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Effects of Natural Plant Products as Primers of Nodal Vines on Early Vegetative Growth of Orange Fleshed Sweet Potato (*Ipomoea batatas* L) Varieties

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Aims: The experiment was conducted to determine the effect of priming on early vegetative growth of varieties of orange fleshed sweet potato (OFSP- *Ipomoea batatas* L.)
Study Design: Treatments were 2 OFSP varieties primed in coconut water, grapefruit juice, mixture of coconut water and grapefruit juice and water (control), in a Completely Randomized Design with 3 replications.
Place and Duration of Study: This study was conducted in the screen house of the Department of Plant Science and Biotechnology, Rivers State University, Rivers State, Port Harcourt Nigeria for a period of 3 months.
Methodology: Nodal vines of 2 varieties of orange fleshed sweet potato *UMUSPO 1* "King J", and *UMUSPO 3* "Mothers Delight" were primed in 10% coconut water, 10% grapefruit juice and a mixture of 10% coconut water and 10% grapefruit juice and water (control) for six hours before planting in plastic containers. Time to new sprouting was recorded. Six weeks after planting, number of leaves, nodes, internodes, and vine length were recorded.
Results: Nodal vines of both varieties primed with coconut water and water (control) and those of the variety *UMUSPO 3* primed with grapefruit juice initiated sprouts significantly (*P* =.05) earlier (4 days) than other treatments. Both varieties primed with coconut water and grapefruit juice mixture

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initiated new sprouts after 7 days. The variety *UMUSPO 1* produced higher number of leaves, nodes, and internodes and had longer vines than *UMUSPO 3* in all treatments. Priming with mixture of coconut water and grapefruit juice produced a significantly (*P* = .05) higher number of leaves, nodes, internodes and vine length in *UMUSPO 1* than all other treatments.
Conclusion: To double vegetative growth for planting materials, farmers should prime nodal vines of *UMUSPO 1* with a mixture of 10% coconut water and 10% grapefruit juice for six hours before planting

Keywords: Nodal vines; coconut water; grapefruit juice; orange fleshed sweet potato.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) with its short growth cycle (3-4months) is able to adapt to different environments and agro-systems, and plays an important role in human and animal nutrition especially in tropical countries where it is widely cultivated [1,2]. The orange fleshed sweet potato (OFSP) which contains beta-carotene is a strategic crop bred to overcome vitamin A deficiency [2,3] and can supply significant amounts of vitamin A and energy simultaneously all year round [4,5]; thus helping to address the twin-problems of Vitamin A deficiency (VAD) and under-nutrition [6,7,8]. The 3 most common OFSP varieties available in Nigeria are UMUSPO 1 commonly referred to as '*King J'* released in December 2012*;* UMUSPO 3 locally referred to as '*Mothers Delight'* containing higher levels of beta-carotene than *King J*, released in June 2013 and *UMUSPO 4* called "*Solo Gold*" released in July 2018 by Nigeria's National Root Crops Research Institute (NRCRI). Vitamin A deficiency, which can result in blindness in children and even death, in developing countries including Bangladesh [9] affects 250,000 - 500,000 children per year in Nigeria, [10] and estimates suggest 29.5% of all children under the age of five are vitamin-A deficient [11]. Rapid propagation of orange fleshed sweet potato is thus imperative not only as a good source of income for farmers but also because of its health implications and life saving potential. In many countries, sweet potato crops are propagated using unrooted sprouts or vine cuttings [12]. This means that once the farmers harvest their crop, the likelihood of preserving the planting material to the next planting season becomes a major challenge. Sweet potato growers worldwide are faced with the unavailability of enough planting materials at the beginning of every planting season. During dry periods, the vegetation of the sweet potato crop is completely desiccated, leading to difficulties in securing vines as planting material at the onset of the rains. The problem is more severe for farmers in drought prone and high disease pressure areas. A researcher [13], working with purple skinned/white fleshed sweet potato, found a low cost technique that can be used for rapid regeneration of sweet potato plantlets from mini tubers. Mini tubers of sweet potato after a preconditioning treatment by soaking in 10% coconut water (1:10 coconut water: water ratio) for 12 hrs before planting regenerated almost 3times the number of plantlets regenerated by mini tubers soaked in water for the same period [13]. Perhaps nodal vines used as planting materials can also benefit from priming, so that farmers can maintain and multiply their own planting materials and even become commercial vine producers/ multipliers of OFSP vines as suggested [14]. Other studies have reported the benefits of priming in plants to include a faster and stronger induction of plant defence responses and enhanced resistance to biotic or abiotic stresses than is observed in unprimed plants exposed to the same stress [15,16]. Priming with optimal concentrations of cytokinin and gibberellic acid has been shown to have beneficial effects on germination, growth and yield of a wide range of plant species [17,18,19,20]. The use of naturally occurring plant products such as coconut water, coconut milk, ground spinach leaves, ground potato tubers, ground carrot, rice flour, green gram, ground pumpkin, banana fruit, orange juice, potato, corn and papaya extracts, tomato juice, honey, grapefruit juice, etc as primers *in vivo* and *in vitro* have been reported with varying degrees of success [21,22,23,13]. Interest in the use of naturally available substances and plant products in crop cultivation processes has increased in recent years [24,23,25,13]. Obviously the avoidance of chemical use will also endear this protocol to all organic farmers. This study was conducted therefore to evaluate the effects of readily available and affordable naturally occurring plant products, coconut water and grapefruit juice for priming of nodal vines for regenerating planting materials of two varieties of orange fleshed sweet potato, *UMUSPO 1*, ('King

J') and *UMUSPO 3* ('Mothers Delight') and to determine their effects on early vegetative growth and establishment of both varieties.

2. MATERIALS AND METHODS

This study was carried out at the Department of Plant Science and Biotechnology in Rivers State University, Port Harcourt, Rivers State, Nigeria. The vines of two varieties of orange-fleshed sweet potatoes (OFSP) with different morphology and growth habits (Table 1), UMUSPO 1 ('King J') and UMUSPO 3 ('Mother's Delight') were obtained from the Rivers State University Teaching and Research Farm. Four priming treatments were applied as follows: (a) Coconut water, (b) Grapefruit juice, (prepared as primers by adding 50ml of each substance to 500ml of water in a 1:10 ratio of natural plant product to water). and (c) Coconut water and Grapefruit juice mixture (50 ml of coconut water + 50 ml of grapefruit juice to 500 ml of water) and (d) Water which served as the control. A calibrated ruler was used to measure from the tip of the vines [26], vine lengths of 10cm in such a way that each vine cutting had at least 2 nodes for each of the 2 varieties *UMUSPO1* and *UMUSPO3* (Fig. 1). The vines were soaked in each of the natural plant products for 6 hours to prime them (Fig. 2). Primed nodal vines were planted in 300 g of loamy soil at a rate of one vine per perforated plastic container giving a total of 24 containers and watered every 3days (Fig. 3). The experimental design used was a completely randomised design, with 2 OFSP varieties *UMUSPO 1* ('King J') and *UMUSPO 3* ('Mother's Delight') and 4 primers (Water (control), coconut water, grapefruit juice and a mixture of coconut water and grapefruit juice) each replicated 3 times. The time (days) to new sprouts/ initiation of sprouting was recorded. Six weeks after priming and planting nodal vines the following data were collected: number of leaves, number of nodes and internodes, number of vines and vine length. All data were analyzed for significant differences using analysis of variance (ANOVA) in a completely randomized design (CRD) at (P = .05). Mean separation was carried out using the Least significance difference LSD at (P = .05).

3. RESULTS AND DISCUSSION

3.1 Effects of Priming on Number of Days to Vine Establishment and Initiation of Sprouting of 2 OFSP Varieties

The effect of the priming on the time taken to initiation of sprouting by the Orange Fleshed-Sweet Potato (OFSP) varieties is shown in Fig. 3. There were significant differences (P =.05) in the average number of days to sprouting of the nodal vines primed with different natural plant products for the two OFSP varieties. Nodal vines of both varieties primed with coconut water and water (control) and those of the variety *UMUSPO 3* primed with grapefruit juice initiated sprouts significantly (P =.05) earlier (4 days) than other treatments (Fig. 3). However, *UMUSPO 1* primed with grapefruit juice, initiated sprouts about 2 days later than those of *UMUSPO 3* (Fig. 3). Both varieties primed with the mixture of coconut

Table 1. Features of *UMUSPO 1* and *UMUSPO 3* varieties of orange fleshed sweet potato

S/N	Characteristics	*UMUSPO 1* (King J)	*UMUSPO 3* (Mother's Delight)
1	Canopy or plant type	Erect	Spreading
2	Vine	Predominant vine colour, green when mature	Light green when mature, green with purple edge when young
3	Leaf	Deep green when mature and green with purple edges when young	Light green when young and mature; heart-shaped and single-lobed
4	Internodes	Intermediate internodes (3-6cm) with intermediate diameter (5-6mm)	Long internodes (5-11 cm) with thin diameter (3-5 mm)
5	Flowering	Very sparse	Early and moderately profuse
6	Maturity period	4 months	4 months
7	Root shape	Long elliptic	Round elliptic
8	Skin colour	Deep Pink	Orange
9	Flesh colour	White-fleshed	Deep orange
10	B-carotene content	700-1650 µg/ 100 g fwb	10,500-14,370 µg/ 100g fwb
11	Potential Root yield	Over 25 t/ha	31.4t/ha

Source: modified [3]

Fig. 1. Nodal vines of *UMUSPO 1* "King J" **Nodal vines of *UMUSPO 3* "Mother's Delight"**

Fig. 2. Priming of OFSP varieties *UMUSPO 1* and *UMUSPO 3* in water, coconut water, grapefruit juice and coconut water and grapefruit juice mixture

water and grapefruit juice initiated fresh sprouts after 7days much later than others. Time to sprouting is important because when vines initiate sprouts early, this helps the plant establish quicker and spread more rapidly, an important asset when early season weed competition is evident and when rapid ground cover is important because of the competitive advantage it confers in gaining early access to growth resources such as water, air, light and nutrients [27,28,29]. Although, vines primed with water (control) sprouted as early as those primed with coconut water, the leaves produced were smaller and pale green to yellow in appearance indicating some level of nutrient deficiency.

The effectiveness of coconut water as a growth-promoting plant product as observed in this study has been reported [13]. Coconut water is one of the important components of basal medium supplements that has been used in tissue culture for obtaining rooting and plantlet formation [23,25]. Its rich composition of sugar, amino acid, myo-inositol, and micro constituent (phenyl urea) has been well documented [30,31,32,33]. Coconut water contains auxin, various cytokinins, and gibberellins [34,35] which are all plant growth hormones that support cell division and promote rapid growth.

3.2 Effects of Priming on Number of Leaves

The average number of leaves produced by nodal vines of both varieties of OFSP primed with natural plant products is presented in Fig. 4. The variety *UMUSPO 1* produced more leaves than *UMUSPO 3* in all treatments. The mixture of coconut water and grapefruit juice produced a significantly (P = .05) higher number of leaves in *UMUSPO 1* than all other treatments. There was no significant difference (P = .05) in the number

of leaves produced by *UMUSPO 3* in all treatments. The mixture of coconut water and grapefruit juice accelerated leaf production significantly only in *UMUSPO 1* but did not have a similar effect on *UMUSPO 3*. Some researchers in their study reported [36] that auxin plays an important role in leaf development and it is potentially able to increase shoot apical meristem at the time of leaf initiation, through increased auxin biosynthesis. The mixture of coconut water containing the phytohormones auxin, various cytokinins, and gibberellins [34,35] which are all plant growth hormones that support cell division and promote rapid growth; in combination with grapefruit juice comprising inositol, vitamin C, vitamin A, vitamin E, thiamine, riboflavin, niacin, folate, pantothenic acid, potassium, phosphorus, manganese, calcium, magnesium, copper and zinc, [37,38] which aid in photosynthetic activities could have aided in the proliferation of leaves on nodal vines primed with coconut water and grapefruit juice mixture. Perhaps a similar effect was not produced in *UMUSPO 3* because the benefit is cultivar dependent and will require further investigation but could be linked to the high beta carotene content in the *UMUSPO 3* variety. It had been reported [39] that the advantages of dipping vine cuttings of sweet potato into a dissolved root hormone were cultivar dependent.

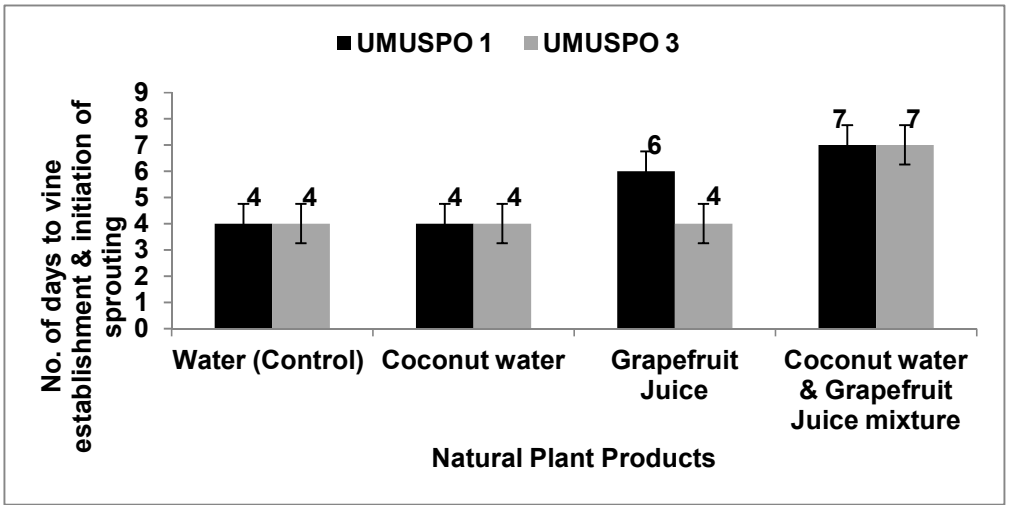

Fig. 3. Effects of priming with natural plant products on number of days to vine establishment and initiation of sprouting of 2 OFSP varieties

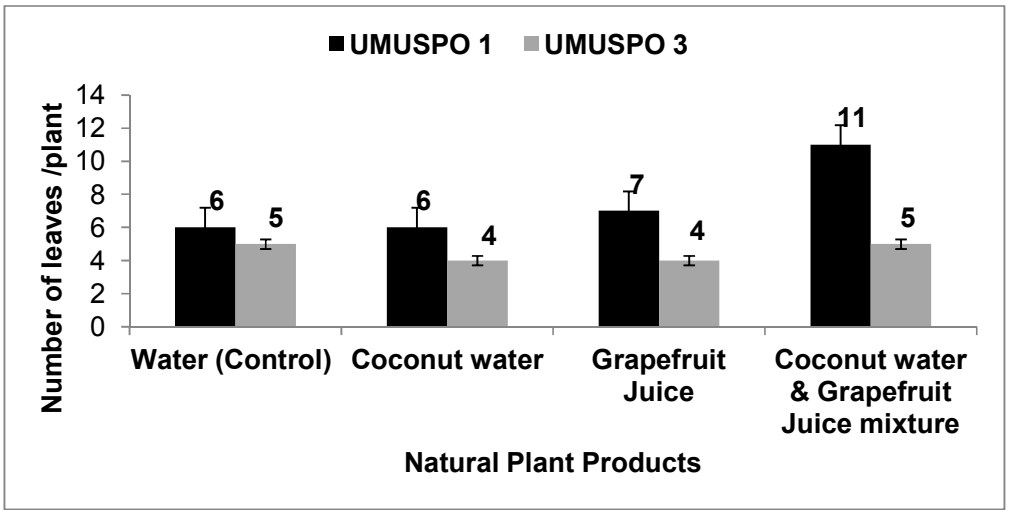

Fig. 4. Effects of priming with natural plant products on number of leaves of 2 OFSP varieties

3.3 Effects of Priming on Number of Nodes of 2 OFSP Varieties

The effect of priming on number of nodes is shown in Fig. 5. The variety *UMUSPO 1* produced more nodes than *UMUSPO 3* in all the priming treatments. The mixture of coconut water and grapefruit juice produced a significantly (*P* = .05) higher number of nodes in *UMUSPO 1* than all other treatments but did not have a similar effect on *UMUSPO 3*. There was no significant difference (*P* = .05) in the number of nodes produced by *UMUSPO 3* in all priming treatments. Priming had a similar response on number of nodes as it did on the number of leaves.

3.4 Effects of Priming on Number of Internodes of 2 OFSP Varieties

There were significant differences (*P* = .05) observed in treatment effects of the natural plant products used as primers on the average number of internodes of the nodal vines of the 2 OFSP varieties. The average number of Internodes was significantly higher (*P* = .05) in *UMUSPO 1* primed with the mixture of coconut water and grapefruit juice than all other treatments as shown in Fig. 6. The OFSP variety *UMUSPO 1* primed with coconut water and grapefruit juice also had significantly more internodes than the UMUSPO 3 variety primed with the same

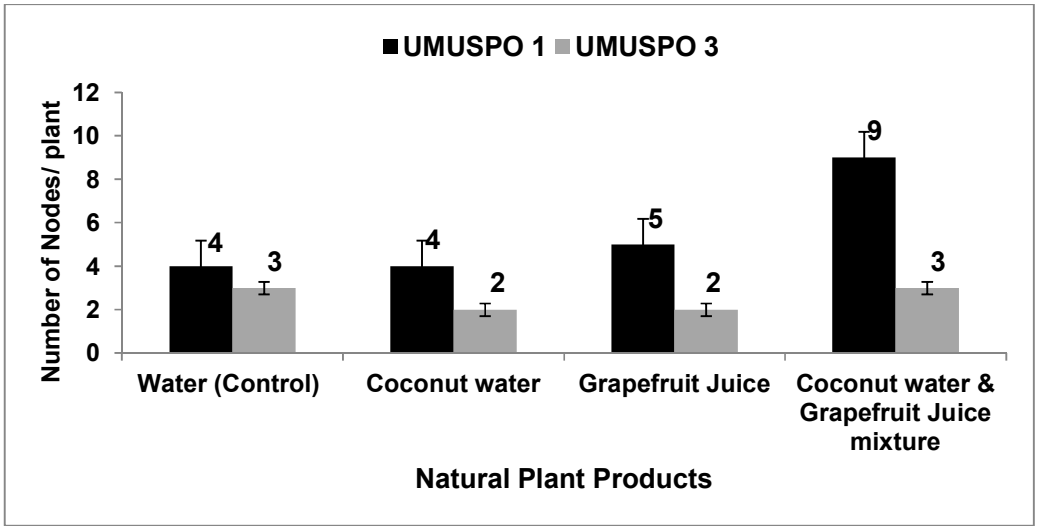

Fig. 5. Effects of priming with natural plant products on number of nodes per plant of 2 OFSP varieties

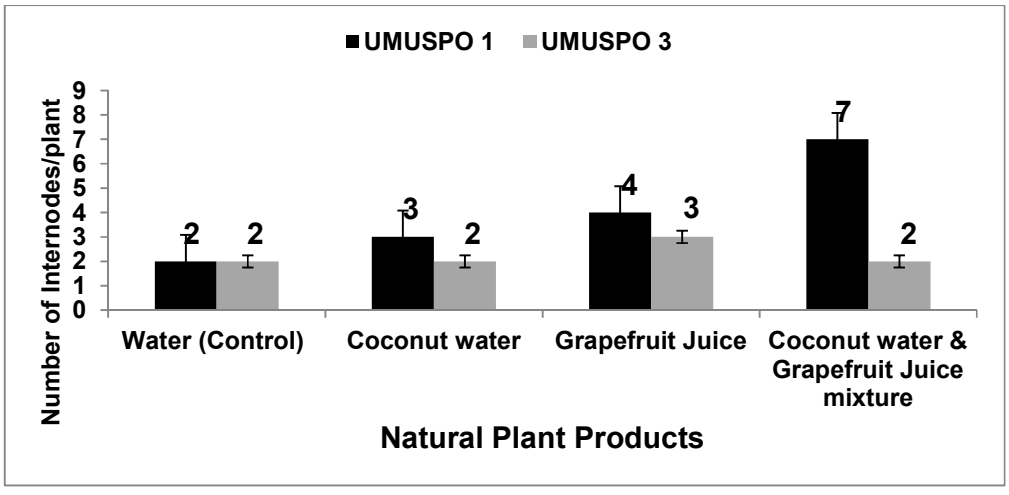

Fig. 6. Effects of priming with natural plant products on number of Internodes per plant of 2 OFSP varieties

materials.The number of nodes of both OFSP varieties primed with water (control) did not differ significantly.

3.5 Effect of Priming on Vine Length of 2 OFSP Varieties

The vine length of both varieties of OFSP primed with natural plant products is presented in Fig. 7. The vines of *UMUSPO 1* variety were significantly (*P* = .05) longer than vines of *UMUSPO 3* variety with all priming treatments. In fact, type of priming material appeared to have no appreciable benefit in terms of vine length as far as *UMUSPO 3* was concerned. The *UMUSPO 1* variety would appear to be a faster growing variety than *UMUSPO 3* and its growth was more vigorous as shown in most of the parameters measured. It had been reported [39] that the advantages of dipping vine cuttings of sweet potato into a dissolved root hormone were cultivar dependent. The variety *UMUSPO 1* primed with coconut water and grapefruit juice mixture had by far significantly longer vines and established more rapidly than all other priming treatments.

The regenerated plantlets at 3 weeks after planting are shown in Fig. 8 being gradually hardened in direct sunlight preparatory to transplanting to the field from 6 weeks after planting.

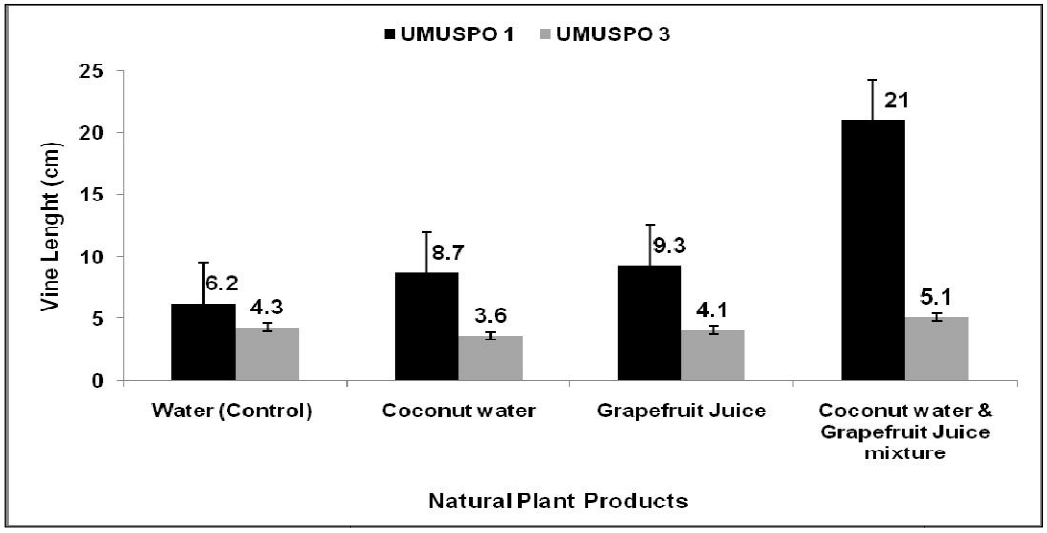

Fig. 7. Effects of priming with natural plant products on vine length of 2 OFSP varieties

Fig. 8. Primed nodal vines planted in soil 3weeks after planting

4. CONCLUSION

The benefits of priming nodal vines of the two OFSP varieties *UMUSPO 1* and *UMUSPO 3* with coconut water, grapefruit juice and coconut water and grapefruit juice mixture was cultivar dependent. Generally, all priming treatments increased the number of leaves, nodes and internodes as well as vine length significantly in *UMUSPO 1* but not in *UMUSPO 3.* The coconut water and grapefruit juice mixture although it did not accelerate early initiation of sprouting, generally doubled the number of leaves, nodes and internodes as well as vine length in *UMUSPO 1* compared to other priming treatments.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Bovel-Benjamin AC. Sweet potato: A review of its past, present and future role in human nutrition. Advances in Food and Nutrition Research. 2007;57:1–59.
2. Abidin PE. Rooting out Hunger in Malawi with Nutritious orange fleshed sweet potato. Year 3 Annual Report submitted by CIP to Irish Aid in December 2012. CIP. Lima, Peru; 2012.
Available:www.sweetpotatoknowledge.org
3. Tumwegamire S, Mwanga ROM, Andrade MI, Low JW, Ssemakula GN, Laurie SM, Chipungu FP, Ndirigue J, Agili S, Karanja L, Chiona M, Njoku JC, Mtunda K, Ricardo J, Adofo K, Carey E, Grüneberg WJ. Orange-fleshed Sweetpotato for Africa. Catalogue. International Potato Center (CIP) Lima, Peru. 2014;2:74.
4. Tsou SCS, Hong TL. The nutrition and utilization of sweet potato. In: Hill WA, Bonsi CK, Loretan PA. (Eds.), Sweet potato technology for the twenty-first Century. Tuskegee, AL: Tuskegee University Press; 1992.
5. Gurmu F, Hussein S, Laing M. The Potential of Orange-Fleshed Sweet Potato to Prevent Vitamin A Deficiency in Africa. International Journal for Vitamin and Nutrition Research. 2014;84:1-2.
Available:https://doi.org/10.1024/0300-9831/a000194
6. Hotz C. A large-scale intervention to introduce orange sweet potato in rural Mozambique increases vitamin A intakes among children and women. British Journal of Nutrition. 2012;108:163-176.
7. Mitra S. Nutritional status of orange-fleshed sweet potatoes in alleviating vitamin A malnutrition through a food-based approach. Journal of Nutrition and Food Sciences. 2012;2:160.
8. Lebot V. Sweet potato. Root and tuber crops: Handbook of plant breeding. J. E. Springer, in Bradshaw, ed., New York. 2013;97–125.
9. Rahman M, Patwary M; Barua H, Hossain M, Naha, S.. Evaluation of Orange Fleshed Sweet Potato (*Ipomoea batatas* L.). Genotypes for Higher Yield and Quality. Agriculturists. 2013;11:21–27.
10. Anyaegbunam HN, Nto PO. Assessment of the Performance of Sweet Potato Marketing System in South East Agro Ecological Zone, Nigeria. American Journal of Experimental Agriculture. 2011; 1(4):477-485.
11. Burri BJ. Evaluating sweet potato as an intervention food to prevent vitamin A deficiency. Comprehensive Reviews in Food Science and Food Safety. 2011; 10(2):118-130.
12. Loebenstein G, Thottappilly G. The sweet potato. Springer, New York; 2009.
13. Wilson V. An Alternative Low Cost Multiplication Technique: Natural Substances for Regenerating Plantlets from Mini Tubers of Sweet Potato (*Ipomoea batatas*, L.) Asian Journal of Research in Crop Science. 2019;4(1):1-9.
14. Abidin PE, Akansake DA, Asare KB, Acheremu K, Carey EE. Effect of sources of sweet potato planting material for quality vine and root yield. Open Agriculture. 2017;2:244–249.
DOI:10.1515/opag-2017-0026
15. Conrath U, Pieterse CM, Mauch-Mani B. Priming in plant-pathogen interactions. Trends in Plant Science. 2002;7:210–216.
16. Conrath U. Molecular aspects of defence priming. Trends in Plant Science. 2011;16: 524–531.
17. Jamil M, Rha ES. Gibberellic acid (GA) enhances seed—Water uptake,

germination and early seedling growth in sugar beet under salt stress. Pakistan Journal of Biological Science. 2007;4:654-658.

18. Alonso-Ramírez A[1], Rodríguez D, Reyes D, Jiménez JA, Nicolás G, López-Climent M, Gómez-Cadenas A, Nicolás C. Evidence for a role of gibberellins in salicylic acid-modulated early plant responses to abiotic stress in Arabidopsis seeds. Plant Physiol. 2009;150(3):1335-44.
DOI: 10.1104/pp.109.139352.
19. Nasri N, Mahmoudi H, Baatour O, M'rah S, Kaddour R, Lachaˆal M. Effect of exogenous gibberellic acid on germination, seedling growth and phosphatase activities in Lettuce under salt stress. Afr. J. Biotechnol. 2012;(11):11967-11971.
20. Kandil AA, Sharief AE, Abido WAE, Awed AM. Effect of Gibberellic Acid on Germination Behavior of Sugar Beet Cultivars under Salt Stress Conditions of Egypt. Sugar Tech. 2014;16(2):211–221.
21. Einset JW. Stimulation of fruit explant cultures with orange juice, Plant Physiology. 1978;62(6):885-888.
22. Aktar S. Nasiruddin SKM, Hossain K. Effects of different media and organic additives interaction on *in vitro* regeneration of Dendrobium Orchid, Journal of Agric. Rural Development. 2008; 6(1&2):69-74.
23. Manawadu I, Dahanayake N, Senanayake SGJN. Effects of Different Natural Organic Additives on in Vitro Shoot Regeneration of *Raphanus sativus* L. Var. Beeralu. Journal of Agricultural Science and Technology. 2014;219-223.
24. Badoni A, Chauhan JS. Some cheaper alternatives to MS media for *in vitro* culture of potato. Libyan Agriculture Research Center Journal International. 2011;2(4): 161-167.
25. Ghazzawy HS, El-Sharabasy SF. Effect of natural additives as coconut milk on the shooting and rooting media of *in v*itro barhi date palm (*Phoenix dactylifera L.*). Materials Research Proceedings. 2019; 11:186-192.
Available:https://doi.org/10.21741/9781644900178-13
26. Wilson JE. Sweet Potato (*Ipomoea batatas)* Planting Material. Agro-facts IRETA. 1988;88(2):1-10.
27. Maguire JD. Speed of germination-aid in selection and evaluation for seedling emergence and vigour. Crop Science. 1962;(02.01):176-177.
28. Stephen GS. Plant Physiology. St. Johns University, Biology Department; 2009.
29. Matsushima KI, Sakagami JI. Effects of seed hydropriming on germination and seedling vigour during emergence of rice under different soil moisture conditions. American Journal of Plant Sciences. 2013; 4:1584-1593.
30. Clements RS Jr, Darnell B. Myo-inositol content of common foods: Development of a high-myo-inositol diet. The American Journal of Clinical Nutrition. 1980;33:1954-1967.
31. Del Rosario JE, Bergonia HA, Flavier ME, Samonte JL, Mendoza EMT. Chromatographic analysis of carbohydrates in coconut water, Trans. the Natl. Acad. Sci.Technol. 1984;6:127-151.
32. Ogundiya MO. Glucose content of nut water in four varieties of coconut palm (*Cocos nucifera*), J. Sci. Food Agric. 1991; 56:399–402.
33. Reddy EP, Lakshmi TM. Coconut Water - Properties, Uses, Nutritional Benefits in Health and Wealth and in Health and Disease: A Review. Journal of Current Trends in Clinical Medicine & Laboratory Biochemistry. 2014;2(2):6-18.
34. Ma Z, Ge L, Lee ASY, Yong JWH, Tan SN, Ong ES. Simultaneous analysis of different classes of phytohormones in coconut (Cocos nucifera L.) water using high performance liquid chromatography and liquid chromatography tandem mass spectrometry after solid-phase extraction. Anal. Chim. Acta. 2008;610:274–280.
35. Wu Y, Hu B. Simultaneous determination of several phytohormones in natural coconut juice by hollow fiber-based liquid–liquid–liquid microextraction-high performance liquid chromatography, Journal of Chromatography A. 2009;1216: 7657–7663.
36. Pinon V, Prasad K, Grigg SP, Sanchez-Perez GF, Scheres B. Local auxin biosynthesis regulation by plethora transcription factors controls phyllotaxis in Arabidopsis. Proceedings of the National Academy of Sciences of the United States of America. 2013;110:1107–1112.
37. Saad AIM, Elshahed AM. Plant tissue culture media. In: Leva A, Rinaldi L. (eds.).

Recent advances in plant *in vitro* culture. Trees and Timber Institute, Italy; 2012. DOI:10.5772/52760

38. Grembecka M, Szefer P. Comparative assessment of essential and heavy metals in fruits from different geographical origins. Environ Monit Assess. 2013;185:9139–9160. DOI: 10.1007/s10661-013-3242-z

39. Holwerda HT, Ekanayake IJ. Establishment of sweet potato stem cuttings as influenced by size, depth of planting, water stress, hormones and herbicide residues for two genotypes. ScientiaHorticulturae. 1991; 48(3–4):193-203. Available:https://DOI.org/10.1016/0304-4238 (91)90127-K.

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