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Research Application Summary

Gross margin comparison between different growth media for potato minituber production

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Abstract

Potato (*Solanum tuberosum* L.) is the second most consumed food crop in Kenya. Due to numerous production challenges, its yield remains low at 8.6 tonnes/ha compared to global productivity of 40-45 tonnes/ha. This gap in productivity is associated with the use of uncertified seeds or minitubers, unsuitable growth media for minituber production, rapid decline in soil fertility, pest and diseases amongst others. The use of unsuitable growth medium affects the quality and quantity of the minitubers and consequently potato production. An experiment was therefore set up to evaluate the effects of different growth media namely untreated cocopeat, treated cocopeat, and soil for the production of certified potato minitubers. A pot experiment arranged in a randomized complete block design (CRD) with three replicates was conducted at the Climate and Water Smart Agriculture Centre of Egerton University, Kenya. Data were collected on tuber yield, number of tubers, and cost of inputs used per treatment and analyzed for the productivity, percentage gross profit margin, and an operating expense ratio. The results showed that the highest yield (20.67 tonnes/ha), number of tubers (22 per plant), and percentage gross profit of 75.01% were obtained in the treated cocopeat (T2). The untreated cocopeat had the second highest yield, number of minitubers, and percentage gross profit of 46.42% followed by the soil treatment (T3) with a percent gross profit of 8.82%. The results suggest that for minituber production under greenhouse condition, the use of treated cocopeat was 28.59% and 66.19% more profitable as compared to the untreated cocopeat and soil, respectively. Therefore, treated cocopeat should be used for the production of potato minitubers because of its high productivity and profitability.

Key words: Cocopeat, gross profit margin, minituber, potato

Résumé

La pomme de terre (*solanum tuberosum* L.) est la deuxième culture alimentaire la plus consommée au Kenya. En raison de nombreux défis de production, son rendement reste faible à 8,6 tonnes / ha comparée à une productivité mondiale de 40 à 45 tonnes / ha. Cet écart de productivité est associé à l'utilisation de graines non certifiées ou de micro tubercules, des supports de croissance inappropriés pour la production micro tubercules, une baisse rapide de la fertilité des sols, des organismes nuisibles et des maladies, entre autres. L'utilisation d'un milieu de croissance inadéquat affecte la qualité et la quantité des micro tubercule et par conséquent la production de pommes de terre. Une expérience a donc été mise en place pour évaluer les effets de différents supports de croissance, à savoir la tourbe de coco non traitée, la tourbe de coco traitée et le sol pour la production de micro tubercules de pommes de terre certifiées. Une expérience de pot disposée dans une arrangement de bloc complet randomisée (CRD) avec trois réplications a été effectuée au Climate and Water Smart Agriculture de l'Université d'Egerton, au Kenya. Les données ont été collectées sur le rendement des tubercules, le nombre de tubercules et le coût des entrées utilisées par traitement, et analysées pour la productivité, le pourcentage de la marge bénéficiaire brute et un ratio de dépenses de fonctionnement. Les résultats ont montré que le rendement (20,67 tonnes / ha), nombre de tubercules (22 par plante) et pourcentage bénéfice brut (75,01%) les plus élevés ont été obtenus avec la tourbe de coco traitée (T2), suivi de la tourbe de coco non traitée qui produit avec un pourcentage de bénéfice brut de 46,42%, en dernier le traitement au sol (T3) qui a généré un pourcentage de bénéfices brut de 8,82%. Les résultats suggèrent que pour la production sous serre de micro tubules, l'utilisation de la tourbe de coco traitée était de 28,59% et 66,19% plus rentable que la tourbe de coco non traitée et le sol simple, respectivement. Par conséquent, la tourbe de coco traitée doit être utilisée pour la production de micro tubules de pomme de terre en raison de sa productivité et rentabilité élevées.

Mots clés: tourbe de coco, marge bénéficiaire brute, micro tubercules, pomme de terre

Background

Potato (*Solanum tuberosum* L.) belongs to the family of Solanaceae, and it is the world's third largest food crop after wheat and rice and second in Kenya (Campos and Ortiz, 2020). It is cultivated in an area estimated at 19 million hectares globally with 378 million tonnes of production (Devaux *et al*., 2020). Global potato consumption accounts for approximately two-thirds of the harvest with about 1.3 billion people eat potatoes as a staple food (Campos and Ortiz, 2020). This shows that potato is one of the food crops with a high potential of contributing towards achieving sustainable development goal (SDG) two of the global (SDGs). In the coming decades, substantial improvements of global food system worldwide to feed the increasing global population are required. An average potato yield in Kenya is 8.6 tonnes/ha compared to global average productivity of 40-45 tonnes/ha (Janssens *et al*., 2013; FAOSTAT, 2020). According to Janssens *et al*. (2013), approximately 1% of the potato areas in Kenya is planted with certified seed and this production meets 2% of effective demand. The shortage of seeds has led farmers to plant uncertified seeds, seeds from the previous years, or seeds from neighbors leading to low productivity and low return from their farms. Use of soil as growth media for seed potato production is discouraged as it increases low multiplication rate of tubers, disease prevalence and more laborious weed control (Darvishi *et al*., 2012; Muthoni *et al*., 2013; Hajiaghaei *et al*., 2019). In Kenya, it is estimated that KES 42,824 is lost per hectare per production season of potato (Wachira *et al*., 2014). Factors such as inadequate water supply, mechanical damage (due to the use of soil), losses in storage, leftover in the field, transport and packaging amongst other attributes contribute to this loss. To reduce these effects, the use of appropriate growth media for minituber multiplication and higher return/income should be considered (Zimba *et al*., 2014).

Alternative methods for seed multiplication are gradually shifting to the use of soilless media such as cocopeat, pumice, peat moss, vermiculite, sawdust amongst others (Zimba *et al*., 2014). Cocopeat, also known as coconut fiber or coir dust is an organic planting media made from coconut husks with high potassium (K) at 38.5-40 cmol kg^{-1} and sodium at 13.04-15 cmol kg^{-1} depending on the source (Kimbonguila *et al*., 2019; Putra *et al*., 2019; Wittman, 2020). Cocopeat has become a major component for both greenhouse and container crop production around the globe. Efforts have been made to make cocopeat suitable for the production of horticultural crops instead of soil. The use of calcium nitrate ($Ca(NO_3)_2$) reduces elements that are naturally bonded to the cation exchange complex of cocopeat (Wittman, 2020; Marock, 2021). Due to the aforementioned challenges in soil and soilless culture, this research aim was to evaluate the gross margin between the use of untreated cocopeat, treated cocopeat, and soil for seed potato minituber production. The gross margin (GM) also termed as gross profit margin (GPM) is the measure of profitability that shows the ratio of the revenue that exceeds the cost of goods sold or the total variable cost of a given business within the same period (Mahdi and Khaddafi, 2020).

Materials and methods

Description of treatments and experimental materials. A completely randomized design pot experiment with three treatments (each six pots) and three replicates was conducted in a greenhouse with average maximum and minimum temperatures of 33.0^{o}C and 13.3^{o}C, respectively. The research was done from August to November, 2020 at the Climate and Water Smart Agriculture Centre of Egerton University, Kenya. The study site is situated at latitude of 0° 23’ south, longitude 35 36’ East with an altitude of 2267 meters above sea level. The soil used was a Mollic Andosols with well-drained, dark reddish clays, slightly acidic as described in Jaetzold *et al*., (2007). Hydrometer method was used to analyse the soil texture (Okalebo *et al*., 2002). The soil texture was clay loam with clay 35%, sand 25%, and silt 40%. For the treated cocopeat treatment, cocopeat was completely soaked with tap water and left standing until there was no more water runoff. Thereafter, 0.60 kg of $Ca(NO_3)_2$ in 90 L^{-1} of water was used to treat 9 kg of cocopeat. Calcium nitrate was dissolved in water and poured on the cocopeat while vigorously and carefully mixing. The leachate solution was vigorously mixed after every six hours and sample collected after 36 hours. Cocopeat media was then thoroughly rinsed using hydrogen peroxide (0.5ml into 1 litre of pure water). To rinse the cocopeat, sixty litres of this solution were used for the entire treated cocopeat treatment. A second rinsing was done with 15 litres of tap water, and the media was left standing for 24 hours to drain the remaining water. After the 24 hours, the treated cocopeat was divided into six equal halves. Thereafter, 1.5 kg each of the untreated cocopeat were placed into six buckets of volume (9,234.54 cm^3) and five litres of tap water without calcium nitrate was added in each pot to moisten the media before planting. The soil treatments were made by placing 14 kg of soil in each of the six buckets and moistened to 50% moisture content before planting. The seed potato apical rooted cuttings Shangi variety sourced from Stockman Rozen Limited, Naivasha, Kenya were then planted in the three treatments (untreated cocopeat, treated cocopeat, soil) (Table 1). The costs for each variable used per treatment were quantified and the values are presented in (Table 3).

Table 1. Treatments for the gross profit, operating expense ratio, and gross margin analysis

Treatments	Description
T1	Untreated cocopeat
T2	Treated cocopeat
T3	Soil

Experimental management. All the treatments were supplied with the same quantity of nutrient and water through drip irrigation with hydroponics nutrient solutions (A and B) mixed at the ratio of 1g/1 liter of water each (Table 2). Water + nutrient supply was fixed at 0.30 liters per plant after every two days up to the flowering period. After flowering, the nutrient/water supply was reduced to 0.30 liters after 3 days. Insect pests were controlled with Thunder (Imidacloprid 100g/L + Beta-cyfluthrin 45g/L) at the rate of 0.5ml/L and late blight using Infinito at the ratio of 0.5ml/L of water. Regular weeding was done on the soil treatment as that was the only treatment that contained weeds.

Data collection on yield parameters and the variable costs

The type of data collected were primary quantitative data. Data was collected on tuber yield, number of minitubers, and the prices of the variable used per treatment. The data collected were subjected to the analysis of gross profit, gross profit margin, and operating expense ratio using the following formulas as described in Jagelavi ius (2013) and in Mahdi and Khaddafi (2020).

GP=TR-TVC

Where; GP is the gross profit, TR is the total revenue, and TVC is the total variable costs.

TR is obtained by multiplying the total number of tubers per treatment by the unit selling price of tuber (18 KES), the TVC is obtained by the addition of the variable costs per treatment as shown in (Table 3).

GM%=GP/TR 100

Where; GM% is the percentage gross margin, GP is the gross profit, and TR is the total revenue.

OER%=100-GM%

Where; OER% is the percentage operation expense ratio

Table 2. Nutrient's composition of each hydroponics solution (A and B)

Elements	Concentration (g kg^{-1})
Potassium K(K_2D)	0.15
Copper proteinate	0.0002
Zinc proteinate	0.0003
Boron proteinate	0.0007
Calcium	0.098
Manganese proteinate	0.002
Phosphate (P_20_5)	0.05
Iron proteinate	0.028
Magnesium	0.048
Nitrogen	0.12

Variable costs per treatment

Table 3. List of variables with their quantities and costs per treatments

Treatments	Variables	Quantity	Variable cost (KES)*
T1	Purchasing of cocopeat	9kg	50.62
	Apical rooted cuttings	6 cuttings	60
	Labour for planting	1 person	20
	Labour for harvesting	1 person	30
	Hydroponics nutrient A	30.3g	20.46
	Hydroponics nutrient B	30.3g	20.46
	Insecticide (Thunder)	1.82ml	12.70
	Infinito	1.82ml	6.36
	Cost of spraying	8 times	36.24
	Khaki bags	5 bags	5
	Experimental manager	1 person	181.82
Total variable cost			443.66
T2	Purchasing of cocopeat	9kg	50.62
	Apical rooted cuttings	6 cuttings	60
	Labour for planting	1 person	20
	Labour for harvesting	1 person	30
	Hydroponics nutrient A	30.3g	20.46
	Hydroponics nutrient B	30.3g	20.46
	Insecticide (Thunder)	1.82ml	12.70
	Infinito	1.82ml	6.36
	Cost of spraying	8 times	36.24
	Khaki bags	2 bags	20
	Calcium nitrate	0.6kg	36
	Hydrogen peroxide	30ml	60
	Labour for treating cocopeat	1 person	30
	Experimental manager	1 person	181.82
Total variable cost			584.66
T3	Digging the soil and filling the buckets	84kg	130
	Apical rooted cuttings	6 cuttings	60
	Labour for planting	1 person	20
	Labour for harvesting	1 person	30
	Hydroponics nutrient A	30.3g	20.46
	Hydroponics nutrient B	30.3g	20.46
	Insecticide (Thunder)	1.82ml	12.70
	Infinito	1.82ml	6.36
	Cost of spraying	8 times	36.24
	Weeding	4 times	40
	Experimental manager	1 person	181.82
Total variable cost			558.04

Note: All of variables in this table are independent of the treatments (for 6 plants) same as the quantities and the costs; * 1 USD = 107.8 KES (Kenyan shillings)

Projected yield (tonnes per hectare)

The projected yield for each treatment were calculated based on yield obtained per six plants, and the planting distance (0.75m 0.3m) using the yield estimation equation (Norman, 1995):

$$\text{Yield (tones hectare)} = \frac{Yield\ obtained\ \ (kg) \times 10{,}000\ M^2}{Number\ \ of\ Plants\ \ harvested\ \ \times planting\ \ distance}$$

Where; harvested plants were 6, and planting distance is 0.75m 0.30m= 0.225 M^2

Projected yield for T1= 2.07 tonnes/ha, T2=20.67 tonnes/ha, and T3=1.48 tones/ha.

Results and Discussion

The results showed significant differences amongst treatments for the gross margin analysis. Regardless of the resources used for treating the cocopeat, the highest gross profit margin was obtained in the treated cocopeat (75.01%) indicating only 24.99% of the total revenue gained goes to the cost of production leaving 75.01% of the revenue as the farmer's gross profit margin. The second highest gross margin of 46.42% was obtained in the untreated cocopeat. This also means more than half of the total revenue obtained by the farmer directly goes to the cost of production or total variable cost (TVC). The least gross profit margin 8.82% was observed in the soil treatment (T3) (Table 4). It is evident when production of minitubers is done in the soil under a greenhouse condition, 91.18% of the revenue gained is most likely to be used for the cost of production. Interestingly, regardless of the high concentration of K, Na, and EC in the untreated cocopeat, its performance was 37.6% better than the soil treatment (T3). For minituber production, the number of tubers is directly proportional to the gross margin. It is important to also note that gross margin highly depends on the prices of goods and services. The higher the prices of commodities, the lower the gross margin, and vice versa (Jagelavi ius, 2013). Ceteris paribus (all other things: prices of goods and services, unit price of minituber, and the inputs used remain constant), the production of minitubers on treated cocopeat remains higher followed by untreated cocopeat, then the soil. The highest number of minitubers was obtained in T2 followed by T1, and the least in T3 (Table 4). The yield projection revealed, when this production is done on a hectare of land for each treatment, 20.67 tonnes/ha is estimated to be obtained in T2. Similar result by Zimba *et al*. (2014) who obtained 19.08 tonnes/ha of potato using vermiculite, 11.36 tonnes/ha using sand, and 4.3 tonnes/ha using sawdust as a growth media. In T1, 2.07 tonnes/ha, and 1.48 tonnes/ha in T3 if the planting distance between the rows of pots and between pots is maintained at 0.75m 0.30m, respectively. Similarly, Struik (2007) also argued that the use of soil for the production of minitubers in a greenhouse reduces the number of tubers between 2-5 per plant depending on the cultivar used. Putra *et al*. (2019) also obtained an average of 5.27 tubers per plant when an untreated cocopeat was used for minituber production at different thickness.

Table 4. Gross margin analysis for untreated cocopeat, treated cocopeat and soil for the minituber production

Treatments	Yield (kg per 6 plants)	Total tubers per 6 plants	Unit price per tuber (KES)	TR (KES)	TVC (KES)	GP (KES)	GM (%)	OER (%)
T1	0.28	46	18	828	443.66	384.34	46.42[b]	53.58
T2	2.79	130	18	2340	584.66	1755.34	75.01[a]	24.99
T3	0.20	34	18	612	558.04	53.96	8.82[c]	91.18

Note: 1 USD = 107.8 KES (Kenyan shillings); values in the same row are independent of their treatments. Percentage followed by different letters in the GM column are significantly different using percentage bars. TR: total revenue, TVC: total variable cost, GP: gross profit, GM: gross margin, and OER: operating expense ratio

Conclusion and Recommendations

Irrespective of the cost of production, the evidence suggests minituber productivity and farmers' income increases when cocopeat is treated at the rate 0.60kg of $Ca(NO_3)_2$. Cultivation of minitubers in soil is unsuitable as it reduces productivity thus giving low profit. When cocopeat is used without treating it with calcium nitrate to reduce the dominant elements, it also reduces productivity/ income by more than half of the total revenue. Therefore, treated cocopeat is recommended for maximum minituber multiplication under greenhouse condition. These evidences are sufficient to demonstrate that the use of untreated cocopeat and soil for minituber production under a greenhouse condition is less profitable than using treated cocopeat.

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