiation (Mehaboob et al., 2019)

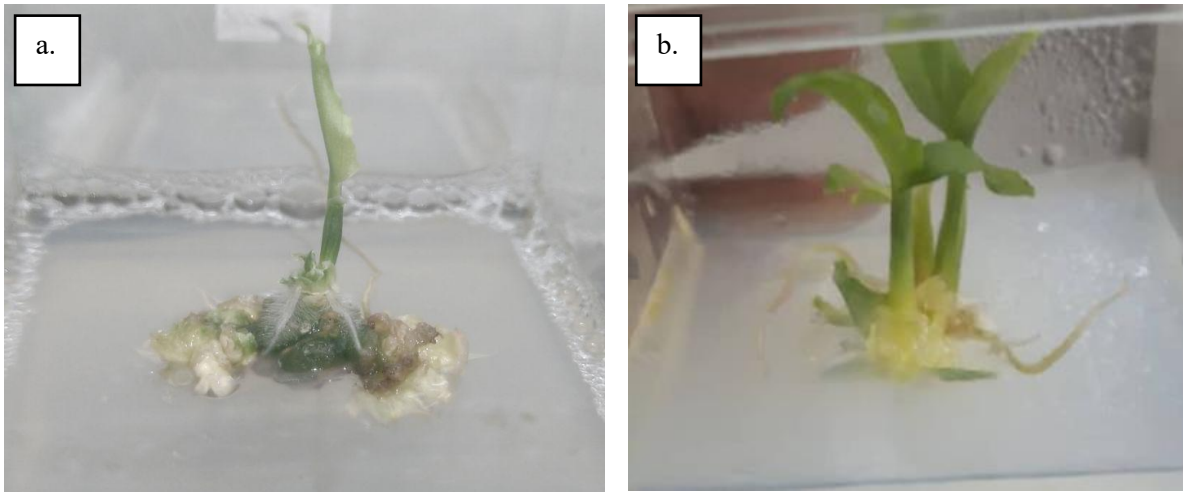

Figure 1: Development of Bentong ginger plantlets using shoot bud explants on MS medium supplemented with 3.0 mg/L BAP + 1.0 mg/L NAA. (a) week 4. (b) week 8.

Strategy 2: *Establishment of Bentong ginger fertigation*

The fertigation projects are more focused on the success of delivering and educating the correct fertigation techniques to the participants. These are as reported in Tajudin et al., 2021 for Bentong ginger fertigation and Sundram et al., 2025 for golden melon fertigation. Prior to conducting hands-on Bentong ginger fertigation training, a workshop seminar on i) soil management for sustainable agriculture and ii) fertigation techniques of ginger were conducted. During the hands-on training, firstly a rain shelter was planned and built on the cleared field area of Gunung Karak site (Figure 2a). This shelter was designed to prevent effects from heavy rains that could deplete the fertilizer supplied to the plants in polybag as well as after rain pest and diseases. A well-calibrated fertigation system was set-up together with the participants, for a steady and controlled delivery of fertilizer and water directly to each plant (Figure 2b). The system consists of one water tank, one fertilizer tank, automated timer, 32mm primary and secondary polypipe, 16 mm dividing polypipe and water drippers. Polybags of the size 24 x 16 inches filled with cocopeat were used as planting medium. Techniques to prepare fertilizer was taught to the participants by diluting the readily available fertilizer A mix powder in one tank and fertilizer B mix powders in another tank according to the dilution methods provided by manufacturers. These fertilizers that were supplied daily, contains combination of macronutrients (nitrogen, phosphorus, potassium, calcium and sulphur) and macronutrients (ferum, mangan, boron, zinc, copper, sodium, ammonium and molybdenum). 9 months old mature ginger rhizomes were cut into pieces of 7-11cm, with at least 2 -3 shoot buds on each piece. These pieces were used as seeds. Once the fertigation system was set, ginger seeds were transferred to polybag containing cocopeat and the system was run. One foot space was maintained between polybags in each row, and 5 feet space were maintained between each row. During the first three week the concentration of fertilizers supplied was EC 1.8 and increased to EC 2.4 after third week. Irrigation of combined fertilizer and water is done 5 times during sunny days and 2 times during rainy day, for 5 minutes. Daily monitoring was conducted by participants and monthly monitoring was conducted by trainers to maintain the of soil and plant health. Adjustments were made to ensure the fertigation system remained effective, resulting in robust Bentong ginger plants. Pesticides and insecticides as mentioned by Yasser and Mohamad, 2016 is applied when required. After 8 months the gingers were harvested as young rhizomes.

*Figure 2: (a) Fertigation of Bentong ginger built under rain shelter. (b) Facilitators teaching participants on setting up fertigation syste*m.

Strategy 3: *Establishment of Golden melon fertigation*

A one-day seminar was conducted to teach participants on the techniques of golden melon fertigation (Figure 3a). The talks presented was on a) preparation of planting materials and seeds; b) setting up fertigation system of Golden melon; 3) pest and disease control; and 4) postharvest management. During season 1, fertigation system and fertilizers similar to fertigation system of Bentong ginger was built and prepared together with participants. 200 Golden melon seeds (Brand CropPower ML 1388 Golden sweet sea) were sown in peatmoss and were covered with black plastic sheets for three days to obtain golden melon plantlets (Figure 3b). Plantlets were then transferred to the polybag (16 x 16 inches) containing cocopeat (Figure 3c) and the system was run. However, all the plants were infected with white flies, as season 1 fertigation was done in open space. This caused cucurbit leaf crumple virus and retarded the growth of golden melon (Figure 3d). In order to avoid further infection, the plants were discarded. Thus, netted green house was built, using shading nets of 0.5 mm mesh size (Figure 3e) to avoid further pest infection. Transparent high-quality plastic sheet was used as roof for sunlight (Figure 3f). New plantlets of golden melon for second growing season and third growing season through fertigation were done in the netted green house (Figure 3g and 3h). EC of the fertilizer was slowly increased starting from EC 1.0 during week 1 to EC 3.5 in week 10 as outlined by Shahid et al., 2009. Pesticides, insecticides and foliar were periodically sprayed to maintain plant health. The plants were maintained by participants through guidance from trainers. One best fruit per tree is selected during week 6 and the rest is discarded from further growth in order to maintain the quality. The fruits were harvested once matured during week 10 (Figure 3i) and sold at RM 12/kg to public (Figure 3j). A total of around 350kg of golden melon fruits were obtained at the end of workshop. The small profit obtained were used to purchase materials for next cycle of golden melon fertigation as well as to run a tahfiz school for B40 students. The pre- and post-analysis on results of two surveys; 1. conducted before beginning of workshops (Table 2) and, 2. conducted at the end of all the workshops (after third growing season) (Table 3) indicated that all respondents were highly interested and positively benefitted from the Golden melon fertigation workshops. The participants improved knowledge and hands-on fertigation skills of Golden melon. Previous studies also indicated that adult learners in the community preferred hands-on training compared to a lectures or theoretical workshops (Yunus et. al, 2024).

Recently, KTMHB was selected as runner-up of Madani Village Awards 2024-Traditional Village category (Figure 4). The success of above-mentioned community engagements and fertigation programmes conducted by DOPS was mentioned as part of the contributing factors for the village to win this national level award.

Table 2: Analysis on outcome of survey conducted before Golden melon fertigation workshop.

QUESTIONS	YES (%)	NO (%)
Are you interested in farming activities?	100	0
Have you ever been involved tree plantings?	80	20
Do you know what trees needs to grow healthy?	45	55
Have you ever planted at least 5 types of plants?	60	40
Do you know the type of suitable planting media?	20	80
Do you know the plants watering schedule?	30	70
Do you know about the plant's fertilization schedule?	25	75
Do you know the methods to plant trees using seedlings?	55	45
Do you have knowledge about fertigation system?	25	75
Have you ever seen plants grown using fertigation system?	60	40
Are you interested in planting trees using fertigation techniques?	95	5
Do you know how to choose suitable plants for fertigation?	15	85
Do you have any knowledge on "Golden Melon" plant?	15	85
Do you know how to plant "Golden Melon" using fertigation techniques?	20	80
Do you know the requirements of fertilizer and water for Golden melon plants	20	80

Table 3: Analysis of the outcome of survey conducted at the end of workshops.

QUESTIONS	YES (%)	NO (%)
Do you understand the seedling transfer method carried out during the practice?	100	0
Do you think Golden Melon "Fertigation" technique could ensure a more systematic and orderly planting system than conventional method?	100	0
Are you clear about EC and the AB fertilizer mixing techniques?	64	36
Do you understand the frequency and control of irrigation system for fertigation?	82	18
Are support ropes essential for Golden Melon tree to grow higher?	82	18
Can you identify the male and female flowers of Golden melon?	64	36
Do you understand the important of assisted pollination techniques on Golden melon?	91	9
Do you think Golden melon fruits grown using the fertigation method are of higher quality?	100	0
The fertigation method in planting Golden melon fruits can prevent soil-borne root diseases.	100	0
Fertigation method provides complete nutrients that can be controlled according to the needs, type and growth stage of the plant.	100	0
Fertigation method can save planting space more efficiently and reduces interference of weeds.	100	0
Yield can be increased through fertigation method.	100	0
The fertigation method is less labour intensive in the cultivation of Golden melon	100	0
Is the fertigation method for Golden melon straightforward and feasible for implementation?	100	0
Does this technology transfer program benefit the community, especially in term of socioeconomic development?	100	0

Figure 3: Golden melon fertigation. (a) One-day seminar on Golden melon fertigation. (b) Golden melon seedlings obtained from seeds sown in peat moss. (c) Transferring seedlings into polybags (16 x 16 inches) containing cocopeat. (d) Growth retarded golden melon plants due to cucurbit leaf crumple virus infection caused by white flies' golden melon. (e) Netted green house built using shading nets of 0.5 mm mesh size to avoid pest infection. (f) Transparent high quality plastic sheet used as roof of netted green house for sunlight. (g) Two weeks old healthy growing golden melon plants through fertigation system in a netted green house. (h) Five weeks old healthy growing golden melon plants through fertigation system in a netted green house. (i) Harvesting the matured golden melon at week ten. (j) Selling golden melon to public.

Figure 4: Runner-up certificate, Madani Village Award 2024

Conclusion

The primary aim was to assist and educate the B40 farming community in KTMHB, and this purpose was successfully accomplished. This aligns with the *Rahmatan lil-alamin* idea of IIUM, which is focused on achieving SDG 1 (no poverty) and SDG 2 (zero hunger) as to serve the humanity. Our first strategy successfully developed a preliminary technique for producing Bentong ginger *in vitro* plantlets. However, this is preliminary research, and further study is currently ongoing to optimize carbon source and acclimatization condition to produce cost-effective *in vitro* plantlets. Fertigation techniques were effectively taught to the participants which have the potential to generate long-term economic benefit for the community.

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