Nutrient Deficiency Symptoms of Sweetpotato Varieties Planted in Degraded Uplands of Pinabacdao, Samar and in Commercial Areas of Leyte and Samar

A. Vegetative Parts

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ABSTRACT

A study was conducted on the assessment of nutritional disorders in four sweetpotato varieties representing two traditional (Kaangi and Kasapad) varieties grown in the degraded upland and two improved or recommended varieties (PSB SP 17 and PSB SP 19) varieties grown in commercial areas using the solution culture technique. Nutrient deficiency symptoms were established for the following elements: without nitrogen (-N), without phosphorus (-P), without potassium (-K), without magnesium (-Mg), without calcium (-Ca), without sulfur (-S), without Fe (-Fe), and without micronutrients (-Micro). For the control , we used sweetpotato receiving complete nutrient elements (Complete treatment). Thirty six healthy stem cuttings of each of the four sweetpotato varieties were used in the study and these were allowed to root for one week before placing them in culture bottles containing the culture solutions representing the various treatments. Sweetpotato were grown in the culture bottles/containers for more than two months and visible deficiency symptoms of each element were noted as they occur in the leaves, shoots and roots of the plants.

Results showed that each nutrient element has characteristic deficiency symptoms although there are some similarities in the general performance of sweetpotato in nutrient deficient culture solutions. These similarities include the stunted growth of the plant, general yellowing of leaves and sometimes in the occurrence of chlorosis. In some instances, different varieties also showed varying responses to these nutritional disorders.

Keywords: sweetpotato varieties, nutrient elements, nutritional disorders, deficiency symptoms

INTRODUCTION

Sweetpotato is considered as one of the important staple and commercial crops in the Philippines. It can grow in wide range of environments, from humid tropics to frost-free temperate zones, and from sea level to 2700 m altitude (Bourke, 1985). In the Philippines, it is commonly grown in upland areas especially in smaller patches and usually in association with other crops such as cassava, coconut and vegetables. The crop is rotated with corn or vegetables like squash or tomato; it is also grown after upland rice or intercropped with coconut, fruit trees or corn (Villamayor and Amante, 1995). One typical example of an upland ecology wherein sweetpotato is grown extensively throughout the year is in Pinabacdao, Samar, which was chosen as the project site representing the degraded upland area.

The establishment of a multi-million Korean owned sweetpotato starch factory (GOSUNG Food Corporation, Inc.) in Dulag, Leyte in 1996, has improved the status of sweetpotato as an important commercial crop of Leyte and Samar islands. This has tremendously increased the areas planted to sweetpotato from a measly 100 hectares at the start of the plant operation to about 1500 hectares now (Roa, 1998). Sweetpotato areas supplying the starch factory are categorized into the low plains dry season areas of Leyte and the sloping wet season areas of Samar.

With this development, it is expected that the continuous cropping of land for subsistence and commercial sweetpotato production in the already depleted areas will cause tremendous problems on crop production, nutrient and pest management and environmental deterioration. The latter refers to proper waste management of sweetpotato waste in the surrounding vicinity of the starch factory.

One major crop production problem that will tremendously affect sweetpotato yield is the deficiency of important soil nutrient needed by the plant for its growth and development. An inadequate supply of one of these important nutrients can cause metabolic disorders in plants (Bergmann, 1992). This will result in a latent deficiency without visual symptoms or the appearance of visual deficiency symptoms. This situation will lead to crop failure and reduced quality or yield. The nutrients that are known to have greatest practical importance to crop growth are the macronutrients which include nitrogen (N), phosphorus (P), sulphur (S), potassium (K), calcium (Ca) and magnesium (Mg), and the micronutrients like boron (B), chlorine (Cl), molybdenum (Mo), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn). Thus identification of different nutrient deficiency symptoms exhibited by the plant at certain growth stages is very important in diagnosing the capacity of the soil to sustain better crop growth especially in terms of its root production. Although nutrient deficiency symptoms are commonly detected during the earlier growth stages of the plant,

their timely diagnosis is important for the crop to recover once the disorder is corrected.

These metabolic disturbances to growth and development of plants results not only in tremendous yield losses and reduction of quality , but they also result in financial losses particularly in modern agriculture with intensive crop production. Farmers, growers and foresters cannot afford unfavorable nutritional conditions which lead to nutrient imbalances in the plants considering their limited resources. Thus early diagnosis of nutrient disorders in plant is important to prevent the above losses.

Visual and analytical diagnosis during growth and development provide two complimentary methods for identifying nutritional disorders of plants which permit them to be distinguished from pathological damages (Bergmann, 1992). One advantage of the production of specific visible symptoms is that it is not dependent on costly laboratory equipment or time-consuming chemical analyses (O'Sullivan, et al., 1995). It should be noted also that in addition to the appearance of a particular symptom, the position of that symptom on the plant must be properly indicated. It is because nutrients are being absorbed by the root system and distributed among various plant parts.

This study was conducted to determine the various nutrient disorders in sweetpotato through visual diagnosis of deficiency symptoms using two traditional sweetpotato cultivars (Kaangi and Kasapad) grown in degraded upland areas of Pinacbacdao, Samar and two recommended sweetpotato varieties (PSB SP 17 and 19) grown in commercial areas of Leyte, Samar and Tarlac provinces. Nutrient deficiency symptoms were categorized into 2 namely: a.) using the sweetpotato vegetative plants parts consisting of the leaves and shoots; and b) using sweetpotato roots. These deficiency symptoms were established using the solution culture technique. This paper will report the deficiency symptoms exhibited by the leaves and and shoots. The nutritional disorders affecting the sweetpotato roots will be reported in succeeding paper.

MATERIALS AND METHODS

A. Preparation of plant samples

Twenty cm of sweetpotato cuttings representing the two indigenous cultivars Kaangi and Kasapad and the two new sweetpotato varieties PSB SP 17 and 19) were taken from healthy plants grown at PRCRTC Germplasm area. These were allowed to root for four days in the laboratory using distilled water as a rooting medium. After four days, these cuttings were transferred in amber colored bottles containing different concentrations of essential elements in solution cultures and allowed to grow for a period of more than two months which

is the critical growth stage of sweet potato plant as shown in the growth curve of a typical sweetpotato plant as represented by sweetpotato VSP-2 variety (Bautista , 1990).

B. Preparation of culture containers

Beer bottles and 600 ml beakers were used as culture containers. The beer bottles were used during initial stage of the experiment up to 2 weeks period. The beakers were used right after the beer bottles when the plants have developed profuse rooting systems which could no longer be accommodated by the mouth of the beer bottles. Both containers were cleaned thoroughly and washed with N HCl to remove any contaminants. Then these were covered with black carbon paper to prevent the oxidation of culture solutions inside the bottles. Nine beer bottles and beakers were labeled as follows: complete, -N, -P, -K, -Ca, -Mg, -S, -Fe, and -Micro. The treatments were replicated three times. In the beer bottles, the sweetpotato cuttings were wrapped with a small piece of cotton as a support to prevent them from falling over. While in the beaker, the sweetpotato cuttings were suspended on a screen wire and placed on top of the beakers containing the different culture solutions.

C. Compounding the culture solutions

The culture solutions were prepared following the concentrations of Hoagland's No. 2 culture solution as presented in Table 1.

Table 1. The salt composition of Hoagland's No. 2 culture solution

SALTS	CONCENTRATION (moles/l)
1. KNO_3	0.006
2. $Ca(NO_3)_2.4H_2O$	0.004
3. $MgSO_4.7H_2O$	0.002
4. $(NH_4)H_2PO_4$	0.001
5. Fe (added as $FeCl_3$)	5 ppm
6. Microelements	
a. H_3BO_3	2.86 gm/l
b. $MnCl_2.4H_2O$	1.81 gm/l
c. $ZnSO_4.5H_2O$	0.22 gm/l
d. MoO_3	0.02 gm/l
e. $CuSO_4.5H_2O$	0.08 gm/l

The different culture solutions representing the nine treatments (-N, -P, -K, -Ca, -Mg, -S, -Fe, -Micro and Complete were prepared using the various salts presented in Table 1 as tabulated in Table 2. Two liters of each treatment were initially prepared and the culture solutions were stored in amber bottles in the laboratory. After the sweetpotato cuttings had started to develop some roots in distilled water, the experimental set-up was started. For the beer bottles, the culture solutions were poured up to the neck of the bottle and one cutting were transferred into each bottle. The sweetpotato cuttings were wrapped with small cotton swab to prevent them from falling over. While in the beakers, four hundred ml of culture solutions representing the nine treatments were poured into their respective beakers and the sweetpotato cuttings suspended on the screen wires were placed on top of the beakers. The plants were then kept in the screen house for a period of two months. The culture solutions in the both in the beer bottles and the beakers were changed every other day and the plants were also aerated two to three times a week.

Table 2. Checklist for the different culture solutions.

SALTS	TREATMENTS								
	-N	-P	-K	-Ca	-Mg	-S	-Fe	-Micro	Complete
KNO_3		X		X	X	X	X	X	X
$Ca(NO_3)_2.4H_2O$		X	X		X	X	X	X	X
$MgSO_4.7H_2O$	X	X	X	X			X	X	X
$NH_4H_2PO_4$			X	X	X	X	X	X	X
Microelements	X	X	X	X	X	X	X		X
Fe	X	X	X	X	X	X		X	X
$NaNO_3$			X						
$CaCl_2.2H_2O$	X								
KCl	X								
$MgCl_2.6H_2O$						X			
Na_2SO_4					X				
NH_4Cl		X							
$NaH_2PO_4.H_2O$	X								
$NaNO_3$ * (2 volumes)				X					

- For –Ca treatment only

D. Care and maintenance of the plants

The plants were put inside the screen house and visual observations for the appearance of deficiency symptoms were noted daily. The culture solutions were regularly replaced every other day to prevent the growth of molds and bacteria which might contaminate the cuttings. The cuttings were also properly monitored for the occurrence of any disease of insect damage. The plants were also aerated regularly to ensure that they receive enough oxygen for its growth and development.

RESULTS AND DISCUSSION

I. Characteristics of the Four Sweetpotato Varieties Used:

Table 3 presents the characteristics of the four sweetpotato varieties used. The different morphological characteristics described include plant type, leaf lobing, leaf color, root skin color and root flesh color. One distinguishing feature of these morphological characteristics which is important in the study is the leaf color since this will in some ways affect the visual appearance of deficiency symptoms exhibited by the leaves.

Table 3 . Varietal characteristics of Sweetpotato varieties Kaangi, Kasapad, PSB SP 17, and PSB SP 19.

Characterisctics	Kasapad	Kaangi	PSB SP 17	PSB SP 19
Plant type	creeping	creeping	creeping	erect
Leaf Color	green	green	yellow/green	purple
Stem Color	green	light purple	green	purple
Leaf Lobing	slightly lobed	heart shaped	slightly lobed	slightly lobed
Root Skin Color	white	purple	purple	light orange
Root Flesh Color	yellow	yellow orange	yellow	light yellow

II. Description of Deficiency Symptoms :

1. Nitrogen Deficiency

General symptoms exhibited by N deficient sweetpotato leaves include yellowing of leaves and early senescence of older or basal leaves (Plate Nos. 1A to 1D) . The leaves of N deficient sweetpotato are also smaller in sizes as compared to those receiving complete treatments. The shade of yellowing differ in varieties wherein the improved varieties

produced intense yellow coloration as compared to the traditional varieties. Nitrogen deficiency symptoms usually affect both the older and younger leaves. This is very evident in the plant shoots which showed stunted growth and generally smaller leaf sizes (Plate Nos. 1E to 1H) as compared to the plants receiving complete nutrient treatments (Plate Nos. E to H).

2. Phosphorus Deficiency

General symptoms of phosphorus deficient sweetpotato leaves include marginal chlorosis or interveinal spotting of basal leaves, drying up of basal leaves, localized yellowing of older leaves with interveinal chlorosis and intense browning or coloration of the tips or edges of leaves (Plate Nos. 2A to 2D). Differences in varietal response to P deficiency was evident in the four sweetpotato varieties used wherein the improved varieties showed more of interveinal chlorosis as compared to the traditonal varieties which showed more of the yellowing and browning of tips of the leaves. Like nitrogen , sweetpotato receiving no phosphorus showed stunted growth as shown by their vegetative parts /shoots (Plate Nos. 2E to 2H). This simply showed the important role played by phosphorus in the growth and development of sweetpotato especially in its involvement in energy transduction (Glass, 1989).

3. Potassium Deficiency

The appearance of potassium deficiency symptoms occur mainly on the older leaves and the general symptoms exhibited by sweetpotato leaves include brown necrotic lesions or spots which developed within the chlorotic zones of the leaves, severe yellow chlorosis in the interveinal and marginal zones and in extreme cases the leaves will turn whitish or completely lost its green coloration (Plates Nos. 3A to 3D). In potassium deficiency, the necrotic stage is usually preceeded by a light green interveinal chlorosis affecting mature to older leaves (O' Sullivan, et al., 1995). The shoots of sweetpotato which is deficient in potassium generally exhibit stunted growth (Plates Nos. 3E to 3H) as compared to those receiving complete nutrient treatments. This has tremendous implication on the development of sweetpotato roots since potassium physiologically affect the root formation of sweetpotato. Bautista (1981) reported the effects of increasing levels of potassium fertilizers on enhancing the root yield of sweetpotato.

4. Sulfur Deficiency

Plates Nos. 4A to 4D show the nutrient deficiency symptoms exhibited by the leaves of four sweetpotato varieties. Generally some of the symptoms include uniform pale green chlorosis throughout the plant, in severe cases, the veins no longer retain the green color, red brown pigmentation developing on older leaves which normally starts at the center of the leaves, browning of leaves and total loss / or reduction of

green pigmentation. In some varieties the leaves appeared wilted and totally dried up with dark yellowing on the sides. In varieties with purple tips, the color becomes paler, while the older leaves would turn golden yellow in color. The shoots of sulfur deficient sweetpotato also showed severe stunting and some variety like the PSB SP 19 which normally have purplish shoot tips tend to lost its dark purple pigmentation while the older leaves turned yellowish in color (Plates Nos. 4E and 4H).

5. Calcium Deficiency

The primary symptoms of calcium deficiency in sweetpotato include necrosis of young expanding leaves which may lead to failure of the leaf to develop and finally to the death of the apex (Plates Nos. 5A to 5D). This is clearly exhibited by the Kasapad variety as shown by its leaf (Plate No. 5B) and shoot (Plate No. 5G) symptoms. In calcium deficiency, the necrosis spread from irregular patches especially along the lateral margins nearing the petiole and extends inward mainly in the interveinal tissues (O' Sullivan, et al., 1995). A similar symptoms were observed with the cultivars from the Pacific. Generally calcium deficient plant failed to extend its growth stage as shown by its inability to increase the shoot length due to shoot "die back". All the sweetpotato shoots we used failed to increase its length as shown in the pictures (Plates 5E to 5H). This is because the root tips of sweetpotato without calcium treatment becomes rotten/swollen and failed to grow making it impossible for the absorption of other nutrients to occur.

6. Magnesium Deficiency

The general symptoms of magnesium deficiency include interveinal chlorosis of the older leaves and the yellowing of the younger leaves (Plates Nos. 6A to 6D). As the chlorosis intensifies, the dark green color of the leaves changed to yellow green, pale yellow to golden yellow . Leaves of other varieties may turn brownish and dry as shown by Kasapad variety (Plate Nos. 6B). The shoots are generally very thin with the younger leaves showing severe chlorosis aside from its stunted growth (Plate Nos. 6E to 6H). The four varieties showed a yellow green to pale yellow color of the leaves which are generally lighter in color as compared to the chlorotic older leaves.

7. Iron Deficiency

One major distinguishing feature of iron deficiency in sweetpotato as shown by our samples is the chlorosis of the younger leaves (Plates Nos. 7A to 7H). At the onset of interveinal chlorosis, a sharply contrasting green network of veins occur which eventually led the development of white chlorosis and the complete disappearance of green color on the younger leaves. This symptom is clearly shown by the leaves and shoots/stem of Kasapad variety (Plate Nos. 7G). In iron deficiency, the youngest leaves will show the greatest intensity of chlorosis. Severely

affected leaf blades become necrotic (Plate Nos. 7A and 7B), with the necrosis usually spreading from the tip and margin into interveinal zones. However as the deficiency intensifies, the leaves will be severely necrotic and die with its color transforming to dark brown.

8. Micronutrient Deficiency

General symptoms of micronutrient deficiency are usually exhibited by the growing tissues such as the shoots and roots. The leaves symptoms include interveinal chlorosis with some veins still retaining the green color, distortion of leaves with the curling of the lateral lobes on the sides (Plate Nos. 8A to 8D). Some variety shows localized chlorosis on the edge of the lateral lobes as shown by the Kasapad variety(Plate No. 8B). The leaves are generally smaller in sizes and the shoots showed stunted growth. Traditional varieties such as the Kasapad and Kaangi tend to be severely affected by micronutrient deficiency as compared to the improved or recommended varieties as shown by their shoot performance (Plate Nos. 8E to 8H). The microelements/micronutrients in the treatments include sources of boron (B), zinc (Zn), manganese (Mn), molybdenum (Mo), and copper (Cu) elements in the solution. The absence of the micronutrients in the uptake of sweetpotato will exhibit any or a combination of the deficiency symptoms of the above elements/nutrients when they are removed singly in the solution cultures. In this case, the deficiency symptoms exhibited by the four sweetpotato varieties reflected mainly the symptoms of B, Zn, Mn, Mo, and Cu deficiencies. This is very evident in the Kasapad variety which showed curling of the lateral lobes and distortion of leaves as an indication of boron deficiency (Plate No. 8B).

III. Relationship of the Laboratory Assessment of Nutritional Disorders With That of Farmers' Perceptions and Farmers' Indigenous Knowledge:

Before we conduct the assessment of crop nutritional disorders in the laboratory, we interviewed the sweetpotato farmers in Pinabacdao, Samar about their own perception of crop health and how would they assess this in the field. They gave us their own indicators of crop health as enumerated in table 4.

Table 4. Indicators of crop health used by sweetpotato farmer's in Pinabacdao, Samar

Indicator	Healthy Crop	Unhealthy Crop	Perceived Cause
Leaf Color	dark green	yellowish	lack of soil nutrients
Leaf Size	large	small	-do-
Growth Rate	normal , fast	slow, stunted	-do-
Storage Root Size	mostly large	mostly small	-do-
Presence of Pest	usually more	usually less	Succulence of Leaves

Matching the farmers' indigenous knowledge (IK) on crop health with that of our own assessment in the laboratory, we could say they have a good perception of a healthy and unhealthy crop based on the above indicators, although they could not pinpoint which specific nutrient is deficient or not. They have more or less a general perception of the performance of crop based on leaf color and leaf sizes. Our own laboratory assessment of deficiency symptoms have shown that the general appearance of nutrient deficient sweetpotato is the yellowing of leaves and the production of smaller leaf sizes. This is true for e.g. in nitrogen, iron, magnesium deficient sweetpotato. The farmers' however lacked a more detailed assessment of specific deficiency symptoms which are exhibited by certain element like the appearance of chlorosis of necrosis in the leaves which they might misinterpret as a disease symptom. Thus our results in the laboratory will help them validate their own assessment in the field and this will greatly help them in further characterizing specific nutrient deficiency symptoms as they occur in their field. This will also give them a better understanding of the importance of proper crop nutrition and the contribution to different nutrient elements on the growth and development of sweetpotato. From our results they could see that different nutrient elements indeed play a major role in the development of the crop since the absence of one major or even micro element would result to stunted crop growth which will greatly affect root production and yield of sweetpotato.

IV. Implications to Integrated Nutrient Management

From the results of our study we have shown the importance of proper assessment of nutritional disorders in sweetpotato and the vital role played by each nutrient element in the growth and development of the crop. Thus proper crop nutrition should be applied in the field to prevent huge crop losses brought about by deficiency of one or more nutrient elements. So before we start planting sweetpotato in the field either in the farmers' field on in large scale production in commercial areas , proper assessment of the fertility/nutritional status of the soil

should be ascertained first. There is also a need for us to apply a wholistic of integrated approach to nutrient management in our field to assure that we not only improve crop/root yield of sweetpotato but protect the environment as well. This situation is very important in the degraded uplands wherein the soil is already depleted of some important nutrient elements and also in commercial areas wherein continuous planting of sweetpotato will eventually deplete the soil of its inherent nutrients .

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