AGRONOMIC CHARACTERISTICS OF NAGARA SWEET POTATOES (*Ipomoea batatas* L.) FROM SOUTH KALIMANTAN WETLANDS

KARAKTERISTIK AGRONOMI UBI NAGARA (*Ipomoea batatas* L.) DARI LAHAN RAWA LEBAK KALIMANTAN SELATAN

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ABSTRAK

Karakteristik agronomi ubi jalar yang ditanam di lahan basah sangat penting dipelajari untuk mengoptimalkan budidaya dan memaksimalkan hasil panen. Pemahaman faktor-faktor seperti morfologi dan hasil tanaman, serta kondisi lingkungan, penting untuk mengidentifikasi varietas dan praktik budidaya yang paling sesuai untuk zona agroekologi tertentu. Penelitian ini bertujuan mempelajari karakter agronomi ubi nagara di lahan rawa lebak Kalimantan Selatan dan mengidentifikasi faktor abiotik yang mendukung pertumbuhannya. Sebanyak 15 aksesi ubi jalar diambil secara acak di area sentra budidaya ubi pada Juli 2024. Analisis kluster hierarki dilakukan untuk melihat kekerabatan aksesi yang ditemukan. Hasil penelitian menunjukkan bahwa karakter agronomi aksesi ubi jalar berbeda dengan varietas yang terdaftar (Ubi Nagara KB-1), terutama pada ciri tipe, jumlah cuping daun, bentuk dan jumlah umbi. Hasil ubi jalar juga ditemukan lebih rendah (14 t ha^{-1}) dibandingkan dengan Ubi Nagara KB-1 (20 t ha^{-1}). Data abiotik ditemukan mendukung agronomi ubi jalar, kecuali pH. Aksesi yang ditemukan masih direkomendasikan untuk dikembangkan di lahan rawa lebak, karena adaptabilitas dan potensinya yang masih lebih tinggi dibanding ubi jalar secara umum (di lahan kering). Uji genetik diperlukan untuk membuktikan perbedaan morfologi disebabkan oleh varietas berbeda (genetik) atau penurunan kondisi lingkungan.

Kata kunci: Adaptif, Genetik, Morfologi, Umbi

ABSTRACT

Understanding the agronomic characteristics of sweetpotato grown in wetland is critical to optimise cultivation and maximise yield. By studying factors such as plant morphology and yield, as well as environmental conditions, is important to identify varieties and cultivation practices that are most suitable for specific agroecological zones. This research aims to study the agronomic characters of nagara sweet potato in South Kalimantan's wetlands and identify abiotic factors that support its growth. A total of 15 sweet potato accessions were randomly

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sampled in sweet potato cultivation hotspot areas in July 2024. Hierarchical cluster analysis was conducted to see the similarity of the accessions found. The results showed that the agronomic characters of sweet potato accessions differed from the registered variety (Ubi Nagara KB-1), especially in characteristics type & number of leaf lobes, shape and number of tubers. Sweet potato yield was also found to be lower (14 t ha^{-1}) compared to Ubi Nagara KB-1 (20 t ha^{-1}). Abiotic data were found to be favourable for sweet potato agronomy, except for pH. The accessions found are still recommended to be developed in lebak swamp land, due to their adaptability and potential which is still higher than sweet potato in general (in dry land). Genetic testing is needed to prove that morphological differences are caused by different varieties (genetic) or decreased environmental conditions.

Keywords: Adaptive, Genetic, Morphology, Tuber

INTRODUCTION

Sweet potatoes (*Ipomoea batatas* L.) are a staple crop in many regions of the world, including Indonesia. As a world crop, it ranks seventh from the viewpoint of total production after maize, wheat, rice, potato, cassava, and barley (FAO, 2022).

They are known for their nutritional value, as a raw material for food and industry, as well as a healthy food source of antioxidants. It is also known to be adaptive to adverse environmental conditions, such as drought, acidic soil, and others (Freitas et al., 2023).

In South Kalimantan, Indonesia, sweet potatoes are widely cultivated in wetland areas, which present unique challenges for crop production due to factors such as waterlogging, nutrient deficiencies, soil acidity, and salinity. Based on the initial survey, several sweet potato varieties were found to be planted in wetlands, including ‘wortel’, ‘kentang’, and ‘madu’ varieties named by local farmers. While in the information of the wetlands research center (Balittra), there are sweet potato varieties of kyai lama, kyai baru, ‘labu’, nagara, and maliku (Andrian, 2018; Balittra, 2001), but few studies have described the morphological differences of these varieties.

The last study describing the morphology of the nagara sweet potato variety was a report by the wetlands research center (Balittra) in 1994, with characteristics that differ from the sweet potato currently grown by many farmers, especially in the characteristics of tuber flesh colour, leaf edges, and harvest age (Saleh & William, 1995). So today most people call the sweet potato that is grown today as the nagara sweet potato.

Nagara Sweet Potato varieties are a local commodity cultivated in the wetlands of South Kalimantan, especially in the fresh water swamplands (lebak swamps). The name nagara comes from the area where many of these commodities are grown (cultivation center), namely North Daha and South Daha Sub-districts (Septeana et al., 2021), which used to be Nagara District during the Banjar sultanate. Currently, this sweet potato is only grown in the area around the nagara river, which is a lebak swamps.

This sweet potato is adaptive to acidic soil conditions of lebak swamps (pH 5.05-5.19) and flooding during the rainy season (Mulyawan et al., 2023). Known for its larger size than the typical sweet potato, this sweet potato possesses significant promise as an alternative carbohydrate source to rice.

Sweet potato is rich of macronutrient such as carbohydrate, protein and total sugar. It is also containing micronutrients such as vitamin C and minerals (Sawicka et al., 2014). Based on classification by Food and Drug Administration, sweet potato with orange-fleshed, is categorized as a rich source of β-carotene (pro-vitamin A) and good source of minerals (magnesium, iron, copper, manganese, calcium, potassium), vitamins (B1, B6, C, E), and dietary fibers (Alam, 2021; Alam, et al., 2020a; Alam, et al., 2020b; Wang et al., 2016). However, this nutritional data has not been extensively researched on nagara sweet potato.

To optimize the potential of this food resource, the improvement of cultivation is important. This can be achieved through systematic monitoring of the performance and results of crops, which is rarely done for nagara sweet potatoes.

In fact, the cultivation of nagara sweet potato has undergone changes as soil and climate conditions have declined. Sweet potato currently grown by farmers was found to have changed in size to be smaller than the varieties that were originally planted. This gap has led to the importance of tracing back the varieties planted, so that it becomes the basis for improved cultivation to support its potential as a food source.

This research aims to investigate the agronomic characteristics of nagara sweet potato cultivated in South Kalimantan wetland, in relation to the characteristics of the variety registered with the Ministry of Agriculture on 2006, namely nagara sweet potato KB-1. Then, factors influencing the agronomic characteristics of Nagara sweet potatoes in wetland environments is also to be identified.

The findings of this study may provide strategic recommendations for improving cultivation sweet potato varieties in wetland environments. By identifying the key traits that contribute to the success of Nagara sweet potato in wetlands, it is possible to sustainably increase production while maintaining local aspects.

MATERIALS AND METHODS

This research is an exploratory description with a qualitative and quantitative approach. The samples/ accession of nagara sweet potato plants were collected from three areas in the South Daha District, Hulu Sungai Selatan (HSS) Regency, South Kalimantan Province in July 2024. HSS is a hotspot of nagara sweet potato cultivation. The selection of the sampling area is based on the most extensive land and consistently growing sweet potatoes for at least 3 years. Fifteen plants were randomly sampled (five accession per area) at a same harvest age of three months (based on local farmers' recommendations).

Agronomical (include morphological) characters was evaluated both in the field and within the Terpadu Laboratory of the Department of Agroecotechnology, Faculty of Agriculture, Lambung Mangkurat University (ULM). Agronomic characters studied were harvest age, leaf length (cm), leaf width (cm), petiole length (cm), number of leaves in one stem, number of branches, stem length (cm), stem internode length (cm), plant fresh weight (kg), tuber unit weight (kg), tuber length (cm), tuber diameter (cm), number of tubers per plant, and average yield (t ha-1). Morphological characters in research focus on qualitative characteristics of accession such as young

leaf colour, old leaf colour, leaf veins colour, petiole colour, leaf shape, leaf veins type, number of leaf lobes, depth (type) of leaf lobes, flower colour, flower shape, shape of stem, stem colour, tuber skin colour, tuber flesh colour, tuber shape, tuber arrangement/formation, and number of tubers per plant.

Abiotic parameters observed in this study were soil physical and chemical properties tested at the soil chemistry laboratory, Faculty of Agriculture, ULM. Climatic data in the form of rainfall was taken from the nearest observation station, while data on light intensity, average daily temperature, and air humidity were taken directly in the field.

Data were systematically organized and analysed using hierarchical clustering with SPSS to group data based on morphological character observed in sweet potato accession and description of varieties registered. Interpretation of cluster analysis results using dendrogram graphs.

RESULT AND DISCUSSION

We studied the morphological characters of nagara sweet potato before its agronomic characters to learn whether the accession mostly grown by local farmers is the same as the variety registered with the Ministry of Agriculture, namely nagara sweet potato KB-1.

Based on the results of the hierarchical cluster analysis presented in the dendrogram (Figure 1), the sweet potato accession found have different groups with the nagara sweet potato KB-1, registered variety.

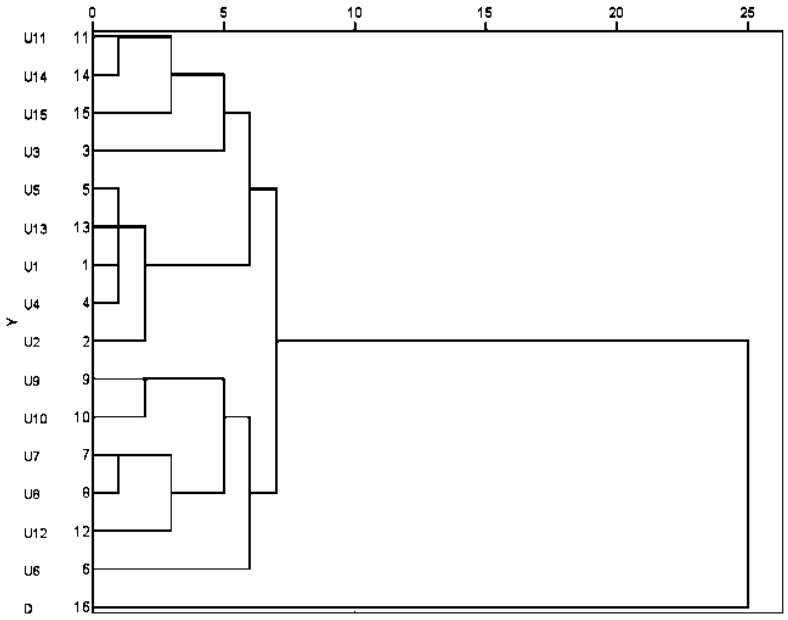

Figure 1. Hierarchical cluster analysis of 15 sweet potato accession and nagara sweet potato KB-1

Based on the dendrogram above, when the classification distance was 7, the sweet potato accession could be classified into two clusters. While the classification based on morphological characters of nagara sweet potato KB-1, showed a great distance (25), indicating a dominant morphological difference between field accession and registered varieties.

Sweet potato accession U11, U14, U15, U3, U5, U13, U1, U4, and U2 classified as cluster 1, while U9, U10, U7, U8, U12, and U6 classified as cluster 2. The dominant differences between this cluster is the number of tubers per plants. These clusters can be merged into one with a classification distance of 25. Nagara sweet potato classified as cluster 3. The longer classification distances indicate distant similarities and significant genetic differences.

Morphological characters that tend to distinguish sweet potato varieties in this study are harvest age, petiole colour, leaf bone colour, leaf shape, number of leaf lobe, and lobe type. This is supported by research on sweet potato clusters in Deli Serdang Regency, that morphological characteristics in the form of old leaf colour and petiole colour are the main distinguishing genotypes of sweet potato groups found in this study (Utari et al., 2017).

Plant morphological characters are influenced by environmental conditions and genetic factors (varieties). These will interact throughout the plant's life cycle, resulting in morphologies that may be either identical or completely different (Harnowo & Utomo, 2020; Hayati et al., 2020). The comparison of morphological characters shown in Table 1.

Table 1. Comparison of Morphological Characters of Nagara Sweet Potato with Registered Variety Description

No	Morphological Character	Nagara Sweet Potato	Nagara Sweet Potato KB-1*
1	Young leaf colour	Green	Green
2	Old leaf colour	Green	Green
3	Leaf veins colour	Purple	Top green, bottom purple
4	Petiole colour	Greenish purple	Purple top, green bottom
5	Leaf shape	Equilateral triangle with palmatilobus leaf margin	Triangle with palmatilobus leaf margin
6	Leaf veins type	Palmate	-
7	Number of leaf lobes	1-3	5-7
8	Depth (type) of leaf lobes	Very slight (teeth)	Moderate to deep
9	Flower colour	Purple white	Purple white
10	Flower shape	Bell-shaped	Bell-shaped
11	Shape of stem	Round	Round
12	Stem colour	Purple	Green
13	Tuber skin colour	Brownish yellow	Yellow
14	Tuber flesh colour	Light yellow	Yellow
15	Tuber shape	Rounded, elliptical, long elliptical, oblongs, irregular	Rounded, oval
16	Tuber arrangement/formation	Very scattered	-
17	Number of tubers per plant	2-10	2-3

*Notes: Description of Sweet Potatoes Registered with the Indonesian Ministry of Agriculture (Kementan, 2006)

In the morphological characters of the nagara sweet potato accession found, there are differences in the morphological characters such as leaf veins colour, petiole colour, leaf veins type, number of angulus, depth of angulus, stem colour, tuber shape, and number of tubers per plant (Table 1). This may illustrate the differences varieties caused by genetic factors, between the accession sweet potato and the registered varieties, but it should be supported by genetic test.

Morphological characters that are influenced by genetics are stable and not influenced by environmental or abiotic factors. Stable morphological characters unaffected by environmental variables include leaf shape, leaf colour, petiole structure, leaf and stem anatomy, sweet potato skin colour, and sweet potato flesh (Hayati et al., 2020).

One of the leaf morphological characters that distinguishes the accession from registered varieties is the number of leaf lobes/ angulus on the leaves and the colour of the petiole. The number of lobes in the accession is three, lower than registered varieties (5-7), with a shallow notch type, and the petiole is purple in colour (Figure 2).

Generally, sweet potatoes have 1, 3, 5, 7, 9 leaf lobes, and that determines the shape of the leaves. For example, a 1-lobe leaf has a rounded shape while the sweet potato we found has 3 leaf lobes, which is a heart-shaped or called cordate (Vazhacharickal & Anu, 2022). When compared to the description of KB-1, their leaf shape is much different, indicating a difference in variety.

Leaf lobes provide greater spatial extension and larger leaf area compared to leaves with smooth and flat margins, thus increasing light absorption and excelling in competition for light sources. Research showed that number of lobes positively correlation with plant leaf length (Zanetti et al., 2017).

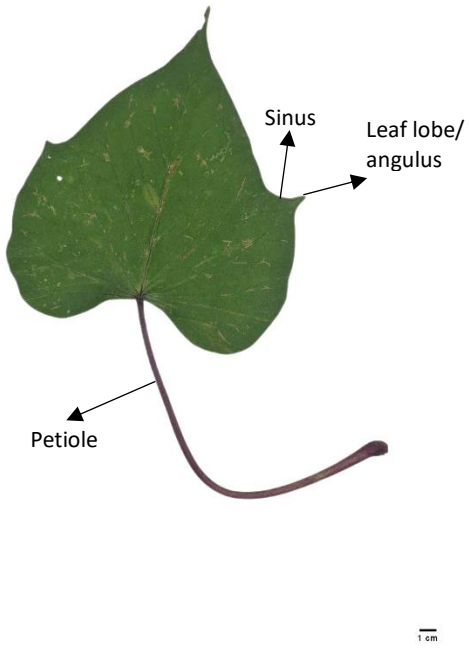

Figure 2. Leaf Morphology of Nagara Sweet Potato

Other differences on morphological characters were found in the tubers. The colour of the tubers tended to be the same, namely yellow (Figure 3), but based on RHS colour chart 2019, we described the colour as light yellow. Colour pigments in the tuber flesh may arise from the beta carotene component of the tuber. The intensity of the colour (orange) correlates positively with the beta carotene concentration. Beta-carotene serves as a precursor to vitamin A, which is advantageous for human health, particularly for eye health (Rahman et al., 2013).

Figure 3. Tuber Flesh Colour classified as RHS2019 11B Light Yellow

The shape of the tubers in the accession was more diverse than the registered varieties. There are tuber shapes such as rounded, elliptical, long elliptical, oblongs, and irregular (Figure 4). Variations in tuber shape can be influenced by genetic or environmental factors. Tuber shape is very important in influencing the market (Hayati et al., 2020). Tubers with a rounded shape tend to have a larger size than elongated ones.

Morphological characters influenced by environmental factors include vine length, petiole length, leaf size, and tuber yield (Harnowo & Utomo, 2020), called agronomical characteristics shown by Table 2. These environmental factors may include soil conditions, climate, or water availability.

Figure 4. Variation in Tuber Shape in Nagara Sweet Potato Accession

We collected sweet potatoes at the three-month harvesting age, reflecting common agricultural practices. Harvesting beyond three months, particularly at four months, the percentage of tuber damage will increase, both due to broken sweet potatoes due to dryness and damaged sweet potatoes due to pests (rat).

This is thought to affect the differences in sweet potato agronomic characters found. The agronomic characters in the nagara sweet potato accession showed a range of values lower than the descriptions of the registered varieties, except in petiole length, number of leaves in one stem, and number of tubers per plant (Table 2). The lower crop performance and yields are thought to be due to the earlier harvest age and genetic (varietal) differences between the two. Although it is possible that environmental factors were more dominant in causing this.

Table 2. Comparison of Agronomical Characteristics of Nagara Sweet Potato with Registered Variety Description

No	Agronomical Character	Nagara Sweet Potato	Nagara Sweet Potato KB-1*
1	Harvest Age	3 months	4-5 months
2	Leaf length (cm)	6,5-12,5	-
3	Leaf width (cm)	7,0-12,0	-
4	Length of petiole (cm)	8-19	10-50
5	Number of leaves on one stem	50-122	75-80
6	Number of branches	5-12	8-10
7	Stem length (cm)	135-238	245-295
8	Stem internode length (cm)	3,2-7,0	2-4
9	Plant fresh weight (kg)	1,8-5,7	-
10	Tuber unit weight (kg)	0,052-1,286	2-5
11	Tuber length (cm)	6,5-14	16,5-17,5
12	Tuber diameter (cm)	2,9-10,83	10-12,5
13	Number of tubers per plant	2-10	2-3
14	Average yield (t ha^{-1})	14	20

*Notes: Description of Sweet Potatoes Registered with the Indonesian Ministry of Agriculture (Kementan, 2006)

The nagara sweet potato accession have more leaves than the registered varieties, this could be because the sweet potato is still in its growth period or is one of the characteristics of different varieties. Growth in the dominant upper plant will cause a decrease in the formation of plant tubers. This can be seen from the smaller tuber size.

In the accession nagara sweet potato, the number of tubers per plant tended to be higher resulting in smaller tuber size compared to the registered varieties, with tuber lengths of 6.5-14 cm while the registered varieties were able to grow up to 16.5-17.5 cm. The unit weight of tubers is much smaller than the variety description, with the largest only reaching 1.286 kg while the potential reaches 2-5 kg. This is in line with the yield which only reached 14 t ha^{-1}, but both are still below from the nagara sweet potato yield potential registered (44-45 t ha^{-1}).

Both morphology and agronomic differences between accession nagara sweet potato found and nagara sweet potato KB-1, may be influenced by genetic factor (the different varieties grown) or environmental conditions. We studied climatic and soil data in the field to describe their status in supporting the agronomic potential of nagara sweet potato.

In the climatic data (Table 3), the average rainfall in the study area from the beginning of nagara sweet potato planting, May to July, was 133, 180.2 and 116 mm, respectively. This condition fits within the category of land suitability class S1, which means it is ideal for growing sweet potatoes (Djaenudin et al., 2011).

Table 3. Abiotic Parameters Status at the Research Site

No.	Parameters		Values	Status
	Climate			
1	Rainfall* (mm)		133; 180,2; 112	S
2	Humidity (%)		44-48	NS
3	Temperature (°C)		38,9-39,3	NS
4	Light intensity (lux)		157.600-162.900	NS
	Soil Physical and Chemical Properties			
5	Texture	Sand (%)	45,7	S
		Dust (%)	31,1	
		Clay (%)	23,1	
6	C-org (%)		47,1-57,1	S
7	N-total (%)		0,3-0,6	S
8	P2O5 (mg/100g)		31,1-67,9	S
9	K2O (mg/100g)		10,5-22,2	S
10	pH (H2O)		3,8-4,5	NS

*Notes: Data taken from the nearest BMKG observation station in May-July 2024, S: Suitable, NS: Not Suitable

The optimum temperature for sweet potato growth is 20-30°C with humidity ranging from 60-80%. In the field, the temperature was high (38,9-39,3°C) with low humidity (Table 3), potentially triggering stress on plant growth. Light intensity was found to be high at more than 10,000 lux leading to increased transpiration rate. This is related to the occurrence of water deficiency in plants, the symptoms found in the field are smaller tuber size and easily cracked tubers before harvest.

Yields of sweet potato is presently restricted by many factors among which are low soil fertility, varietal selection, planting date, weather condition, soil type, weed, insect and disease pressure and crop management practices among others (Onunka et al., 2012).

The physical properties of the soil observed in the field have a sandy loam texture. The sandy loam soil texture is rather coarse, the structure is loose and has good drainage, which is very suitable for the cultivation of food crops including sweet potato (Utami & Budiningsih, 2015).

In soil chemistry such as organic carbon (C-org), nitrogen total, phosphorus (P_2O_5) and total potassium (K_2O), fall into the category of very suitable (S1) to moderately suitable (S2) for sweet potato growth. Chemical properties that are not suitable are soil acidity or pH, which is 3.8-4.5, classified as acidic.

Acid soils have been studied to be a major limiting factor in various wetland areas (case study in Arisan Jaya, South Sumatra), so their mitigation needs special attention (Priatna et al., 2020). Acidic soils can cause deficiencies in other nutrients such as phosphorus, but this did not occur in the field.

The adaptive nature of nagara sweet potato is thought to play a role in this resistance, one of which is the presence of

anthocyanin pigments (purple colour) in the stem, petiole, and leaf bones. Although not as abundant as in purple-fleshed sweet potatoes, these pigments are very important in protecting the plant against environmental stress.

Despite the adaptive nature of plants, additional soil treatment can be done to reduce soil acidity through liming. Dolomite application combined with vermicompost at a dose of 1.5 t ha^{-1}, can increase soil pH and organic matter by 1% on acidic soils. Dolomite and Bio-vermi can help nutrient uptake and growth and production of sweet potato on acid soil (Nufus et al., 2021).

Another study mentioned that the application of Pulverized Wood Charcoal (PWC) combined with inorganic fertilizers was able to increase sweet potato yields in acidic soils (Paderes & Baňoc, 2022). This increase also occurred in the observed agronomic characters such as vine length, number of leaves, leaf area index, and plant wet weight.

Improving crop cultivation requires a well-thought-out and sustainable strategy. Sweet potato cultivation in wetlands is largely traditional and low-input. The addition of external inputs should be done as efficiently as possible so as to save production costs. Farmers usually only remove weeds at the beginning of planting and never add fertilisers (organic & inorganic) and other chemicals.

The influence of the environment on the agronomic characters of sweet potato is important to be studied further to see the trend of changes in swamp land conditions and their impact on the yield of locally grown commodities. Although previous studies have mentioned that the same variety can experience morphological changes due to differences in planting locations (lowlands and highlands) (Irwan et al., 2019), this cannot be referred to as the cause of morphological differences in this study, because planting was still carried out on the same area (lebak swamp).

Based on abiotic parameters in the field, agronomic characters of sweet potato that are lower than registered varieties are thought to be caused by differences in harvest age and differences in varieties planted. Characterization of all varieties sweet potato crops in wetlands needs to be done to find out what varieties are planted there, so that cultivation development can be carried out for better production.

CONCLUTIONS

1. The morphology and agronomic characters of nagara sweet potato that are widely grown today are different from the variety registered at the Ministry of Agriculture (nagara sweet potato KB-1). The dominant differences are seen in qualitative and quantitative characters such as stem colour, petiole colour, number of leaf lobes, number of tubers per plant, and yield.
2. The abiotic factors studied favoured the growth of nagara sweet potato except for the acidic soil/ low pH.

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