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CONTENTS

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Effects of Timing of Goat Manure and Inorganic Fertilizer Application on Productivity and Profitability of Sweetpotato (*Ipomoea batatas* (L.) Lam.)

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Abstract

It is known to everyone that organic fertilizer must be applied a month before planting to decompose and efficiently utilized by the growing plants. Organic fertilizer like goat manure may improve the agronomic characteristics and yield components of sweetpotato. Hence, this study was conducted to evaluate the effects, determine the appropriate and assess the profitability of sweetpotato as influenced by the timing of goat manure application. The treatments as follows; T_1 = No fertilizer application (control), T_2 = 45-45-45 kg ha^{-1} N, P_2O_5, K_2O applied 1 week after planting, T_3 = 10 t ha^{-1} goat manure applied 4 weeks before planting, T_4 = 10 t ha^{-1} goat manure applied 2 weeks before planting; and T_5 = 10 t ha^{-1} goat manure applied at planting. An experimental area of 341 m^2 was prepared and the experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Sweetpotato plants applied with 10 t ha^{-1} goat manure applied at planting (T_5) had the longest main vine with more number of lateral vines comparable to inorganic fertilizer application at the rate of 45-45-45 kg ha^{-1} N, P_2O_5, K_2O (T_2) as compared to other treatment plants. Plants applied with organic fertilizers regardless of timing of application was comparable in fresh herbage yields. With regards to yield components, plants applied with 10 t ha^{-1} goat manure regardless of timing in the application obtained number of marketable roots, weight of marketable roots (t ha^{-1}) and total root yield (t ha^{-1}) comparable to the unfertilized plants. The highest values on these parameters were obtained from those applied with inorganic fertilizer at 45-45-45 kg ha^{-1} N, P_2O_5, K_2O (T_2). Highest harvest index was obtained by 10 t ha^{-1} goat manure applied at planting (T_5) but comparable to 10 t ha^{-1} goat manure applied 2 weeks before planting (T_4). Plants with 10 t ha^{-1} goat manure applied at planting (T_5) seemed to enhance the root yield of sweetpotato resulting in the higher gross margin of PhP12,016.75 ha^{-1}. This was low compared to plants applied with 45-45-45 kg ha^{-1} N, P_2O_5, K_2O of inorganic fertilizers.

Keywords: Organic production, assessment, timing, fertilizer, yield and income

Research article

INTRODUCTION

Sweetpotato (*Ipomoea batatas* (L.) Lam) locally known as "camote" is a viny annual crop belonging to family Convolvulaceae which is generally cultivated for its enlarged roots. It is widely grown as one of the staple food crops aside from cereals in many parts of the tropics and subtropics regions. This crop is highly recognized for its various uses as food, feed and raw material for industrial food products. It is also adapted to various production systems in a wide range of environmental conditions. It ranks fifth as the most important food crop after rice, wheat, maize and cassava in developing countries (Som, 2017). The crop is known as a highly tolerant root crop to high temperatures, poor soils, floods and had resistance to some pests and diseases. BAS (2013) reported that production of sweetpotato in Leyte and Samar Philippines is 527.69 thousand metric tons. In 2020, the world average annual yield for sweetpotato crop was 13.2 tons per hectare. However, our sweetpotato in the country is faced with production and economic constraints. Labor costs are high in some localities while yields remained low due to low soil fertility, post-harvest losses and low price. Onunka et al., (2012) added that yield of sweetpotato is also restricted by presence of weeds, insects and disease and some inappropriate management practices. Hence, strategies to increase crop yield like integrated nutrient management should be employed. Growers still prefer to use inorganic fertilizer to increase yield but due to prohibitive cost, they look for alternative source of fertilizer. The common organic materials that are readily available in farms are crop residues and animal manures.

Animal manure as fertilizer can add nitrogen, phosphorus and potassium to the soil. It is one of the potential sources of organic fertilizers. When properly decomposed, it improves the structure, aggregation, permeability and water holding capacity of the soil. In addition, organic fertilizer affects the chemical properties of the soil. However, timing of nutrient application is guided by some basic considerations which include nutrient availability when crops need it, avoiding waste and enhancing nutrient use efficiency (Brady and Weil, 2008). Kolawole (2014) reported that in Nigeria, poultry manure applied two weeks before planting improved maize grain yield and nutrient uptake compared with poultry manure applied at 2 weeks after planting and at planting. Abrantes (2014) cited that application of 10 t ha^{-1} goat manure at 2 weeks before or during planting + 30 or 60 kg ha^{-1} muriate of potash significantly increased the number of primary lateral vines, weight of marketable roots and total root yield of sweetpotato. Proper timing greatly affects availability of nutrients and consequently the growth and yield performance of the crop. Hence, this study was conducted to assess the productivity and profitability of sweetpotato production using goat manure and inorganic fertilizer as influenced by the timing of application.

MATERIALS and METHODS

An experimental area of 341 m^2 was used in this experiment. It was plowed and harrowed twice at weekly interval using tractor-drawn implement. This operation was done to pulverize the soil, allow decomposition of weeds and crop stubbles, improve soil tilth and minimize weed population. After the last harrowing, ridges were prepared 75 cm apart. Initial soil analysis, ten (10) soil samples were collected randomly from the experimental area before planting at a depth of 20 cm. These were composited, air-dried, pulverized and sieved through a 2-mm wire mesh and placed in labeled bags.

The composite sample was submitted to Central Analytical Services Laboratory (CASL), PhilRootcrops, VSU, Visca, Baybay City, Leyte for the determination of soil pH (Potentiometer Method at 1:1 soil water ratio), % Organic Matter (Modified Walkley-Black Method), total Nitrogen (Kjeldahl Method) extractable P (Modified Olsen Method) and exchangeable K (Atomic absorption spectrophotometer after extraction with ammonium acetate). Five soil samples were collected separately per treatment plot after harvest for the final soil analysis evaluated of the same soil parameters. The different treatments were designated as follows: T_1 = No fertilizer application (control), T_2 = 45-45-45 kg ha^{-1} N, P_2O_5, K_2O applied 1 week after planting, T_3 = 10 t ha^{-1} goat manure applied 4 weeks before planting, T_4= 10 t ha^{-1} goat manure applied 2 weeks before planting, T_5 = 10 t ha^{-1} goat manure applied at planting. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Each replication was divided into five plots measuring 18 m^2 (4 m x 4.5 m) with six rows and 16 hills per row. A one m alleyway between replication and 0.5 m between treatment plots were provided to facilitate farm operation and data gathering.

Analysis and Application of Fertilizers

Goat manure was procured at the Department of Animal Science, VSU, Visca, Baybay City, Leyte. A 100 g sample was taken and brought to Central Analytical Services Laboratory (CASL), PhilRootcrops, VSU, Visca, Baybay City, Leyte for the analysis of total Nitrogen, Phosphorus, Potassium, % OM and pH. Goat manure analysis showed that the goat manure had a pH of 6.64, 4.56% organic matter, 4.16% total N, 0.13 mg kg^{-1} available P and 0.95 me $100g^{-1}$ exchangeable K. Goat manure was applied by hand and incorporated along the furrows at 10 cm deep and was covered thinly with soil at the time of application specified in the treatment. Complete fertilizer was applied one week after planting 10 cm away from the base of the plants at a depth of 10 cm at 6 g per hill. The rates of fertilizer were based on the specified treatments per plot.

Planting Materials, Planting, Care and Management

Sweetpotato (NSIC Sp25) tip cuttings with lengths of 25-30 cm were gathered from healthy plants. A total of 1440 cuttings for the whole experiment were procured at PhilRootcrops, VSU, Visca, Baybay City, Leyte a day before planting. To prevent dehydration, it was stored in a moist and shady area near the experimental site a day prior to planting. One cutting was planted per hill on the ridges at a distance of 75 cm between rows and 25 cm between hills. Replanting was done one week after planting to meet the desired population of 53,333 plants per hectare. Hand weeding was done two weeks after planting using bolo to control the weeds. It was followed by hilling up using a bolo two weeks later to loosen up the soil and enhance the development of the roots. Occasional hand weeding operation was done on each treatment plot and surroundings to maintain the cleanliness of the experimental area. Harvesting was done 4 months after planting. This was done by using bolo to dig up the fleshy roots within the harvestable area of 10.5 m^2 with 4 rows and 14 hills per row. Each plot had six rows with one border row in each side and one end plant in each end of the row. Extra care and attention was observed to minimize damage of the fleshy roots. The roots were cleaned and classified into marketable and non-marketable one. The marketable roots were those free from damage and measured 2.5 cm in diameter and 6.5 cm in length. The non-marketable roots were those that do not qualify the marketable category. The sorted roots were counted and weighed per treatment plot.

Data Gathered

Agronomic Characteristics

1. Length (cm) of the main vine. This was obtained by measuring the main vine of the plant from the base to the tip of the vine using ten (10) sample plants per treatment plot. This was done by carefully locating the specific vine of the particular sample where the lateral vines were connected.
2. Number of primary lateral vines per plant. This was recorded by counting the number of primary lateral vines from ten (10) sample plants in each treatment plot.
3. Leaf area index (LAI). This was obtained by measuring the length and width of all functional leaves within the 50 cm ×50 cm quadrat at 60 days after planting. The product was multiplied by the correction factor of 0.497 (Cajefe, 2003). The total leaf area within the quadrat was divided by the effective ground area (cm^2) within the quadrat to get the leaf area index (LAI).

$$\text{TLA} = \text{Sum}\ (\text{L}\ \times \text{W})\text{CF}(0.497)$$

$$\text{LAI} = \frac{\text{Total Leaf Area (TLA)}}{\text{Area of the quadrat }(2{,}500\ \text{cm}^2)}$$

4. Fresh herbage yield (t ha^{-1}). This was determined by weighing the vines of all the harvested plants from the four inner rows in each treatment plot, excluding the border row in each side of the plot and 1 end plant in each row. This was converted into tons per hectare using the formula:

$$\text{Herbage yield (t ha}^{-1}) = \frac{\text{Fresh herbage yield (kg ha}^{-1})}{\text{Harvestable area (10.5 m}^2)} \times \frac{10{,}000\ \text{m}^2\ \text{ha}^{-1}}{1{,}000\ \text{kg ton}^{-1}}$$

Yield and Yield Components

1. Number of marketable and non-marketable roots per hill. This was obtained by sorting the marketable and non-marketable roots of 5 sample hills within the harvestable area per plot. Marketable storage roots were those that have 2.5 cm diameter and 6.5 cm long and were healthy and free from pest and diseases. Those that did not meet the criteria were considered as non-marketable roots.
2. Weight (g) of marketable and non-marketable roots per hill. This was obtained by weighing separately the marketable and non-marketable fleshy roots from 5 sample hills within the harvestable area per treatment plot.
3. Number of marketable and non-marketable roots per plot. This was obtained by sorting the marketable and non-marketable roots from the inner rows within the harvestable area per treatment plot.
4. Weight (t ha^{-1}) of marketable and non-marketable roots. This was obtained by weighing separately the marketable and non-marketable fleshy root harvested per treatment plot and converting it into tons per hectare using the formula:

$$\text{Root yield (t ha}^{-1}) = \frac{\text{Root yield (kg plot}^{-1})}{\text{Harvestable area (10.5 m}^2)} \times \frac{10{,}000\ \text{m}^2\ \text{ha}^{-1}}{1{,}000\ \text{kg ton}^{-1}}$$

5. Total root yield (t ha^{-1}). This was obtained by adding the weights of the marketable and non-marketable fleshy roots in tons per hectare using the formula:
   Total root yield (t ha^{-1}) = wt. of marketable roots (t ha^{-1}) + wt. of non- marketable roots (t ha^{-1})

Other Parameters

Harvest Index was evaluated using the formula:

$$\text{HI} = \frac{\text{Total root yield (5 sample plants)}}{\text{Total root yield + fresh herbage yield (5 sample plants)}}$$

Gross margin was computed by subtracting the total variable cost from the gross income using the formula: Gross Margin = Gross Income – Total Variable Cost

Data on total monthly rainfall (mm), average daily minimum and maximum temperatures (˚C) and relative humidity (%) from the time of planting up to the time of harvesting were taken from the records of the Philippine Atmospheric Geophysical Astronomical Services Administration (PAGASA) Station, Visayas State University, Visca, Baybay City, Leyte. The data were computed and the analysis of variance (ANOVA) was analyzed using Statistical Tool for Agricultural Research (STAR) software. Comparison of means was done using Fisher's Least Significant Difference (LSD) Test.

RESULTS and DISCUSSION

Soil Analysis

Table 1 presents the initial and final soil analysis. Result showed that the soil had a pH of 5.40, 2.50% organic matter, 0.47% total nitrogen, 1.75 mg kg^{-1} available phosphorus and 0.85 $me100g^{-1}$ exchangeable K. The results indicated that the soil is strongly acidic, low in organic matter, medium total N, very low available P and high exchangeable K (Landon, 1991).

Table 1. Soil test results before planting and after harvest of sweetpotato (NSIC Sp25) as influenced by timing of goat manure application

Treatment	Soil pH (1:2.5)	Organic Matter (%)	Total N (%)	Available P (mg kg^{-1})	Exchange able K ($me100g^{-1}$)
Initial Analysis	5.40	2.50	0.47	1.75	0.85
Final Analysis					
T_1	5.55	2.00	0.50	0.71	0.48
T_2	5.00	1.00	0.59	1.57	0.66
T_3	5.30	1.50	0.51	1.15	0.53
T_4	5.20	2.00	0.54	1.23	0.56
T_5	5.30	2.50	0.57	1.48	0.61
Mean	5.29	1.92	0.53	1.32	0.62

Legend:
T_1 = No fertilizer (control)
T_2 =45-45-45 kg ha-^{1} N, P_2O_5, K_2O applied 1 week after planting
T_3 =10 t ha^{-1}goat manure applied 4 weeks before planting
T_4 =10 t ha^{-1} goat manure applied 2 weeks before planting
T_5=10 t ha^{-1} goat manure applied at planting

Final soil analysis revealed that total N slightly increased after harvest which could be due to the added goat manure into the soil. However, soil pH, % organic matter, available P and exchangeable K slightly decrease. The decrease in soil pH was due to the application of goat manure that released carbonic acids during the decomposition process (Cosico, 2005). On the other hand, the decrease in organic matter, available P and exchangeable K could be attributed to crop removal and losses due to leaching. Similarly, Onunka, et al., 2012) attributed the decrease in exchangeable K to plant uptake and assimilation. Goat manure analysis showed a pH of 6.64, 48.56% organic matter, 4.16% total N, 0.13 mg kg^{-1} available P and 0.95 me 100g^{-1} exchangeable K. Results indicate that goat manure contain high organic matter, high nitrogen content, very low available P and exchangeable K (Landon, 1991).

Agronomic Characteristics

Table 2 presents the agronomic characteristics of sweetpotato as influenced by timing of goat manure application. Statistical analysis revealed that the length of main vines (cm) and leaf area index (LAI) were markedly affected by the treatments applied. Sweetpotato plants applied with 10 t ha $^{-1}$ goat manure applied at planting (T_5) significantly produced longer main vines (319.47 cm) which was higher than T_3 plants (224.13 cm) and T_4 plants (281.67 cm) and the unfertilized plants T_1 (216 cm) but comparable to plants applied with 45-45-45 kg ha^{-1} N, P_2O_5, K_2O (T_2). Plants applied with 10 t ha^{-1} goat manure 4 weeks before planting (T_3) had comparable length of main vines to unfertilized plants (T_1).

Table 2. Agronomic characteristics of sweetpotato (NSIC Sp25) as influenced by timing of goat manure application

Treatment	Length of main vines (cm)	Number of primary lateral vines	Leaf Area Index	Fresh Herbage Yield (t ha^{-1})
T_1	216.00 c	5.00 b	0.62 d	7.49 c
T_2	329.43 a	6.67 a	2.44 a	16.54 a
T_3	224.13 c	5.50 b	1.05 cd	10.70 b
T_4	281.67 b	5.73 b	1.09 c	10.42 b
T_5	319.47 a	6.50 a	1.95 b	12.24 b
Mean	274.14	5.68	1.43	11.68
CV (%)	7.25	7.25	17.05	14.59

Means within the same column followed by a common letter are not significantly different from each other at 5% level using LSD Test.

Legend:

T_1 = No fertilizer (control)
T_2 =45-45-45 kg ha-^{1} N, P_2O_5, K_2O applied 1 week after planting
T_3 =10 t ha^{-1}goat manure applied 4 weeks before planting
T_4 =10 t ha^{-1} goat manure applied 2 weeks before planting
T_5 =10 t ha^{-1} goat manure applied at planting

The number of primary lateral vines of plants applied with 10 t ha^{-1} goat manure regardless of timing of application (T_3-T_5) were comparable to the unfertilized plants (T_1). Plants applied with 45-45-45 kg ha^{-1} N, P_2O_5, K_2O (T_2) obtained the most primary lateral vines. In terms of LAI, plants applied with 10 t ha^{-1} goat manure at planting (T_5) obtained bigger LAI among the treatments tested but lower than that plants applied with 45-45-45 kg ha^{-1}, P_2O_5, K_2O (T_2). LAI of plants with 10 t ha^{-1} goat manure applied 2 weeks before planting (T_4) were comparable to plants applied with 10 t ha^{-1} goat manure applied 4 weeks before planting (T_3). Plants with 10 t ha^{-1} goat manure applied 4 weeks before planting had LAI (1.05) comparable to the unfertilized plants which obtained the lowest LAI value (0.62). On the other hand, plants with 10 t ha^{-1} goat manure applied at planting (T_5) obtained fresh herbage of 13.24 t ha^{-1} comparable to T_4 plants (10.42 t ha $^{-1}$) and T_3 plants (10.79 t ha^{-1}) but lower than that applied with 45-45-45 kg ha^{-1} N, P_2O_5, K_2O (T_2) of 16.54 t ha^{-1}.

However, T_4 plants (10.42 t ha^{-1}) and T_3 plants (10.70 t ha^{-1}) were comparable to unfertilized plants T_1 (7.49 t ha^{-1}). The differences of the aforementioned parameters could be attributed to the amounts of macronutrients that supported the growth and development of longer main vine, broader LAI and apparently higher fresh herbage yield of sweetpotato.

According to Brobbey (2015), sweetpotato plants increase its main vine length and leaf area when applied with complete fertilizer as it is readily available for plant use as compared to organic sources which had a gradual release of nutrients to soil. The findings imply that application of 10 t ha^{-1} goat manure at planting (T_5) seemed the best time application as it achieved longer length of main vines (cm) and broader leaf area index (LAI) than other time of application but lower compared to plants applied with 45-45-45 kg ha^{-1} N, P_2O_5, K_2O (T_2) from inorganic fertilizers. This result can be attributed to the finding of (Montecalvo, 2011; Sorita, 2010) that sweet corn yield increases when applied goat manure during planting.

Yield and Yield Components and Harvest Index

Yield and yield components and harvest index of sweetpotato as influenced by timing of goat manure application is presented in Table 3. Analysis of variance revealed that the number of marketable roots, marketable root yield (t ha $^{-1}$), total root yield (t ha^{-1}) and harvest index of sweetpotato were significantly affected by the timing of application of 10 t ha^{-1} goat manure and inorganic fertilizer.

Table 3. Yield and yield components and harvest index of sweetpotato (NSIC Sp25) as influenced by timing of goat manure application

Treatment	Number of Roots ha^{-1}		Root Yield ($t\ ha^{-1}$)		Total Root Yield ($t\ ha^{-1}$)	Harvest Index (HI)
	Marketable	Non marketable	Marketable	Non marketable		
T_1	20.67 b	38.67	1.65 b	1.16	2.81 b	0.25 d
T_2	60.67 a	47.00	6.13 a	1.70	7.82 a	0.53 a
T_3	27.00 b	44.00	2.27 b	1.72	3.97 b	0.31 cd
T_4	28.67 b	40.67	2.38 b	1.14	3.52 b	0.37 bc
T_5	35.00 b	49.00	2.68 b	1.57	4.25 b	0.41 b
Mean	34.40	43.87	3.02	1.46	4.47	0.37
CV (%)	25.53	18.63	34.25	31.97	26.06	12.27

Means within the same column followed by a common letter are not significantly different from each other at 5% level using LSD Test.

Legend:

T_1 = No fertilizer (control)
T_2 =45-45-45 kg ha-^{1} N, P_2O_5, K_2O applied 1 week after planting
T_3 =10 t ha^{-1}goat manure applied 4 weeks before planting
T_4 =10 t ha^{-1} goat manure applied 2 weeks before planting
T_5 =10 t ha^{-1} goat manure applied at planting

Sweetpotato plants applied with 10 t ha^{-1} goat manure regardless of timing of application (T_3, T_4 and T_5) obtained marketable roots $plot^{-1}$ comparable to the unfertilized plants (T_1). Plants applied with 45-45-45 kg ha^{-1} N, P_2O_5, K_2O (T_2) of inorganic fertilizer (60.67) gave the highest number of marketable roots $plot^{-1}$. The same trend was noted in the marketable root yield (t ha^{-1}) and total root yield (t ha^{-1}). Those applied with 45-45-4 kg ha^{-1} N, P_2O_5, K_2O obtained the highest values in the aforementioned parameters. This is expected as inorganic fertilizers are immediately bioavailable to plants thus resulting in enhanced growth and yield (Brady and Weil, 2008). Moreover, harvest indices of T_4 (0.37) and T_5 plants (0.41) were comparable but markedly lower than plants applied with inorganic fertilizers (0.53). According to Suge et al., (2011), organic inputs alone would not meet the nutritional needs of crops because they contain comparatively low quantity and slow availability of nutrients than inorganic fertilizers. The unfertilized plants (T_1) obtained the least harvest index value (0.25). The findings imply that application of 10 t ha^{-1} goat manure at planting seemed the best time application as it obtained more number and higher yield of marketable roots than other time of application and consequently high total root yield (t ha^{-1}). This was lower compared to plants applied with 45-45-45 kg ha^{-1} N, P_2O_5, K_2O from inorganic fertilizers.

Cost and Return Analysis

The cost and return analysis of sweetpotato production as influenced by timing of goat manure and inorganic fertilizer application is shown in Table 4. Sweetpotato applied with inorganic fertilizer (45-45-45 kg ha^{-1} N, P_2O_5, K_2O) obtained the highest gross income of (PhP85,800.75 ha^{-1}) among treatments.

On the other hand, plants applied at planting of goat manure organic fertilizer 10 tha^{-1} obtained the highest gross margin of (PhP12,016.75.00 ha^{-1}). This could be attributed to the marketable yields obtained on this treatment.

Table 4. Cost and return analysis ha^{-1} of sweetpotato (NSIC Sp25) production as influenced by timing of goat manure application

Treatment	Marketable Roots (t ha^{-1})	Gross Income (PhP)	Total Variable Cost (PhP ha^{-1})	Gross Margin (PhP ha^{-1})
T_1	1.65b	33,000.00	28,833.25	4,166.75
T_2	6.13a	122,600.00	36,799.25	85,800.75
T_3	2.27b	45,400.00	41,333.25	4,066.75
T_4	2.38b	47,600.00	41,083.25	6,516.75
T_5	2.68b	53,600.00	41,583.25	12,016.75

The gross income was based on the prevailing market price of PhP 20.00 per kg of sweetpotato during the time of harvest.

Legend:
T_1 = No fertilizer (control)
T_2 =45-45-45 kg ha-^{1} N, P_2O_5, K_2O applied 1 week after planting
T_3 =10 t ha^{-1}goat manure applied 4 weeks before planting
T_4 =10 t ha^{-1} goat manure applied 2 weeks before planting
T_5=10 t ha^{-1} goat manure applied at planting

This was followed by application 2 weeks before planting (PhP6,516.75 ha^{-1}) and 4 weeks before planting (PhP4,166.75 ha^{-1}). Unfertilized plants (T_1) gave the lowest gross margin (PhP4,666.75 ha^{-1}) due to low gross income as a result of low marketable root yield compared to fertilized plants. Vincent et al., (2005) reported that the primary objective of producers is profit maximization but the quantity of fertilizer being used is quite high resulting in high variable cost hence, gross margin remained low, (Aviles, 2010).

CONCLUSION

1. Plants applied with goat manure (10 t ha $^{-1}$) at planting (T_5) obtained significantly longer main vines, leaf area index as well as harvest index but lower than the plants applied with 45-45-45 kg ha^{-1} N, P_2O_5, K_2O inorganic fertilizer (T_2).
2. Plants applied with 45-45-45 kg ha^{-1} N, P_2O_5, K_2O inorganic fertilizer gave the highest total root yield 7.82 tha^{-1}.
3. Timing of goat manure application on sweetpotato did not differ significantly in yield and yield components except on harvest index.
4. Application of 10 t ha^{-1} goat manure at planting obtained a higher gross margin of PhP12,016.75 compared to unfertilized plants due to production of more marketable roots, but significantly lower than the plants applied with 45-45-45 kg ha^{-1} N, P_2O_5, K_2O inorganic fertilizer of (PhP85,800.75) due to the cost of organic fertilizer.

RECOMMENDATION

1. Application of inorganic fertilizer at the rate of 45-45-45 kg ha^{-1} N, P_2O_5, K_2O (T_2) is recommended to produce higher marketable roots of sweetpotato**.**
2. Application of 10 t ha^{-1} goat manure is recommended for sweetpotato production if growers had access to goat manure in the locality.
3. A follow up study is strongly recommended in similar condition using other sweetpotato cultivars and / or varieties.

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Eurasian Journal of Agricultural Research 2020; Vol: 4, Issue: 1, pp: 11-22

Agronomic Performance of Lowland Rice (*Oryza Sativa* L.) Psb Rc82 Under Different Nursery Management and Seedling Age at Transplanting

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Abstract

Nursery management and age of seedlings at transplanting affects growth and yield of lowland rice. A field experiment was conducted at the experimental area of the Department of Agronomy, Visayas State University, Baybay, Leyte to: (1) evaluate effects of nursery management and seedling age on the growth and yield of lowland rice PSB Rc82; (2) determine the appropriate nursery management and seedling age for optimum yield; and (3) evaluate the profitability of PSB Rc82 production under different nursery management and seedling age. Different nursery management were designated as the mainplot and age of seedlings as the subplot. Wetbed method of nursery management, irrespective of seedling age resulted in earlier heading and maturity, higher crop growth rate at 21-42 DAT, more filled spikelets and consequently higher grain yield (2.18 t ha^{-1}). Using 25 -day old seedlings at transplanting resulted in earlier heading and maturity, higher harvest index and net assimilation rate at 21-42 DAT. Older seedlings gave more filled grains per panicle resulting in higher grain yield than younger seedlings. Thus, this study recommends 25-day old seedlings at transplanting under wetbed method for PSB Rc82 lowland rice production.

Keywords: crop growth rate, dapog method, harvest index, net assimilation rate, wetbed method

Research article

INTRODUCTION

As a cereal grain, rice (*Oryza sativa* L.) is the most widely consumed staple food for a large part of the world's human population, especially in Asia. It is the agricultural commodity with the third highest worldwide production of 741.5 million tons in 2014, after sugarcane and maize of 1.9 and 1.0 billion tons, respectively (FAOSTAT, 2017). Out of 3.3 M ha total rice production area in the country, about 1.4 M ha are irrigated lowland rice (Bureau of Agricultural Statistics, 2015). The country's palay yield obtained from April - June 2017 increased by 11.72% from 3.73 million MT in 2016 to 4.15 million MT (www.psa.gov.ph). This increase is attributed to adequate water and available seeds of high yielding varieties (HYV) and fertilizer support from Department of Agriculture and Local Government Units during the cropping period. To markedly sustain the said level of production, management even at the initial stages of growth or in the nursery is needed.

Two of the various management practices being adopted by farmers in the country are appropriate seedling age and proper nursery establishment. One of the considerations in aiming high yield is the use of healthy seedlings which can be attained by proper nursery management. considerations in aiming high yield is the use of healthy seedlings which can be attained by proper nursery management.

Rice seedlings can be raised in nurseries through dapog and wetbed method. Dapog method is preferable in areas where water management is not a problem. The dapog seedbed can be watered with a sprinkler or wet broom sticks to lessen displacement of seeds in the seedbed. This method reduced the duration of seedling in the seedbed, reduced seedbed area, have more choices for seedbed location but with less root or stem injury and labor cost in pulling the seedlings.

On the other hand, wetbed method is preferable in areas where water control is applicable. Wetbed raised seedlings has uniform size, free from diseases, insect pests and damage. Moreover, only fewer seeds are required per unit area and seedlings are easy to transplant (http://rice-production.blogspot.com).

In rice, distance of planting varies with variety and seedling age. Transplanting shock is a setback to growth due to injury or damage in uprooting the seedling. It increases as the seedling becomes older. In general, yield of rice increases with younger age of seedling at transplanting. Seedling age also varies with environmental conditions and the type of nursery management. Enzyme activity, photosynthesis and respiration set a minimum and maximum age for a particular nursery by considering its dependency on its growth. When a plant established its root system and its leaves are large enough to begin making its own food continued processes for development happened. Studies claimed that transplanted rice raised by dapog and wetbed method is resistant to lodging due to healthy and vigorous seedling growth, established tillers and more vigorous and fibrous root system (https://www.dawn.com/news/). However, researches on seedling age and nursery management in lowland rice is still limited, hence, this study.

MATERIAL and METHOD

An experimental area was flooded for seven days at a depth of 5-6 cm. The field was puddled using hand tractor on a biweekly interval to remove weeds and provide desirable tilth and texture of the soil. Canals were constructed to facilitate water management. Final puddling was done a week before planting leaving 2.5 cm of standing water. For the initial soil analysis, ten soil samples were collected randomly from the experimental field at depths 0-20 cm. These were composited, airdried, pulverized, sieved using 2mm wire mesh and analyzed at the Central Analytical Services Laboratory for soil pH, organic matter content, total nitrogen, extractable phosphorus and exchangeable K. For the final soil analysis, three samples were collected from each treatment plot right after harvest. These were processed and analyzed for the same soil parameters mentioned above.

This study was conducted at the SeedNet area of the Department of Agronomy, VSU, Baybay City, Leyte from February 3, 2018 to May 11, 2018.

The experiment was laid out in split plot arranged in randomized complete block design in three replications with nursery management as the mainplot (M_1 – Wetbed and M_2 – Dapog) and age of seedlings (T_1 =10-day old seedlings, T_2 =15-day old seedlings, T_3 =20-day old seedlings, T_4 =25-day old seedlings) as the subplot.

Lowland rice PSB Rc82 variety was used in the study. In wetbed method, the seeding rate was 40 kg ha^{-1}. The seeds were soaked in tap water for 24h and then incubated for 48h. A 1 m x 1 m bed was prepared per age of seedling treatment. Pre-germinated seeds were sown thinly and uniformly on raised seedbeds. Complete fertilizer at 1 tablespoon per square meter or approximately 15 grams per square meter was applied. Drainage canals were constructed around each seedbed to remove excess water. Four (4) days after, the seedbed was irrigated about 2- 3 cm deep and gradually increasing the water level to 5 cm to control weeds and to make pulling of seedlings easier.

For dapog method, the same seeding rate was used. The seeds were soaked in tap water for 24h and then incubated for 48h. A bed of 0.40 m x 1.80 m (0.72 square meter) per seedling age treatment was constructed beside the wetbed seedbed. The surface of the raised soil bed was covered with polyethylene sheets. Compost of 1 cm thick was placed on the sheet as medium for pre- germinated seeds and served as seedbed. To prevent the soil and seeds from washing away, sticks were placed to fence or protect the bed. This was pressed with a wooden flat board right after seeding and was sprinkled with water when needed.

The water level in the field was maintained at 2-3 cm. The fertilizer rate used was 120-60-60 kg N, P_2O_5 and K_2O per hectare. Nitrogen was applied in 3 splits. The whole amount of P_2O_5 and K_2O was applied together with the first N application by broadcasting and incorporating into the soil before transplanting. The second and third N application was carried out during mid-tillering (20 DAT) and panicle initiation stages by topdressing. Panicle initiation was determined by dissecting and visually observing the furry tip of panicle at the center of the stem.

Before transplanting, ducks were pastured for several weeks. Handpicking of adults and egg masses of golden snail was done a day before transplanting. Excess water in the field was drained prior to transplanting. Seedlings were transplanted at the age specified in the treatments at a distance of 20 cm x 20 cm between rows and hills. There were 15 rows per plot and 25 hills per row. Replacement of missing hills was done 3-7 days after transplanting.

Depth of water was maintained at 2-3 cm. Rotary weeding was done in all treatment plots at ten (10) days after transplanting including the alleyways and borders. The area was irrigated the day after weeding to prevent buried and uprooted weeds from recovering. Thereafter, spot handweeding was done to control weeds.

Three days after transplanting, the area was irrigated gradually at a depth of 2.5 cm and gradually increased as the plants grew. During panicle initiation, water was increased to a depth of 3 cm to 5 cm and was drained during fertilizer application and two weeks before harvest to facilitate harvesting operation and data gathering. Irrigation was resumed 3-5 days after application.

Golden apple snail **(***Pomacea canaliculata* L.) was controlled by handpicking the adult snails and egg clusters before and after transplanting the seedlings. During heading and milking stages, botanical pesticides were applied to minimize the attack of insect pests. The experimental area was kept clean to keep rats from inhabiting them. Guarding of birds as well as the use of scarecrow were employed.

Harvesting was done when approximately 85% of the grains in the panicle in each treatment plot was ripened. At this stage, grains were considered ripe and are ready for harvest when they turn yellow and the grains at the base of the panicle are at hard dough stage.

All the plants within the harvestable area of 4.20 m x 2.20 m (9.24 square meter) with 11 rows and 21 hills row^{-1} were cut at the base using a sharp sickle. Two end rows in each side and two end hills (both ends) in each row served as borders. The panicles were threshed and cleaned by winnowing before the necessary data were gathered.

Data Gathered

Agronomic characteristics of lowland rice were evaluated based on the days from sowing to heading, days from sowing to maturity, plant height (cm) and fresh straw yield (t ha^{-1}) using the following formula:

$$\text{Fresh straw yield (t ha}^{-1}\text{)} = \frac{\text{Straw yield (kg)}}{\text{Harvestable area (9.24m}^2\text{)}} \text{ x } \frac{10000\text{m}^2\text{ha}^{-1}}{1000 \text{ kg t}^{-1}}$$

Yield and yield components were determined on the number of productive tillers per hill, number of filled grains per panicle, percentage of filled spikelets per panicle, weight of 1,000 grains (g) and grain yield (t ha^{-1}) using the formula:

$$\text{Grain yield (t ha}^{-1}\text{)} = \frac{\text{Plot yield (kg) at 14\% MC}}{\text{Harvestable area (9.24 m}^2\text{)}} \text{ x } \frac{10000 \text{ m}^2\text{ha}^{-1}}{1000 \text{ kg t}^{-1}}$$

Physiological parameters were evaluated on Leaf Area Index (LAI), Net Assimilation Rate (NAR)**, C**rop Growth Rate (CGR) and Harvest Index (HI).

For profitability analysis, the production cost was determined by recording all the expenses incurred throughout the conduct of the study from land preparation up to harvesting. These include cost of chemical, materials and labor used in the field. The gross income was determined by multiplying the yield of each treatment plot by the current price of palay per kilo.

The net return was determined by subtracting the total expenses from the gross income for each treatment. The gross income, net return and benefit cost ratio was determined using the following formula:

Gross income = Yield (kg ha^{-1}) x current price kg^{-1}
Net return = Gross return – Total cost
Benefit cost ratio = Net income (PhP ha^{-1}) / Total cost (PhP ha^{-1})

All data collected were analyzed using Statistical Analysis Software (SAS) Version 9.2. and treatment means for significant parameters were compared using Tukey's Studentized Range (HSD) test.

RESULTS and DISCUSSIONS

Soil Analysis

The soil used in this experiment was very strongly acidic at 4.88. It has low in organic matter (2.24%), low in available phosphorus (5.66 mg/kg), medium total N (0.21%) and exchangeable potassium (0.33 me/100 g soil) (Landon, 1991).

Agronomic Characteristics of Lowland Rice

Table 1 shows the agronomic characteristics of lowland rice under different nursery management and seedling age at transplanting. Statistical analysis revealed that the number of days from sowing to heading and maturity were significantly affected by the treatments used. Plant height was affected by age of seedlings but not by nursery management. No significant difference was observed in straw yield for nursery management and age of seedlings used.

Lowland rice under dapog method delayed its heading and maturity. This could be due to the high seeding rate of dapog which resulted in closer spacing in the seedbed and leads to slow growth of seedlings. Furthermore, dapog - grown seedlings only relied on the endosperm to permit seedlings to grow at their early days without receiving any outside nutrients except air, water and sunlight. Once the food material contained in the endosperm have been exhausted, the seedlings quickly begin to die off (https://nature-and-farming.blogspot.com). Since nutrients are limiting on dapog seedlings, growth and development were affected leading to longer maturity periods.

Twenty-five-day old seedlings resulted in longer days to heading and maturity comparable to 10 and 20- day old seedlings. Nahar et al (2009) and Shah (2001) explained that older seedlings had delayed heading and maturity due to low solar radiation intercepted during vegetative stage of the crop due to its planophile - like canopy structure. Menete et al (2008) pointed out that plants from younger seedlings (10–20 days old) completed their vegetative growth earlier (5–9 d) thus matured earlier than plants from older seedlings (30 days old). However, this response is variety-dependent, due to inherent genetic differences in the duration of the crop’s life cycle. Lampayan et al (2015) found that seedling competition in the seedbed extends maturity in late transplanted seedlings.

They further stated that 10 days delay in transplanting resulted in an additional 5–6 days in the field both in high and low seeding rates.

In terms of plant height, using 25 -day old seedlings at transplanting produced taller plants than 10 -day old seedlings (Table 1). This is because during transplanting, plants in 25 -day old seedlings were already taller and bigger compared to 10 -day old seedlings.

Table 1. Agronomic characteristics of lowland rice as influenced by nursery management and seedling age at transplanting

Treatments	Number of days from sowing to		Plant height (cm)	Fresh straw yield (t ha^{-1})
	heading	maturity		
Nursery Management				
M_1 = Wetbed	86.50b	116.50b	97.35	24.46
M_2 = Dapog	91.25a	121.25a	94.78	25.08
Age of Seedlings				
T_1 =10 -day old seedlings	89.33ab	119.33ab	91.98b	25.37
T_2=15 -day old seedlings	86.67b	116.67b	96.63ab	23.77
T_3 =20 -day old seedlings	88.83ab	118.83ab	5.48ab	24.35
T_4 =25 -day old seedlings	90.67a	120.67a	100.18a	25.59
C.V. (a) %	0.69	0.52	5.53	16.03
C.V. (b) %	2.23	1.67	4.35	12.67

Means within column followed by the same letter are not significantly different at 5% level, HSD.

Physiological Parameters

Statistical analysis revealed that leaf area index and net assimilation rate from 42 to 84 days after transplanting were not significantly affected by nursery management and seedling age. However, harvest index and net assimilation rate from 21 to 42 days after transplanting were significantly influenced by the age of seedlings particularly the older seedlings (Table 2).

Higher harvest index was observed in rice when 25 -day old seedlings were used at transplanting. However, it was comparable to 15 and 20 -day old seedlings. Harvest index is a variable factor in crop production that indicates plants efficiency to convert the absorb nutrients and products of photosynthesis into grains in proportion to straw yield (Yang and Zhang, 2010). Plants at 25-day old seedlings resulted in higher NAR than younger seedlings (10-day old) at early vegetative stage. Murty et. al (1986) stated that net assimilation rate of crop plants obtained at early growth stages without mutual competition is the manifestation of photosynthetic capacity of a specific variety in a given climatic conditions.

Table 2. Physiological characteristics of lowland rice as influenced by nursery management and seedling age at transplanting

Treatments	Leaf Area Index	Harvest Index	Net Assimilation Rate (g m^{-2} d^{-1})			
			21-42 DAT	42-56 DAT	56-70 DAT	70-84 DAT
Nursery Management						
M_1 = Wetbed	8.12	0.39	11.48	2.82	6.44	4.97
M_2 = Dapog	8.37	0.36	11.11	3.14	6.36	4.53
Age of Seedlings						
T_1=10-day old seedlings	8.80	0.35b	7.12b	3.09	6.23	4.44
T_2=15-day old seedlings	8.27	0.36ab	10.36ab	3.25	6.33	4.48
T_3=20-day old seedlings	8.26	0.38ab	2.39ab	2.82	6.59	5.15
T_4=25-day old seedlings	7.66	0.41a	15.31a	2.76	6.47	4.94
C.V. (a) %	22.33	18.78	30.57	30.75	19.86	30.48
C.V. (b) %	11.01	8.86	39.34	15.34	35.89	39.49

Means within column followed by the same letter are not significantly different at 5% level, HSD.

Crop growth rate (CGR) is significantly affected by nursery management and age of seedlings at early growth stage of lowland rice (Table 3). Higher crop growth rate was attained with wetbed method. Crop growth rate is a measure of crop productivity. It is the rate of dry matter accumulation per unit area per unit time. This suggests that wetbed method is more productive in terms of dry matter accumulation than dapog method. An interaction between nursery management and age of seedlings on crop growth rate at 21-42 DAT was likewise observed (Table 4). Under wetbed method, transplanting of 20-25 -day old seedlings resulted in higher crop growth rate, however, using younger seedlings reduced the crop growth rate either in wetbed or dapog method. It was observed that there was a continuous increase on growth rate of rice until 70 DAT and declined towards maturity of the crop because some leaves senesced as the rice plant gets matured.

Table 3. Crop growth rate of lowland rice at different growth stages as influenced by nursery management and seedling age at transplanting

Treatments	Crop Growth Rate (g m^{-2} d^{-1})			
	21-42 DAT	42-56 DAT	56-70 DAT	70-84 DAT
Nursery Management				
M_1 = Wetbed	16.69a	33.86	52.49	42.66
M_2 = Dapog	6.07b	26.95	45.45	38.56
Age of Seedlings				
T_1 =10 -day old seedlings	6.20c	28.27	44.32	36.78
T_2 =15 -day old seedlings	7.54bc	32.82	52.27	44.16
T_3 =20 -day old seedlings	13.86ab	29.81	49.71	41.87
T_4 =25 -day old seedlings	17.91a	30.71	49.58	39.64
C.V. (a) %	25.18	21.10	34.64	32.39
C.V. (b) %	36.91	22.83	30.75	39.45

Means within column followed by the same letter are not significantly different at 5% level, HSD.

Table 4. Interaction effects between nursery management and age of seedlings on crop growth rate at week 1 (21-42 DAT) of lowland rice

Age of seedlings	Nursery Management	
	M_1 = Wetbed	M_2 = Dapog
T_1 - 10 -day old seedlings	6.13b	6.27b
T_2 - 15 -day old seedlings	8.65b	6.43b
T_3 - 20 -day old seedlings	22.26a	5.46b
T_4 - 25 -day old seedlings	29.70a	6.11b

Means within column followed by the same letter are not significantly different at 5% level, HSD.

Yield and Yield Components

The yield and yield components of rice as influenced by nursery management and age of seedlings are shown in Table 5. Statistical analysis revealed that among the parameters studied only the percentage filled spikelets panicle^{-1} and grain yield (t ha^{-1}) were significantly affected by the nursery management and age of seedlings at transplanting. The number of productive tillers hill^{-1}, number of filled grains panicle^{-1} and weight of 1000 grains were not affected by the treatments.

Moreover, interactions between nursery management and age of seedlings on number of filled grains panicle^{-1}, percentage of filled spikelets panicle^{-1} and grain yield (t ha^{-1}) were observed (Tables 6-8). Wetbed method of crop establishment produced higher number of filled grains panicle^{-1} regardless of age of seedlings. However, in dapog method using 25 -day old seedlings for transplanting reduced the number of filled grains panicle^{-1}. Similar trend was observed on the percentage filled grains panicle^{-1} (Tables 6 and 7).

The grain yield of PSB Rc82 was affected by the interactions between nursery management and age of seedlings (Table 8). Transplanting older seedlings (25 -day old seedlings) under wetbed method gave higher yield than using younger seedlings (10 -day old seedlings). However, 25 -day old seedlings gave comparable yield with 15- and 20-day old seedlings. Generally, dapog method gave lower yield than wetbed method which is comparable when younger seedlings were used under wetbed method. Using older seedlings (25 -day old seedlings) gave higher yield than younger seedlings (10 -day old seedlings) under wetbed method probably because older seedlings had good head start over younger seedlings especially under biotic stress.

Table 5. Yield and yield components of lowland rice as influenced by nursery management and seedling age at transplanting

Treatments	Number of productive tillers hill^{-1}	Number of filled grains panicle^{-1}	Percent filled spikelets panicle^{-1}	Weight of 1000 grains (g)	Grain yield (t ha^{-1})
Nursery Management					
M_1 = Wetbed	14.27	55.77	43.04a	26.43	2.18a
M_2 = Dapog	16.59	42.58	34.33b	30.81	1.57b
Age of Seedlings					
T_1=10 -day old seedlings	15.12	44.25	37.69ab	22.22	1.32b
T_2=15 -day old seedlings	16.37	57.10	43.31a	25.14	1.89ab
T_3=20 -day old seedlings	13.75	51.38	40.74ab	28.20	1.89ab
T_4=25 -day old seedlings	16.48	43.93	32.99b	38.93	2.40a
C.V. (a) %	11.73	25.31	9.81	20.80	12.19
C.V. (b) %	18.48	19.61	15.21	37.12	26.37

Means within column followed by the same letter are not significantly different at 5% level, HSD.

Table 6. Interaction effects between nursery management and age of seedlings on number of filled grains panicle^{-1} of lowland rice

Age of seedlings	Nursery Management	
	M_1 = Wetbed	M_2 = Dapog
T_1- 10 -day old seedlings	40.73ab	47.76a
T_2- 15 -day old seedlings	55.13a	59.06a
T_3- 20 -day old seedlings	60.46a	42.30ab
T_4- 25 -day old seedlings	66.73a	21.13b

Means followed by the same letter are not significantly different at 5% level, HSD.

Table 7. Interaction effects between nursery management and age of seedlings on percentage of filled spikelets panicle^{-1} of lowland rice

Age of seedlings	Nursery Management	
	M_1 = Wetbed	M_2 = Dapog
T_1 - 10 -day old seedlings	31.99ab	43.38a
T_2 - 15 -day old seedlings	44.73a	41.88a
T_3 - 20 -day old seedlings	47.61a	33.88ab
T_4 - 25 -day old seedlings	47.82a	18.16b

Means followed by the same letter are not significantly different at 5% level, HSD.

Older seedlings may have more assimilates stored in the stalks, thus could remobilize these assimilates for the repair of tissues damaged by pests.

Table 8. Interaction effects between nursery management and age of seedlings on grain yield (t ha^{-1}) of lowland rice

Age of seedlings	Nursery Management	
	M_1 = Wetbed	M_2 = Dapog
T_1 - 10 -day old seedlings	1.28b	1.37b
T_2 - 15 -day old seedlings	1.93ab	1.85b
T_3 - 20 -day old seedlings	2.29ab	1.49b
T_4 - 25 -day old seedlings	3.22a	1.59b

Means followed by the same letter are not significantly different at 5% level, HSD

This result conforms to the observations of most Leyte conventional farmers who found out that older seedlings performs better than younger seedlings. However, results of this study are in contrast with the Systems of Rice Intensification (SRI) where younger seedlings (10 -day old) produced more yield than older seedlings (25 -day old). SRI proponents stated that rice seedlings transplanted before commencing the fourth phyllochron retained their higher tillering potential than those of more than 14 days old.

Cost and Return Analysis

The cost and return analysis of PSB Rc82 under different nursery management and seedling age at transplanting are presented in Table 9. The variations in the net income of lowland rice could be attributed to the difference in the production cost and yield. Wetbed method and 25 -day old seedlings, obtained the highest net income of Php 2,531.00 and Php 6,651.00, respectively. The rest of the treatments resulted in net loss due to lower yield. Rice tungro virus and rice bug contributed to lower yield of PSB Rc82.

Table 9. Cost and return analysis of lowland rice production as influenced by nursery management and seedling age at transplanting

Treatments	Grain yield (t ha^{-1})	Gross Income (PhP ha^{-1})	Production Cost (PhP ha^{-1})	Net Income (PhP ha^{-1})
Nursery Management				
M_1 = Wetbed Method	2.18	41,420.00	38,889.00	2,531.00
M_2 = Dapog Method	1.57	29,830.00	40,449.00	-10,619.00
Age of seedlings				
T_1 = 10 -day old seedlings	1.32	25,080.00	40,389.00	-15,309.00
T_2 = 15 -day old seedlings	1.89	35,910.00	39,909.00	-3999.00
T_3 = 20 -day old seedlings	1.89	35,910.00	39,429.00	-3519.00
T_4 = 25 -day old seedlings	2.40	45,600.00	38,949.00	6, 651.00

Current price of palay= PhP 19.00 kg^{-1}

CONCLUSIONS

Based on the results obtained, the following conclusions can be drawn:

1. Wetbed method resulted in early heading, maturity and higher crop growth rate at 21-42 DAT. Twenty-five-day old seedlings gave higher harvest index, net assimilation rate and crop growth rate at 21-42 DAT. Using older seedlings gave higher yield under wetbed method.
2. Wetbed method and 25-day old seedlings were the appropriate nursery management and age of seedlings for PSB Rc82 under stress condition.
3. Transplanting 25-day old seedling gave higher income of Php 6, 651.00 while wetbed method of transplanting seedlings gave a net income of Php 2, 531.00.

RECOMMENDATIONS

1. It is recommended to use 25 -day old seedlings at transplanting under wetbed method of nursery management for PSB Rc82 lowland rice production under VSU conditions.

2. Follow- up study using PSB Rc82 as test crop at different planting seasons under similar agroclimatic conditions is recommended to validate the results of the study.

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Effect of maturity stage on quality and shelf life of tomato (*lycopersicon esculentum* mill) using refrigerator storage system

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Abstract

Tomatoes (*Lycopersicon Esculentum* Mill) are well known vegetable that contains vitamins, antioxidants and other health beneficial substances. This study evaluates quality (vitamin C, protein, fat, crude fibre, ash content, moisture content, carbohydrate, weight loss, firmness and antioxidant activity) and shelf- life of tomatoes under refrigerator storage method at 10^{o}C using three maturity stages (breaking stage, pale red stage and light red stage) of 'Beefmaster HYBRID VFNASt' tomato varieties cultivated in a greenhouse, harvested and stored for 18 days. The physical qualities were determined during storage whilst antioxidant activity (lycopene and carotenoid concentrations) was evaluated before and after 18 days of storage. The results obtained shows that before storage; tomatoes has high moisture content (95.36%) and protein content (1.04%) at breaking stage, highest value of fat content (0.59%) and crude fibre content (1.13%) was recorded at pale red stage, while the highest ash content (0.43%), carbohydrate (3.17%), carotenoid content (0.3272 mg/g), lycopene content (0.7309 mg/g) and vitamin C content (0.1268 mg/g) was recorded at light red stage. An increase was observed in the antioxidant activities and proximate composition after 18 days of storage. The concentration of vitamin C content of tomato fruit after storage compare with the fresh sample is significantly ($p<0.05$) depends on maturity stages of the tomato fruit. The highest nutritional value (quality and shelf-life) was recorded for breaking stage. The results obtained also shows that carotenoid and vitamin C contents of the tomato fruits slight increase at the end of the storage period in breaking stage and this increase is significantly depends on maturity stage. It was observed that ripening stage has significant influence on the nutritional values which indicate that the ideal maturity stage to maintain optimal shelf life and nutritional quality is breaking stage of tomato fruit which is the most suitable for storage.

Keywords: Tomatoes, Maturity stages, Refrigerator system, Shelf life, Quality

Research article

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is one of the most popular and widely grown vegetables in the world; it belongs to the botanical family *Solanaceae*, it (Chapagain and Wiesman, 2004) is a rich source of minerals and vitamins (A, B, and C). It is second most important in the world next to potato both in terms of area and volume of production. The main producers and exporters in the world are China, USA, Turkey, Egypt and India (USDA, 2007). Since the consumers purchase the fruits on the basis of quality, the quality of tomato fruit is largely dependent on the stage of maturity of fruits and various ripening conditions.

Tomato plants have many branches which spread from 24-72 inches and recumbent when fruiting but a few forms are compact and up right leaves are more or less hairy, strong odorous, pinnate compound, up to 18 inches long (Harvey and Chan, 1983**)**. The flowers are yellow in 2cm across pendant and clustered. Fruits vary in diameter from half to three inches or more, there are usually red, scarlet or yellow that vary in shape from almost spherical through over and elongated to pear shaped. Tomato varieties were classified into two groups: determinate and indeterminate (Henry, 2018). Determinate are tomato varieties that are space-saving or bush type in the garden. They are grown with or without support. The tomatoes ripen within a concentrated time period. This type of varieties is considered if you want a supply of ample amounts of tomatoes for canning while indeterminate are tomato varieties that should be staked, trellised, or caged for best results. Mini tomato is another variety of tomatoes that stands out as a product with high aggregated value and its market price is 20 to 30% higher than traditional tomatoes (Junqueira et al., 2011). This type of tomato has high level of carotene and antioxidant activity than conventional tomatoes (Raffo et al., 2002). These properties are intensified when the fruits are at the most advanced ripeness stage, ideal for consumption (Kader, 2008).

In Nigeria, the crop is regarded as the most important vegetable in terms of production, marketing and consumption Its production zones cover the Northern and Upper Regions as well as the Southern Region of Nigeria (Nkansah et al., 2003). Tomato maturity stage is classified into six stages (Green, Breaking, Turning, Pink or Pale red, Light Red, and Red) based on its colour (USDA, 2007). The harvesting time of tomato is an important issue to be considered in other to determine its quality and post-harvest behaviour. Tomato must be harvested at the right time because overripe tomato is more susceptible to physical injury than ripe and pink ones, as a result of this, colour is the most important criterion to determine the harvesting time of tomato. The fruit is soft, succulent, berry red or yellow in color contain too many cells of small seeds surrounded by jelly like pulp. It also consists of water and soluble and insoluble solids. Soluble solids are traditionally expressed as degrees Brix (°Brix) and mainly consist of sugars (sucrose and fructose) and salts (Beckles, 2011); therefore, tomato solids are very valuable at the factory processing. Higher amount of tomato solids need less amount of fruits to produce the same amount of tomato products (Beckles, 2011; Siddiqui, 2015). It is used raw in salads served as a cooked vegetables used as an ingredient of various prepared dishes and pickles (Wills et al., 2004).

Quality of agricultural product is an important factor to both the producers and consumers (Idah and Aderibibge, 2005). Usually after harvesting, the quality of fruits and vegetables cannot be improved. All efforts are directed towards production quality. The following are some of the qualities that aid extension of shelf life during or after storage of some of agricultural produce such as tomato. viz: firmness, mass loss, pH level, colour measurement, vitamin C content etc. The proximate chemical composition of some agricultural fruit such as sweet peppers, tomato and eggplant are presented in Table 1 (USDA, 2007). The data gives an overall indication of the relative nutritive value of each species at the time of commercial utilization.

Post-harvest losses in tomato cannot be eliminated, but can be reduced within certain limits by maintaining appropriate maturity stage of harvesting. Post-harvest losses in quality of tomato fruit are related to immaturity at harvest, inadequate initial quality control, incidence and severity of physical damage, exposure to improper temperature, and delays between harvest and consumption (Melkamu et al., 2008).

Extending the quality and shelf life of tomato is very important for domestic and export marketing. Therefore, extension of the quality and shelf life of tomato fruit by harvesting at appropriate maturity stage accompanied with proper post-harvest handling can be achieved to some level. Hence, Olympio and Kukuaih (2002) suggested that, there should be need to come up with varieties that could withstand the transportation damages or improve the handling ability of varieties grown.

In this study, the effect of maturity stage on quality and shelf life of tomato fruit are investigated with the view to generate basic data or information that can be used to determine the best maturity stage that will minimize post-harvest handling losses and maintain optimal shelf life and quality value of the tomato fruit.

Table 1. Approximated composition of fresh eggplant, pepper and tomato fruit at the stage of commercial consumption.

Constituent	Amount 100 g-1 fresh weight		
	Eggplant	Pepper (red)	Tomatoes (red)
Water	92.40%	92.20%	94.50%
Carbohydrates	5.70%	6.00%	3.90%
Protein	1.00%	1.00%	0.90%
Fat	0.20%	0.30%	0.20%
Fibre	3.40%	2.10%	1.20%
Sugar (total)	2.35%	4.20%	2.60%
Calcium	9 mg	7 mg	10 mg
Magenesium	14 mg	12 mg	11 mg
Phosphorus	25 mg	26 mg	24 mg
Iron	0.24 mg	0.43 mg	0.27 mg
Potassium	230 mg	210 mg	237 mg
Vitamin A	27 IU	3100 IU	830 IU
Thiamine	0.04 mg	0.054 mg	0.04 mg
Riboflain	0.037 mg	0.085 mg	0.02 mg
Niacin	0.65 mg	0.98 mg	0.6 mg
Vitamin C	2.2 mg	127.7 mg	12.7 mg
Energy	24 kcal	31 kcal	18 kcal

Source; (USDA 2007)

MATERIALS and METHODS

Experimental Procedure

The tomato fruits (*lycopersicon esculentum* mill) used for the study is 'Beefmaster Hybrid VFNASt' cultivated in greenhouse at Tisco farm limited, Emure-ile Owo in Ondo State Nigeria to ensure adequacy and avoid bias. It belongs to an indeterminate group of tomato varieties. It takes 80 days before it reaches maturity stage.

Temperature, humidity, ventilation and irrigation of the greenhouse was measured by a fully automated (Hortimax and Netherlands) measurement system before and during the experiment. Cultural practices such as spraying of insecticides (Karate at 30 ml/15L Knapsack) and fungicides (10 g of Shavit F 71.5 WP) and staking was carried out when necessary.

Organic compound fertilizer called bonus (foliar fertilizer in liquid form) was applied at the rate of 7-8g into 15 litres of water at nursery and 1g into 2litres of water to each plant, in three (3) weeks after transplanting in September 2018. Three weeks after the bonus application, multi K of potassium sulphate was also applied. Thirty of the tagged fruits inside the greenhouse was harvested on the same day when they reached the expected maturity ripe stage. Ripe stages of fruit were determined on the field using subjective evaluations of fruit size, position on the plant, smoothness of fruit shoulder and by observation of locular development in some representative fruit (Toivonen, 2007).

Fruit was harvested at three (3) different ripening stages (Breaking ripening stage, Pale red ripening stage and Light red ripening stage) in 17^{th} December, 2019. After harvest, fruits were held overnight at about 10-15^{0}C and transported the following day to the post graduate Laboratory of Biochemistry Department of Federal University of Technology Akure, Ondo State of Nigeria. Upon arrival at the laboratory, the tomato fruit was sorted and stored in Haier thermocool fridge of model number HRF.260Sliver with current rating 150 W/1.6A and freezing capacity of 3.5 kg/24h for a period of eighteen (18) days. Fruit quality and shelf-life was evaluated before, during and after storage from 18^{th} December to 31^{st} December 2019.

Experiment Evaluation

Weight loss, and firmness was examined at every three (3) days interval of storage while vitamin C, carotenoid, lycopene and proximate compositions was examined before and after the experiment.

Weight loss

The tomato fruits were weighed before and during the storage period using adventurer pro Av8101 balance

$$\text{Weight loss (\%)} = \frac{A-B}{A} \times 100\% \qquad (1)$$

Where, A is initial weight of the sample with the weight of basket and B is final weight of the sample with the weight of basket in gram.

Fruit firmness

Firmness of the tomato fruit was determined using fruit penetrometer GY-3 at an interval of three days for the period of 18 days at which the fruit has lost its firmness. The value was determined as follows:

$$\text{Firmness (\%)} = \frac{\mathrm{Re}\,ading}{no\_of\_replicate} \times \frac{23.8}{1} \qquad (2)$$

Where, reading is the addition of values obtained from the measurement for example a+b+c, no of replicate is the number of time the reading was taken for each sample examined and 23.8 is constant (AOAC, 2005).

Vitamin C

It was determined following methodology described by (Vinha et al., 2012; AOAC, 2005). Five gram of each sample was treated with 90 ml of oxalic acid (0.4%) for 1 hour and homogenized.

The 2 ml of filtered extracts was diluted in 50 ml of distilled water and titrated with Tillman's reagent. Quantification was obtained from a standard curve based on the reduction of DIP and results was expressed as mg of ascorbic acid/100 g.

Lycopene

It was determined following methodology described by (Fish et al., 2002). One hundred gram of the sample was ground to a homogeneous puree using an electric tissue blender and transferred into 250 cm^3 beaker. Subsequently, 50 cm^3 hexane-acetone-ethanol mixture (2:1:1 v/v/v) was added into the beaker and shaken for 15 min on an electric shaker. Thereafter, 3 cm^3 of distilled water was added and the sample was shaken for another 5 min. The solution was transferred into 250 cm^3 separator funnel and allowed to stand for 5 min to enable phase separation thereafter the upper layer (hexane) was then collected into an amber screw capped vial. An aliquot of the hexane extract was then transferred into a 1 cm^3 quartz cuvette and the absorbance taken at 503 mm against the solvent-blank using JENWAY (6405) UV Visible spectrophotometer.

Carotenoid

It was determined following methodology described by (FAO, 1992). 2.5 g of the sample was weighed into conical flask with 30 ml of hexane and 20 ml of ethanol was added again into the conical flask with 2 ml of 2% Nacl. The mixture was thoroughly mixed and the content was transferred into a separating funnel where the filtrate was allowed to stand for about 10 minutes to allow for extraction of carotenoid. The lower content was discarded and the upper layer (extractant phase) was collected. The absorbance was then estimated by using the equation below with spectrometer at 436 nm.

Determination of Moisture content

Ten gram of tomato was chopped into a pre-weighed petri-dish and dried in an oven at 105^{o}C for four hours and then allowed to cool. The petri dish was then weighed. This process was repeated many times until the weight of the petri-dish with its content remained constant. Triplicate determinations was made for each sample (Gharezi et al., 2012). Where:
The weight of empty crucible $W0$
Weight of crucible plus samples $W1$
Weight of crucible plus oven-dried sample $W2$

$$\text{Moisture content \%} = \frac{W1-W2}{W1-W0} \times \frac{100}{1} \quad (3)$$

Determination of Protein

Zero point two gram of each homogenized sample was weighed into the digestion tube followed with the addition of 5 g of Kjeldahl catalyst mixture and 15 cm^3 of concentrated sulphuric acid.

The tube was swirled gently until the mixture has thoroughly mixed. The mixture was heated continuously for 2 hr until the solution became clear and 15 cm^3 of 40% NaOH was added. The mixture was allowed to cool and then transferred into 100 cm^3 volumetric flask and diluted mark with distilled water. Another 10 cm^3 of 2% boric acid was measured into 100 cm^3 Erlenmeyer flask and few drops of Methyl red indicator was added.

Furthermore, 10 cm^3 of digested aliquot was transferred into a distillation apparatus and then distilled into the boric/indicator for 15 min. The distillate was then titrated with 0.025 ml HCl to a pink end point (AOAC, 2005).

Determination of Fat

Petroleum spirit at (40 – 60^0C b.pt) was used as reagent. 1 g of tomatoes samples was weighed into fat free extraction thimble and plugged lightly with cotton wool. The thimble was placed in the extractor and fitted up with reflux condenser and a 250 ml sox-let flask which has been previously dried in oven was cooled in the desiccators and weighed. The sox-let flask was then filled to ¾ of its volume with petroleum ether at boiling point between 40 – 60^oC, extractor plus condenser set was placed on the heater for six hours with constant running water from the tap for condensation of ether vapour. The set was constantly watched for ether leaks and the heat source was adjusted appropriately for the ether to boil gently. The ether was left to siphon over several times, at least 10 – 12 times until it was short of siphoning. It was after this; it was noticed that any ether content of the extractor was carefully drained into the ether stock bottle. The thimble containing samples was then removed and dried on a clock glass on the bench top. The extractor flask and condenser was replaced and distillation continues until the flask was practically dry. The flask which now contains the fat or oil was detached, its exterior cleaned and dried to a constant weight in the oven (AOAC, 2005). Thus, if the initial weight of dry sox-let flask is W_0 and the sum of final weight of oven dried flask and fat is W_1, percentage fat was obtained by the following formula:

$$\% \text{ fat} = \frac{W1 - W0}{weight\_of\_sample} \times \frac{100}{1} \quad (4)$$

Determination of Ash

It was determined following methodology described by (Owusu et al., 2012). Two gram of the chopped tomato sample was placed in a porcelain crucible and ashed in a muffle furnace at 600^oC for 3 hr. The crucible was allowed to cool and the weight of the ash was taken. The percentage of ash was calculated using the formula below:

$$\% \text{ ash} = \frac{Weight\_of\_ash}{Original\_weigt\_of\_sample} \times \frac{100}{1} \quad (5)$$

Determination of fibre

It was determined following methodology described by (Adebooye et al., 2006). One hundred gram of the chopped sample was weighed into a beaker and 50 cm^3 of H_2SO_4 (1.25%) was added. The mixture was then boiled for 1 hour, filtered and the residue boiled with distilled water to dilute the excess acid. 50 cm^3 of NaOH (1.25%) was added and the mixture was boiled for another 1 hour. It was then filtered, washed with distilled water until it was free from alkali.

The residue was then rinsed with acetone and dried in oven at 110°C for 2 hr. The dried residue was ashed in a muffle furnace at 600°C for 3 hours, cooled in a desiccator and weighed to obtain the weight as $W1$. The crucible containing white or grey ash (free of carbonaceous material) was cooled in the desiccators and weigh to obtain $W2$. The crude fibre content was calculated by difference in $W1$ and $W2$.
The formula below was used to obtained percentage of fibre;

$$\%\ \text{fibre} = \frac{W1 - W2}{weight\_of\_sample} \times \frac{100}{1} \qquad (6)$$

Determination of Carbohydrate

The addition of the value obtained from protein, fibre, fat, ash and moisture content minus 100 gives the value of carbohydrate in the sample (AOAC, 2005).

Shelf Life Determination

Shelf life of tomato fruit is the period of time which started from the harvest and extends to the time the sample stayed in storage systems before rotting begins (Gomez et al., 2008). This was calculated by counting day at optimum marketing and eating qualities.

Data Analysis

The collected data on various parameters was statistical analysis using XL stat version 2016 and Minitab version 17 statistical package. Results was statistically evaluated by variance analysis (ANOVA) and statistical differences with p-values under 0.05 was considered significant. Post-hoc test (Duncan multiple tests) was performed to analyse differences among the means of independent observations, to assess the differences between maturity stage, bioactive compounds content, antioxidant activity and also to establish association between various quality and shelf life for tomato cultivar studied. Pearson correlation tests ($p \leq 0.05$) was used to ascertain the existence of linear relationships between variables: (lycopene content/colour, lycopene/antioxidant activity, carotenoid content/antioxidant activity and ascorbic acid/antioxidant activity).

RESULTS and DISCUSSION

The results of the physiological evaluation made on three ripening stage of 'Beefmaster Hybrid VFNASt' tomato fruit cultivars during 18 days of storage are explained using summary and variance analysis as shown in (Tables 2 and 3).

Effect of storage on Weight loss (%)

Tomato ripening stages had significant effect on weight lost, weight loss is one of the key indicators of deterioration, degrading, and lost in the quantity of tomato fruit (Brummell, 2006). In term of ripening stage, light red stage has the highest weight loss (14.35%) followed by (9.58%) pale red and the lowest value (5.4%) was recorded for breaking stage as shown in (Table 2).

Table 2. Summary of the total weight loose (%) of the tomato fruit

	Ripening Stages		
Statistics	Breaking stage	Pale red stage	Light red stage
Mean	5.4 a	9.58 ab	14.36 b
Max	5.95	10.83	17.06
Min	4.43	7.23	9.08
SD	0.85	2.04	4.57
CV (%)	15.66	21.3	31.84

Mean values in the same row with different lower case alphabet are significantly different ($p < 0.05$).

The highest value (14.35%) might be due to the fact that the rate of transpiration and respiration was lower due to higher concentration of CO_2 and lower concentration of O_2 inside the storage system (Ajayi and Oderinde, 2013). The results of these findings was in agreement with the result of (Ali and Thompson, 1998) and (Bhattarai and Gautam, 2006) who reported the loss in weight of tomatoes sample during storage. Significant variation responsible for the lowest weight loss in the storage system was found due to the effect of constant temperature (10^{o}C) in respect of percent weight loss of tomato. However, 5.4% weight loss at breaking stage showed less weight loss as compared to order two ripening stage evaluated in this research work. This shows that tomatoes with lower weight loss can be stored for longer time as compared to other samples.

The statistical analysis shows that there is no significant difference between the weight loss of pale red and breaking and pale red and light red tomato fruit stored but light red significantly higher when compared to breaking ($p< 0.05$). The differences in the weight loss show that breaking stage has the ability to be stored for longer period. This shows that the storage system has favourable storage conditions that can accommodate any of the samples for a period of time in terms of weight loss values as it is mostly lower when compared with other researcher Bhattarai and Gautam (2006) and (Okolie and Sanni, 2012) reports. The table also shows that at the end of the experiment storage method adopted has no significant different on three samples stored when compared to the results obtained at the beginning of the experiment ($p<0.05$). The result of these findings are in agreement with Bhattarai and Gautam (2006) report. The results reveal that the physicochemical profile of tomato fruits changes significantly over time and with the storage methods as already reported by other researchers (Okolie and Sanni, 2012).

Effect of storage on Firmness (N)

On the basis of objective firmness evaluation, it was found that the minimum acceptable levels or marketability scores of tomato firmness at which an individual tomato fruit could be acceptable for sale at retail level is about 1.45 and 1.46 Nmm^{-1} respectively (USAD, 2007) which is in conformity with the results obtained in this report. However, this study is similar to the finding of (USDA, 2007) which reported that the firmness values of the tomatoes generally used at home is about 1.28 and 1.22 Nmm^{-1} acceptability score respectively.

Ripening stage had significant effect on the firmness of the tomato at the end of shelf life in each of the samples studied. The result shows that the highest value of firmness (4.879 Nmm^{-1}) was found at light red stage after 18 days of storage followed by pale red stage (4.76 Nmm^{-1}) and breaking stage (4.522 Nmm^{-1}).

The lowest firmness (4.522 Nmm^{-1}) was found in breaking stage after 18 days as shown in Figure 2. The significant variation in the samples resulted from the combination of different ripening stages of the fruits and some physical variations that occurs during the storage period, this result was in agreement with the results of (Ketelaere et al., 2004).

The results in (Table 3) show that ripening stages caused a slight softening in tomato when compared with less ripe tomato fruits. After 18 days, nearly all the samples stored was still very firm and they had good finger feel firmness for marketing purpose particularly light red ripen stage. After 18 days of storage it was observed that the firmness values of tomato fruits used for this research work was acceptable because it was in conformity with that of 1.31 Nmm^{-1} result of Thompson, (1996).

Significant differences in firmness values was observed for acceptability levels of both samples of tomatoes. Figure 1 shows that firmness values of tomatoes sample were accompanied by decreasing acceptability levels from breaking stage – pale red – light red sample. Firmness values of the three samples decreased as the storage period increases. This reduction was between 9 and 18 days for acceptability level as compared with result of Thompson, (1996). The variation between minimum and maximum values of samples at acceptability levels (very firm) is slightly higher than the variations of other acceptability levels. This variation might be due to some difficulty in categorization, especially in the homogeneity of samples acceptability levels. At the end of the experiment all samples were very firm when touched by hand.

Table 3. Summary of the firmness (N) of the tomato fruit

Storage time	Ripening Stage		
	Breaking stage	Pale red stage	Light red stage
fresh	156.29±19.38^{ab}	174.53±41.79^{a}	111.86±16.66^{ab}
9 days	103.93±7.65^{abc}	64.26±30.39^{abc}	71.4±31.48^{abc}
15 days	76.16±6.3^{ac}	53.55±8.33^{ab}	56.33±57.58^{a}
18 days	45.22±8.58^{ad}	47.6±11.9^{ab}	48.79±1.19^{a}

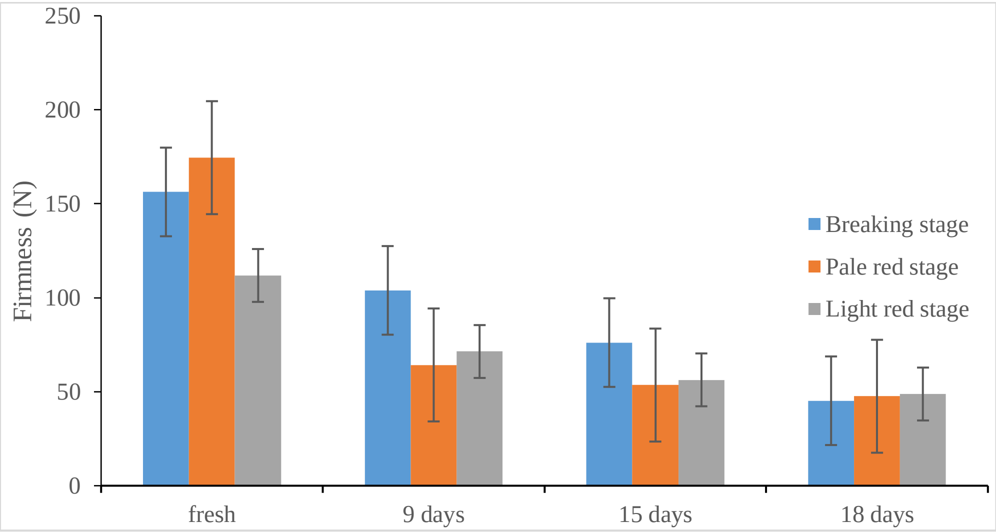

Figure 1. Variation in the firmness of tomato fruits stored under the same storage condition.

Effect of storage Bioactive Compounds and Antioxidant Capacity

It has been shown that skin and seeds are important contributors to the major antioxidant compounds of tomatoes (Toor and Savage, 2006), it is on this note that chemical analyses was performed on whole tomatoes. It is a product that has high value of antioxidant content (Hanson et al., 2004; Rosales et al., 2006). Tomato fruit possess constituents of several molecules with this capability of which lycopene, ascorbic acid and carotenoid was hereby selected. The quantity of these molecules varies along with ripening stages and with the storage methods applied as shows in Table 4, and their results are in agreement with the report of (Valverde et al., 2011; Oms-Oliu et al., 2011).

Effect of storage Vitamin C content (mg/g)

Vitamin C is one of the most important nutritional value parameter in fruits and vegetables (Tigist et al., 2013). The average content of ascorbic acid of the three samples are 1.125±0.0177 breaking, 1.076±0.019 pale red, and 1.293±0.026 light red, mg/g respectively as indicated on Table 4. The value of the three samples are in the lower range when compared to that of reported values (Adebooye et al., 2006; Olaniyi et al., 2010; Adubofuor et al., 2010; Gharezi et al., 2012) which might be due to environmental factors. Thus, it is observed from the result that the concentration of vitamin C follows these sequence, breaking stage < pale red stage but > light red stage, this implies that pale red stage is significantly different from breaking stage and light red stage but breaking stage and light red stage are not significantly different from each other ($p<0.05$). The results also suggest that, in general, when comparing the ripening stages of tomato fruits, breaking stage and pale red stage are not significantly different from each other but significantly different from light red stage ($p<0.05$). It is recognized that high levels of acidity are responsible for the stability of vitamin C in breaking stage during storage. Furthermore, phenolic substances have also been linked to the stability of vitamin C due to its protective effect (Ajayi and Oderinde, 2013). These results are consistent with other studies (Dumas et al., 2003; Toor and Savage, 2006). Finally, it was also observed that content of vitamin C increase till the last day of the storage as shows in figure 2.

Table 4. Summary of the Bioactive Compounds and Antioxidant Capacity content (mg/g) of the tomato fruit

Ripening	vitamin C		Lycopene		Carotenoid	
stage	Control	After	Control	After	Control	After
Breaking stage	0.6688± 0.0088[a]	1.125± 0.0177[ab]	34.34± 0.0141[ab]	64.4353± 0.0075[ab]	0.0963± 0.0007[ab]	0.2996± 0.0058[ab]
Pale red stage	0.7813± 0.0619[ab]	1.0763± 0.0194[ab]	20.7624± 0.1731[a]	114.021± 0.0297[abc]	0.0877± 0.0058[a]	0.4383± 0.0144[ab]
Light red stage	1.2688± 0.0088[bc]	1.2938± 0.0265[bc]	73.0984± 0.0023[ab]	133.0066± 0.0048[bc]	0.3272± 0.0101[ab]	0.4056± 0.0029[ab]

Mean values in the same column with different lower case alphabet are significantly different ($p < 0.05$).

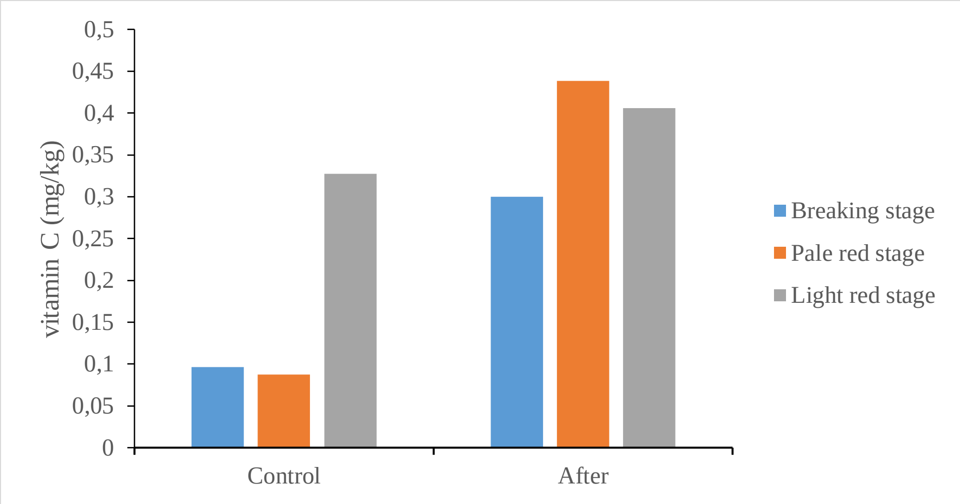

Figure 2. Vitamin C (ascorbic acid) content of tomato fruit at different ripening stages

Effect of storage Lycopene content (mg/kg)

As a major carotenoid in human blood, lycopene protects against oxidative damage to lipids, proteins and DNA. Lycopene is a potent quencher of singlet oxygen (a reactive form of oxygen) which suggests that it may have comparatively stronger antioxidant properties than other major plasma carotenoid. This antioxidant (lycopene) is cancer preventative phytonutrient that also protect the body from damage caused by compounds known as free radicals.

Table 4 shows the concentration level of lycopene in the three samples before and after the experiment and varies accordingly light red stage < pale red stage < breaking stage, this implies that light red stage is significantly different from breaking stage but not significantly different from pale red stage. Breaking stage and pale red stage are not significantly different from each other ($p>0.05$). In general, it was observed from the results that there is a positive change in lycopene concentration with time for the three samples at the end of storage period.

For example, breaking stage exhibited almost 50% higher levels of lycopene after 18 days of storage when compared to control while the rate of increase in pale red and light red stage was 20% and 35% respectively when compared to control as shows in Figure 3. Various values have been previously reported for tomatoes lycopene and the values obtained in this report was in agreement with Malami and Mohammed, (2013); Wawrzyniak et al., (2005) the range of 3.79 - 17.53 mg/100g. At the end of the experiment, a higher antioxidant activity was observed in comparison to the start of the experiment, these results are consistent with the results of Dumas et al., (2003); Toor and Savage, (2006).

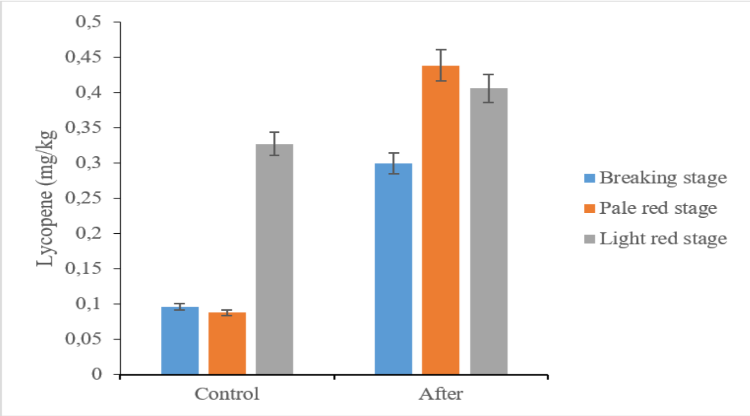

Figure 3. Lycopene content of tomato fruit at different ripening stages

Effect of storage Carotenoid content (mg/kg)

Carotenoid quantity varies as the ripening of the samples varies and this result is similar to the results presented by Valverde et al., (2011) and Oms-Oliu et al., (2011). Table 4 shows difference in the content of carotenoid between the samples before and at the end of the experiment ($p < 0.05$).

Regarding the effect of the storage conditions, carotenoid is expressed mainly in the rate of change of concentrations rather than on their maximum values. This observation is certainly linked with the increased concentrations of lycopene. The influence of storage conditions on the level of carotenoid has already been mentioned by other authors, who reported an increase in carotenoid content between 3.6 and 9.0 mg/100g in tomatoes stored for 14 days (Maul *et* al., 2000).

However, at the end of these experiment, it was observed that the tomatoes sample stored shows deterioration in their values of bioactive compounds. Since antioxidant activity is related to the contents of carotenoid compounds, it is not surprising that its follows a trend that is parallel with those observed for those samples when compared with control as shows in Figure 4.

Table 5. Summary of proximate composition (%) of the tomato fruits

Ripening stage	moisture content		protein		ash content		crude fibre		carbohydrate		fat	
	Control	after	control	after	control	after	control	after	control	after	control	after
Breaking stage	95.36± 0.16^{bc}	91.67± 0.13^{a}	1.04± 0.00^{b}	1.04± 0.00^{b}	0.34± 0.08^{a}	0.82± 0.01^{abc}	1.00± 0.00^{a}	1.00± 0.00^{a}	1.75± 0.06a	4.96± 0.15^{b}	0.51± 0.014^{ab}	0.51± 0.00^{ab}
Pale red stage	95.13± 0.96^{abc}	93.05± 0.03^{ab}	1.01± 0.00^{ab}	1.00± 0.00^{ab}	0.36± 0.03^{ab}	0.79± 0.02^{abc}	1.13± 0.18^{ab}	1.00± 0.00^{a}	1.79± 1.11ab	3.66± 0.01^{ab}	0.59± 0.01^{b}	0.51± 0.01^{ab}
Light red stage	93.88± 0.35^{a}	95.51± 0.55^{ab}	0.95± 0.00^{a}	0.97± 0.01^{ab}	0.43± 0.04^{ab}	0.83± 0.00^{bc}	1.00± 0.00^{ab}	1.00± 0.00^{ab}	3.17± 0.38^{b}	1.19± 0.56^{ab}	0.58± 0.01^{ab}	0.51± 0.01^{a}

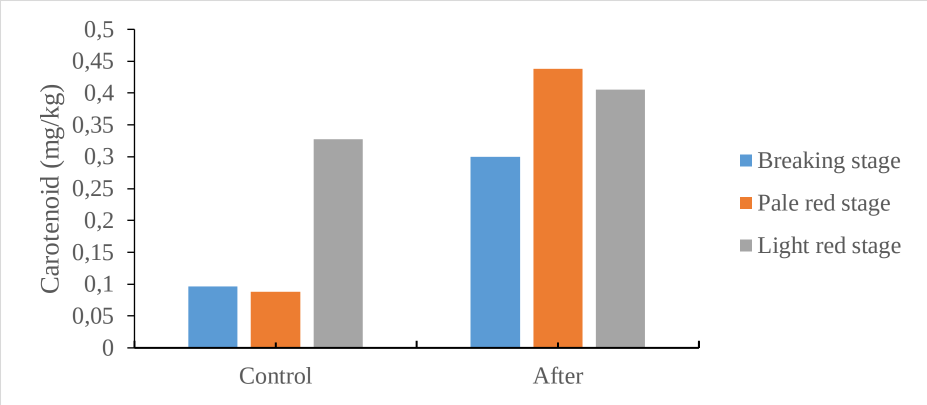

Figure 4. Carotenoid content of tomato fruit at different ripening stage

Proximate Composition Results

Table 5 shows the proximate composition of tomatoes for control and after storage *Mean values in the same column with different lower case alphabet are significantly different ($p < 0.05$).* The results of the proximate analysis revealed that in the entire sample, moisture content was higher than other elements analysed and this was in agreement with the findings of Agbemafle et al. (2015); Idah et al. (2010). Table 5 shows the initial level of proximate composition results of tomatoes samples before storage ; for breaking stage and pale red stage the value of moisture content (MC) is 95% and light red is 93%, for breaking stage and pale red the value of protein is 1.04 and 1.01% which are not significantly different from each other and the value of protein for light red is 0.95%, for breaking stage, pale red and light red, the value of fat content are 0.51%, 0.59% and 0.58%, for breaking stage and light red the value of crude fibre is 1.00% and pale red is 1.13%, for breaking stage and pale red the value of ash content are 0.34 and 0.36% which is statistically not different from each other and the value of ash content for light red is 0.43% and for breaking stage, pale red and light red stage, the value of carbohydrate is 1.75%, 1.79% and 3.17% respectively. These level of proximate composition was different from the one that was obtained from two varieties of tomatoes, in Ogbomosho local and Ibadan local: 42.55% and 29.39% protein content, 3.72% and 3.86% fat content and 6.94% and 7.42% fibre as reported by Olaniyi et al. (2010).
These deviations could be attributed to differences in ecological distribution of the tomato varieties and genetic differences among the varieties.

Moisture content (%)

Since foods with low moisture content have longer shelf life, thus results obtained in Table 5 shows that breaking stage have relatively longer shelf lives compared with pale red and light red. Various levels of moisture content for tomatoes have been previously reported and the results of this report was in agreement with those of Oko-Ibom and Asiegbu (2007); Adubofuor et al. (2010); Hossain et al. (2010) who have reported the moisture content in the range of 88.19 - 90.67%, but higher than those of Adebooye et al. (2006) who reported 78.56%. Figure 6 shows the variation in moisture content as regards the ripening stages. However, the moisture content of 95% for this report is close to the work of Okorie et al. (2004) that reported 93% MC and Idah and Aderibigbe (2005) 92.2% MC of harvested sample of tomatoes before storage. Figure 5 shows the proximate composition of tomatoes for control and after storage.

Protein (%)

The average crude protein content obtained for this research work and the values are in the lower range than the results that was previously reported by Olaniyi et al. (2010). However, the result shows that all the three samples has no significant different when compared with the control at the end of the experiment. Since there was no significant difference among the results obtained for the three samples at the control stage of the experiment, therefore the results are in conformity with USDA (2007) standard for fresh tomatoes. However, tomato Fruits contain a low amount of protein but aged tissues such as overripe fruits usually have a higher amount of non-protein nitrogen as reported by Vincent et al. (2009). Pale red had highest percentage lipid, however, significantly higher than 0.20% as estimated by Idah et al. (2010). The agronomical activities during production as also account for dissimilarity. Fatty acids are very essential in physiological functions of human as they participate primarily to produce hormone-like substances which control blood pressure, blood clotting, the immune response, blood lipid levels and the inflammatory response as reported by Vincent et al. (2009). However, the results show that storage method adopted for the research is the best storage method to be adopted for storing tomato at any ripening stage. Figure 6 shows the behaviours of the samples before and after storage.

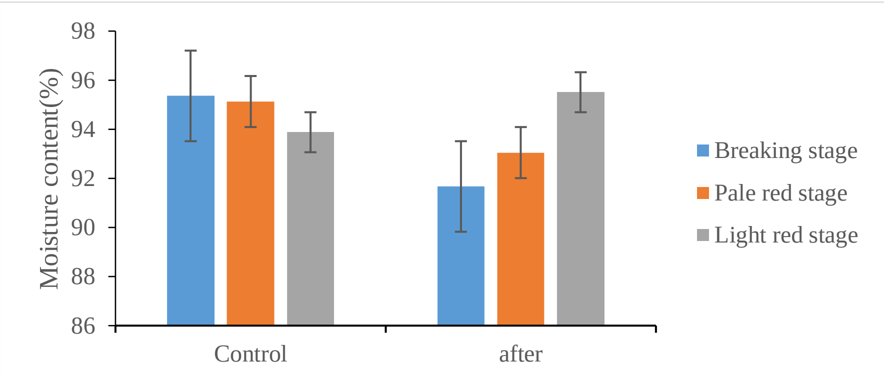

Figure 5. moisture content of tomato fruit at different ripening stage

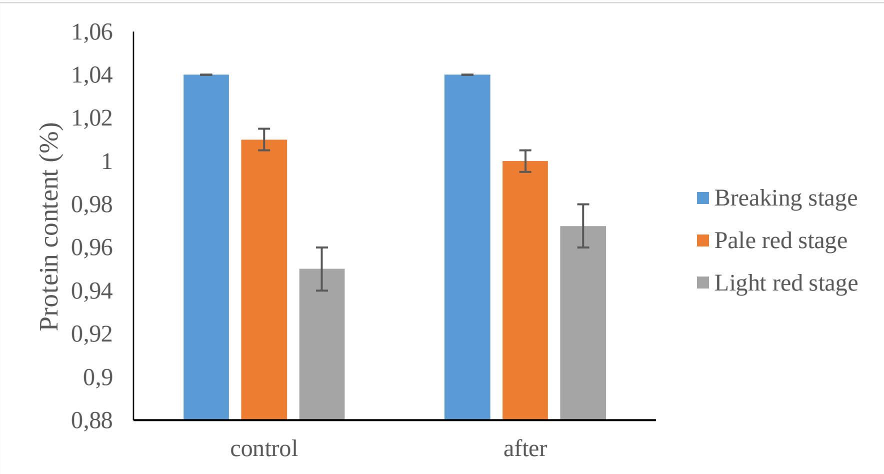

Figure 6. protein content of tomato fruit at different ripening stage

Ash content (%)

The ash content of a food substance depicts the total crude minerals. Light red had the highest ash content (0.43%) at control and the value fall in the range of 0.47% - 0.98% as reported by Agbemafle et al., (2015). Table 5 shows the average ash contents of breaking stage, pale red and light red at control level as 0.34±0.08, 0.36±0.03, and 0.43±0.04% ($p<0.05$) respectively and the results was closely in agreement with the results of Adubofuor et al. (2010); Suleiman et al. (2011) whose reported values ranging from 0.2 – 0.4%. From the results light red, has more ash content and hence contains more mineral than breaking stage and pale red this indicate that the mineral levels was independent of the source. This observation is similar to the findings of Nielsen (2002) who evaluate the nutritional quality of these cultivars and observed that Roma VF (beefmaster tomato) light red ripening stage has more minerals than those of breaking and pale red ripening stage. Plants accumulate these nutrients through absorption by roots in the medium of water, thus this action decreases especially in water-stressed plants as reported by Akinci and Losel (2012). The crude mineral concentrations in fruits are unchanged during the storage except when there are leakages from the tomato fruits and also when they are not metabolized as reported by Hui (2006). The variances in ash content in each samples are as a result of storage methods coupled with the influence of preservatives. Figure 7 shows variance in level of ash content between the three samples (breaking stage, pale red and light red) when compared with the control.

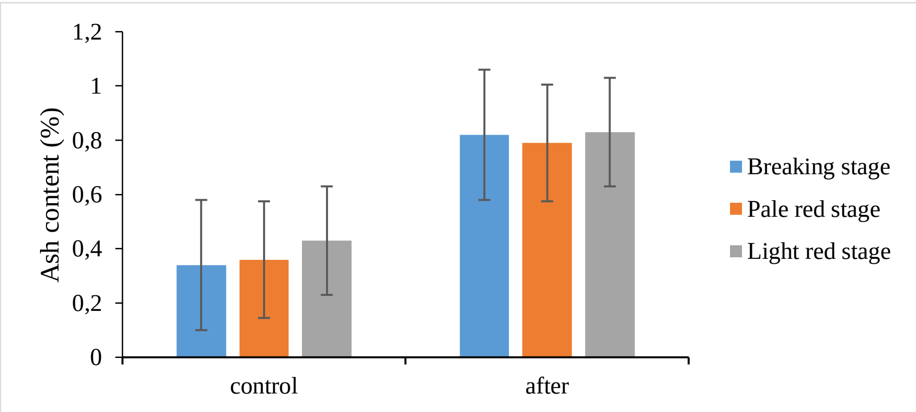

Figure 7. Ash content of tomato fruit at different ripening stage

Crude fibre content (%)

According to the results presented in Table 5, The average levels of crude fiber content in the three samples was found to be, for breaking stage 1.00±0.00%, for pale red 1.00±0.00% and for light red 1.00±0.00% respectively ($p<0.05$). The results obtained at the control for the samples are breaking stage 1.00±0.00%, pale red 1.13±0.18% and light red 1.00±0.00% which was within the range of 0.70 – 3.25% when compared with the reports obtained by Onifade et al. (2013); Alvi et al. (2003); Adebooye et al. (2006); Olaniyi et al. (2010). All samples used contain a considerable amount of fibre in varying quantities. Onifade et al. (2013) reported that the percentage of crude fibre in Yoruba variety of tomato was 2.50%, comparatively higher than the similar variety used in this current study.

The principal components of dietary fibres are lignin, cellulose, hemicelluloses, pectins, resistant starch and non-digestible oligosaccharides. The cell wall makes up to 1% to 2% of the fresh weight of fruits and cellulose constitutes about 33% of that amount Vincent et al. (2009). Brummell (2006) reported that the quantity of cellulose fluctuates during fruit ripening. Dietary fibre is an indigestible component of food that enhances peristaltic movement of bowels. It prevents constipation as well as colon cancer as reported by Terry et al. (2001). The crude fibre values were found to vary widely alongside with the samples as shown in Figure 8. Regarding the effect of the storage methods, it is expressed mainly in the rate of change of concentrations rather than on their maximum values. However, in comparing all the results with control, all the samples perform best because is not significant different from control ($p<0.05$).

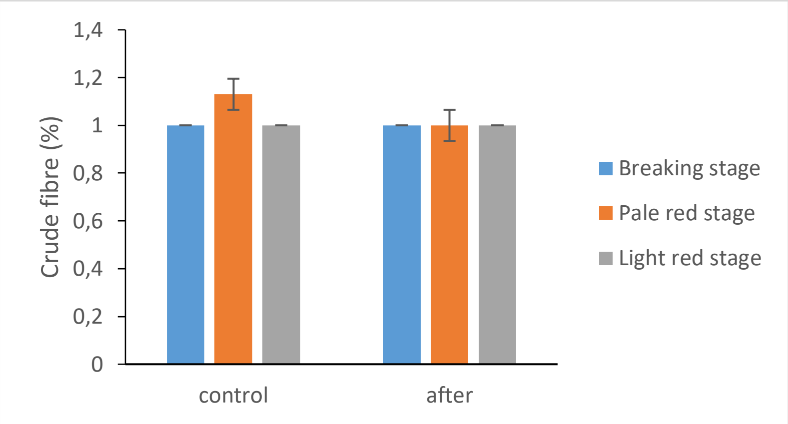

Figure 8. Crude fibre content of tomato fruit at different ripening stage

Carbohydrate content (%)

Carbohydrate is an essential nutrient in the body as it is the major energy source in the body. The range of carbohydrate content of all the samples used was 0.48% – 4.96% higher than 1.0% - 3.90% as reported by USDA (2007) as shows in Table 5. The differences may be as a result of varietal influence, environmental conditions and other agronomical practices during production Agbemafle et al. (2015). The differences in carbohydrate content can also be attributed to storage methods employed which may have differential effects on the activities of cell wall enzymes such as α-galactosidase, β-galactosidase, β-mannosidase and β-glucosidase. These are also responsible for the rotting and softening of the tomato fruit Emadeldin et al. (2012).

The amount of carbohydrate is second to moisture in all the samples as shows in Table 5. It was observed that there is interplay between the moisture and carbohydrate contents without the influence of storage methods. This assertion was supported by Idah et al. (2005) that the percentages of moisture and carbohydrate are increasing and decreasing respectively as the storage period increasing as shows in figure 9. In figure 9, the results obtained for breaking stage perform better more than other two samples and the result is in conformity with USDA (2007) reports. With respect to storage methods, significant differences were recorded in all the samples. The storage method significantly enhanced the carbohydrate content of tomato stored over the control in all the samples except light red.

The control, however, showed significantly higher value of moisture and fibre contents when compared to other reports. The results indicated that the use of the storage method adopted promoted higher values of carbohydrate.

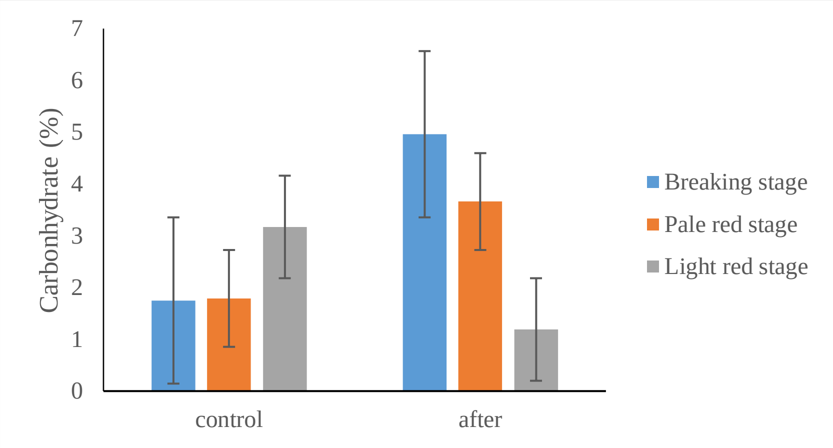

Figure 9. carbohydrate content of tomato fruit at different ripening stage

Fat content (%)

Fat is one of the most important nutritional value parameter in tomato fruits as reported by Tigist et al. (2013). The fat content at control level was from 0.51% (breaking stage), 0.59 % (pale red) to 0.58% (light red). These values are in agreement with the concentration of fat as reported by Ochoa-Velasco et al. (2016), but less than findings of Vinha et al. (2012); Kelebek et al. (2017).

In this report it was found that fat content during storage for the samples reduces at the end of the storage as shows is Figure 10. Moreover, we could conclude that decreases significantly ($p \leq 0.05$) depend on tomato variety and storage methods adopted. The values recorded for the fat content are 0.51% breaking stage, 0.51% for pale red and 0.51% for light red. The fat content in all the samples decreases at the end of storage period and the decreases was 0.02% less compared with the control level of the experiment. Similarly, Ajayi and Oderinde (2013) observed the same decrease in fat content. Table 5 shows that fat content values obtained in this report is higher when compared with USDA (2007). As we all known that light red is the one that is commonly marketed. It was found that at this stage (light red) the values of fat content is 0.51%. The light red colour is a little more overripe more than pale red at the beginning of the experiment. Tomatoes which reached the red colour stage (light red) might have had a long overall storage time or might have stayed on the vine too long. Variation in fat content of the samples (breaking stage, pale red and light red) readings range between maximum and minimum values increased at the end of storage time. The fat content increased with increasing maturation (Batu, 1995). It is interesting to note that in this report that modern storage has enhanced the shelf-life of all the samples, recording the highest shelf life in modern storage.

This finding was supported by the results of Idah et al. (2005) who reported that evaporative cooler system (pot-in-pot) was a promising storage mechanism that enhanced the shelf life of fruits and vegetables which operate in the same principle as modern storage. However, with some careful modifications in modern storage system, preserving fruits and vegetables will be more effective in the rural areas in Nigeria.

Shelf life (days)

The shelf life of tomato fruits was significantly influenced by the storage methods applied. 18 days was recorded as the maximum shelf life at the end of storage period. Storage systems had significant effect on the shelf life of tomato. There was a significant variation among the samples resulted from the combination of deferent ripening stage in respect of shelf life of tomato.

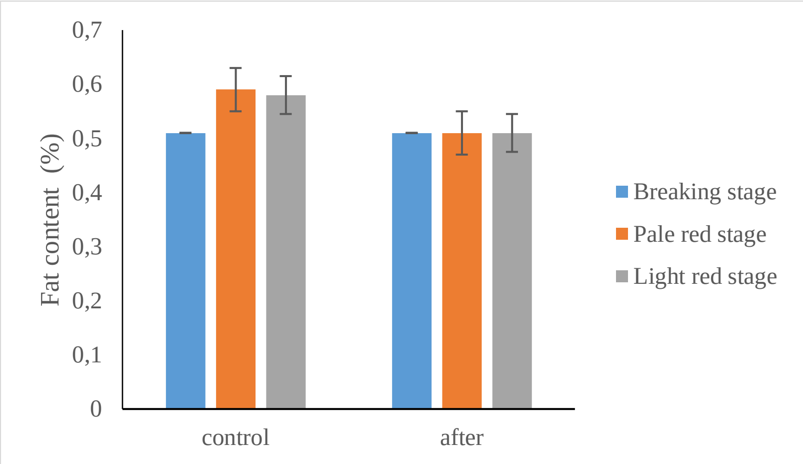

Figure 10. Fat content of tomato fruit at different ripening stage

CONCLUSION and RECOMMENDATION

In conclusion, this research work demonstrates the effect of storage time on physiological and proximate composition parameters of three ripening stage of tomato fruits namely, breaking stage, pale red and light red. At the end of storage period, physiological parameters were the most affected during storage period and the concentrations of the antioxidant compounds (lycopene content) increased over time in all analyzed samples and the storage method adopted maintain optimal selected physiological properties and proximate composition profiles. All the samples analysed had the most extended shelf-life and has the highest nutritional values. Since the firmness values of samples obtained in this research are above 1.28 Nmm^{-1} and 1.46 Nmm^{-1} before and after storage, this shows that they are suitable for easily marketable in the supermarket and even for marketing. In order to improve the post-harvest handling and nutritional qualities of tomatoes fruits it is recommended from this study that modern storage method (refrigeration conditions) should be used and tomato fruits should be harvested at breaking stage to help the handlers and storage of tomato for at least few weeks before it gets to processing or final users with little variation in the quality.

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Sustainable Agriculture and New Food Marketing Management System

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Abstract

Food security is a global problem. Unforeseen problems such as infrastructure problems in agricultural areas, income uncertainty in these areas, climate change, population growth and change in eating habits and reduction of agricultural land threaten food security.Sustainable agriculture is the whole of the production activities that human beings carry out to access the food they need in order to survive. In order to achieve this, a new food marketing management system is needed. The food marketing management system is part of the value chain. Value chain includes all pre-harvest and post-harvest activities in agricultural products. For success in the food marketing management system, all activities in the value chain must be evaluated together. In this study, the components that a new food marketing management system to be prepared in agriculture should contain.

Keywords: Agriculture, climate change, eating habits, food security, harvest, value chain

Review article

INTRODUCTION

Regardless of their level of development of the countries, the agricultural sector has an important place in every country's economy. A significant portion of the foodstuffs and raw materials they use for people to survive is provided by the agricultural sector and therefore an alternative to this sector cannot be considered. Agriculture is an important and indispensable tool that every country should consider in policy making, due to its positive contributions to the supply of raw materials to industry, labor transfer, foreign currency income and national income (Tunçer and Günay, 2017).

The food industry is of vital and strategic importance for the future of countries. Preventing increases in food prices and developing policies to reduce the negative effects of these increases are of great importance to ensure long-term and permanent price stability in our world. In this context, there is a need for policies that will ensure agricultural transformation, reduce migration from the countryside, increase rural welfare, support production planning, productivity increase, production and increase in the number of producers. In this way, increases in agriculture and food prices can be controlled and inflation expectation targets can be achieved (Eştürk and Albayrak, 2018). The rise in prices of agricultural products will push a part of society into poverty. Inflation is the increase in the general level of prices. Due to climate change and rapid population growth, an increase in food prices in general will adversely affect the inflation rates of countries.

In the division of labor in the world countries in agriculture, developed countries become agricultural raw material exporters, while developing or underdeveloped countries become dependent on agricultural food imports. In order to increase the export of agricultural products, it is increasingly required to import raw materials. This, on the one hand, leads to low added value and at the same time, the positive contribution to total foreign trade is gradually disappearing (Aydın and Aydın, 2018).

Agricultural production contains more risks in its structure than its other sectors in terms of its commitment to nature. Risks faced by agricultural enterprises are production, finance, technology, human origin, marketing, official and social risks. When agriculture is taken into account depending on nature, producers face many natural risks such as drought, flood, frost, hail and storm. Realization of such risks will not only affect the income of the producers negatively, but will also affect the country's economy negatively. It would be wrong to limit the risks faced by agricultural enterprises to only natural risks. In addition to natural risks, risks such as changes in product and input prices, government policies, sickness or death of the farmer, and failure to keep up with new technological developments also affect agricultural enterprises negatively. As a result, sustainability of agriculture is negatively affected. When the risks faced by growers are clearly identified, it will be easier to take precautions against risk. A wide variety of risk management strategies have been developed for this. Risk management strategies should be developed based on the degree of risk faced by the manufacturer and the possibilities for occurrence. Risk strategies will not produce healthy results unless the level of risk and probability of occurrence are clearly revealed (Erdoğan and Bayramoğlu, 2017).

Spring freeze is the most important risk sources in some fruits production. A lot of fruit producers are not aware of the advantages of agricultural insurance. Designing the farmers' education program may increase the information related to agricultural insurance. Monitoring the fruit market and sharing the market information with fruit farmers may decrease the market risk faced with fruit producers. Spread of the cooperation among the fruit farmers has the positive contribution to the fruit producers for designing optimum risk management strategy (Gunduz et al., 2016).

Good Agricultural Practices (GAP); It is the production model that ensures traceability, sustainability and food safety in agriculture by agricultural production in a way that does not harm the environment, human and animal health, and the products produced as a result of production are certified. On the important effects of good agricultural practice on soil quality; known that pollution in soil was prevented and soil fertility increased as a result of the decrease in fertilizer use and balanced use of fertilizer. Similarly, it is known that there is no drug residue in the soil or that it decreases very much since there is no excessive use of drug (Aydın et al., 2016).

The goal of organic agriculture to protect biodiversity and soil fertility ensures that the "possibilities of future generations to meet their own needs" stated in the definition of sustainable development are ensured. Chemicals, hormones and drugs used in the production of food products have reached a worrying level for many consumers. In the case of organic food products, it will be effective to bring better product performance to the forefront in terms of taste as well as the important competitive advantage related to food health and safety (Eti, 2014).

Some countries have sufficient potential in terms of the production of many agricultural products due to their soil and ecological conditions. However, production merely is not enough to be among the important exporters in the world. Export value should be high as well as production. Therefore, it is very important to increase the export of agricultural products. In order for these countries to increase their competitiveness in the agricultural products market, importance should be given to productivity, quality and technology in production (Bashimov and Çiçek, 2017).

Besides agricultural production, agriculture-based industries and marketing channels should be developed and competitiveness should be increased in national and international markets. In the processing and marketing of agricultural products, a structure that complies with the standards should be established (Bayraç and Yenilmez, 2005).

Since there are too many middlemans in the value chain in our country's agriculture sector, it affects the traceability negatively. However, new technologies and techniques are increasingly making traceability a cost-effective expense, and in the following years the system pays off, making the business competitive (Yılmaz and Yılmaz, 2017). The developments in today's technology and the increased level of consciousness in humans provide an opportunity for the situations that may be negative for the future to become more positive. Today is an important opportunity for the future, and it is important for the future of the food to be managed in the best way. Traceability covers all stages from production to consumption, including production and distribution phases and export. It is aimed to ensure food safety by monitoring the traceability and sustainability of natural resources in the agriculture and food sector (Gökırmaklı and Bayram, 2018). The use of agricultural lands for other purposes should be prevented.

Some Suggestions for Sustainable Agriculture

Since the food sector is a highly dynamic sector, it undergoes major transformations over time and these transformations closely affect the decisions and consumption habits that all stakeholders of the sector should take. The trends in the food industry are influenced by many factors. Due to the healthy lifestyle trends, it is thought that foods with high mineral and vitamin content but low in fat and sugar content will continue to be important in the future, and the demand for these products will continue to increase especially in developed and developing countries. Health, convenience, pleasure, sustainability, authenticity trends reveal as the five main trends that have an important place in food and beverage consumption and may affect the industry in many areas such as production, consumption, investment and market orientations in the future (Keskin and Güneş, 2019).

The effects of global climate change in all areas of life, especially in recent years, show themselves on agricultural production and trade in the form of yield and price fluctuations. These fluctuations in prices and yield levels make it difficult for companies whose main inputs are agricultural products to continue their activities in a stable manner. The deterioration in the financial structures of companies that do not manage the risks caused by fluctuations well can be priced by investors, which can have a lowering effect on the market values of companies. On the other hand, it is possible to say that the picture will be positive for companies that can manage these risks well. Changes in air temperatures affect agricultural production and prices of agricultural products in our country as well as in the world, affecting the activities of companies operating in the field of food and beverage production (Durmuşkaya, 2016).

The main reason for the lack of potential competitive advantage in the trade of agricultural raw materials is the export of processed products. Importing agricultural raw materials to support the export of processed products reduces competitiveness in this sub-sector. Therefore, priority should be given to domestic production rather than agricultural raw material imports (Mangır & Fidan, 2017). The change in exchange rates affects the prices of agricultural products determined by the producers due to the import of raw materials and intermediate goods of the food industry (Tay Bayramoğlu and Koç Yurtkur, 2015). Applications such as the use of effective technology that will increase productivity and competitiveness in agriculture and improving the infrastructure of agricultural enterprises should be focus on (Bayraç and Yenilmez, 2005).

Although investments in the agricultural sector have a significant contribution to production, employment and rural development, foreign direct investments are shifted to areas with high profitability in the short term. Investing in the production, processing and marketing of products for which we have a comparative advantage by region will be very useful in terms of rural development and employment (Koçtürk et al., 2013).

Taking measures for the diversification of rural income and shifting from product-based supports to producer-based supports will increase the efficiency of the support and reduce the burden on public finance. The agricultural sector should be transformed from a labor-intensive sector into a technology-intensive sector, but social policy practices should also be taken into account while doing this (Erçakar, 2010).

Products, which are cultivated in a region with its geographical, ecological and human factors, are known as the name of the regions that they produced. Those products are featured and prestigious agricultural products and they can be sold for a higher price than similar products in other regions and countries.

As a result of customer awareness in the world, quality and confidence became the most important attributes that they want in products. In order to protect regional agricultural and food products, geographical indication, origin and related laws and practices gained more importance in EU in last decade. There are plenty of prestigious agricultural products that are marketed by the agricultural sales cooperatives for many years. Marketing the prestigious and famous agricultural products under their own names with geographical indications will provide significant added value to both cooperatives and the manufacturers. The market shares of prestigious local agricultural products have been increasing in the last decade. This situation is very desirable for producers who grow specialty agricultural products. Increasing the market share of local products is extremely important for farmers and rural development (Ertan, 2010). Geographical indications of natural food products specific to the city should be taken. The acquisition of geographical indications will not only ensure that the products are produced and protected to a good quality standard, but also prevented the different city local ownership of these local products. In addition, products with geographical indication registration will have a great contribution to finding customers in domestic and foreign markets at a good price. Efforts should be made to brand specific geographic products by prioritizing them according to their potential to produce added value and their marketing. It is important to develop strategies to develop, market and support processed derivatives without harming the naturalness of these products (Arslan, 2018).

The fact that the consumers are not conscious enough about organic products and the prices of organic products are higher than conventional products are the main factors that prevent the increase of domestic consumption of organic products. To this end, there is a need to raise awareness of consumers to increase the consumption of organic products. Local organic markets where producers and consumers meet by reducing the number of intermediaries are important in increasing the demand for organic products in the country. Thanks to these markets, consumption of organic products will increase, and cultural interaction between producers and consumers will be ensured and organic products will be recognized by wider environments. In addition, since the use of input will be more effective with improvements in production technology, the production cost will decrease in organic products (Eryılmaz and Kılıç, 2019). Growing the production of organic agricultural products will contribute to the increase in exports.

Although the production cost of medicinal and aromatic plants varieties is low, high prices due to insufficient production affect consumption negatively. In particular, it is becoming a rapidly increasing sector. In order to improve the production of medicinal and aromatic plants, unconscious collection, which is the main problem of collecting from nature, should be prevented and culture of medicinal and aromatic plants should be ensured due to the increase in both domestic and foreign market needs (Mert and Dağıstan, 2016).

Pesticides can cause a number of problems due to unconscious use and improper application. In the solution of the problem, it is thought that it is important to be sensitive in the use of pesticides and to give more weight to the practices and methods in which possible damages are minimized. It is considered important to raise the awareness of producers by making educational extension activities widespread and effective in the unconscious use of pesticides and inadequate implementation of the relevant measures. Countries with an increasing trend of pesticide use continue to import pesticides. More imports mean more foreign currency losses. Providing the need for consumption through domestic facilities can be effective in reducing import expenses. In addition, the use of drugs that will minimize risks in terms of environment, natural balance and human health is also important. In this context, it would be appropriate to support research and development studies for drug production with low risk. At the same time, giving priority to the development of alternative practices to pesticides is important in terms of reducing the risks of medicines (Arslan and Çiçekgil, 2018).

Soon, we will have the opportunity to monitor the whole farm with cloud-connected and unmanned aerial vehicles, such as controlling natural elements such as humidity and temperature, preventing unnecessary use of natural resources. In addition, it will be possible to evaluate the production and analyze all the products and resources in the farm. The internet of things in agriculture will increase in productivity with the spread of technology. What needs to be done is to make smart agriculture easy to use, economical and more accessible to all users (Aytekin et al., 2019).

The agricultural mechanization is the use of machinery and new technologies in planting or planting, watering, fertilizing, protecting plants from diseases and pests, harvesting and many other agricultural activities, which makes plant and animal production less affected by natural disasters. Traditional production methods should be adapted to today's technologies. The increase in welfare that may occur in the world countries can increase the potential of countries to import. In order to be prepared for this situation, we must increase the number of producers in agriculture.

What Processes Should A Standard Field Crops, Fruit and Vegetable Products Global Value Chain Include?

Population growth in the world necessitates an increase in agricultural production. However, since this increase rate is not the same rate, since the number of consumers without production increases, the importance of living in harmony with nature is not understood and human being is faced with nutrition problems. The value chain in agricultural products is a collection of activities that include all processes before and after harvest, that is, the sustainability of agriculture. When we think about contracted agriculture and similar production patterns, we can understand that the first stage contains much earlier than production. Market research, research and development work, product supply contracts with consumer and producer commitments, inputs and supports to farmers are available prior to the start of the production phase in this chain. In the Global Value chain, post-harvest operations include processing, packaging, storage, sale, marketing activities such as advertising to strengthen the brand value, digital marketing and many more. Increasing the value in the value chain should be ensured by highlighting product differences, not by reducing labor. Reduction of costs can be provided increase of production area with high yield, long-lasting varieties with increasing of shelf life, increasing fertilization, irrigation, labor cost reduction, using modern irrigation methods, increasing the state support given to products, reducing costs with the continuity of support given to farmers (Gökkür and Çelik, 2016).

While global competition is increasing, the competition understanding also changes. Production processes, which were previously carried out under a single roof, can now be carried out in more than one place and specialization areas are created in production. Thus, the different stages of the value chain can be deployed in different geographies (Erol, 2015; Gökkür and Çelik, 2016).

The Global Value chain can help businesses to stand out with their product diversity by increasing their competitiveness. The world's population is growing rapidly, and each business can find customers with good planning. World agriculture is interdependent. Considering the changes in yields due to climate changes, and the changes in the harvest dates, there is the potential to be transformed into a competitive system in food. The impossibility of farmers to access the market through production contracts is an issue to be considered. Research The development phase should be one of the first stages of the value chain. Product diversity is customer satisfaction and should be included in the Research Development phase in the value chain. Research and development services will reach the farmers quickly by increasing the communication of research institutes and farmers and demonstrations (Gökkür and Çelik, 2016).

The first condition to enter international markets is to ensure food security. Quality standards put an additional burden on manufacturers. These loads cannot be easily met by small businesses. In addition, standards should be developed not only for the foreign market but also for the domestic market (Alemdar, 2008; Gökkür and Çelik, 2016).

Post-harvest studies are important in storage efficiency. In our country, importance should be given to increase the number of cold stores and to expand the licensed warehousing. By expanding packaging technology throughout the country, the brand value of the products should be strengthened. In the Global Value Chain, all activities are important, and therefore, distinguishing between primary and supportive activities can provide for some important processes to be ignored (Gökkür and Çelik, 2016). Measures should be taken to minimize the losses in agricultural products during and post-harvest storage.

In a standard Field Crops, Fruit and Vegetable Products Global Value Chain should include the following processes (Porter, 1985; Gökkür and Çelik, 2016):

- Research & Development Studies (Early or Late Harvest Date, High Efficiency, High Quality, Shelf Life Long, Different Product Development Stages, Farmer Trainings)
- The Process to Decide on the Farmer's Area to Be Investigated
- Consumers 'and Producers' Procurement of Products (Procurement Activities-Entering Logistic Operations)
- Commitment of the Business Owner, Love of Interest
- Financial Status Inputs to be Provided to the Farmer etc. Advances
- Supply
- Raw Material (Seed, Sapling, Fertilizer, Water) Production Costs
- Packaging Costs
- Infrastructure of the Company (Land, Land Leasing, Land Location, Soil Properties, Irrigation Water Quality, Labor Force Supply (Human Resources Management-Management Infrastructure) Technology Development)
- Production
- Product Type, Quality Characteristics
- Production Quantity

- Harvest and Delivery
- Price
- Payment Time
- Post Harvest Cooling
- Transportation and Marketing
- Distribution Storage
- Packing
- Processing (Outbound logistics)
- Marketing and Sales
- E Trade (Exports, Imports)
- Evaluation of Excess Agricultural Products Produced (Funds Established for Combating Poverty, Evaluation in Canned Food Industry, Internet Oriented Marketing Systems)
- Presenting Different Properties of Products with Correct Branding and Sustainable Demand in Global Markets
- Agricultural Innovation Systems: innovation with research and development activities in all systems from production to marketing

CONCLUSIONS

In many parts of the world, climate change threatens food access and food security. National Food Safety Strategy should be determined. Dependency on food should be reduced to other countries. It is necessary to plan the consumption and food supply of the country together. The yields of the varieties vary according to the regions where they are grown. Production areas in agriculture should be planned taking into account the regions where the yields are high. Planning should be done on the basis of self-sufficiency in agriculture. Production of some products can be increased according to the need. Consumption should be provided as much as possible from domestic production. If the domestic demand cannot be met and there are regions with suitable conditions in terms of cultivation of the imported products, the cultivation of the imported products in the country should be increased with the incentives to be given. Consumers access to food should be facilitated. This will help restrain the price increase in food in the medium term. In places where few agricultural products are grown, alternative products with high profitability can be grown. Our export potential can be increased by growing agricultural products needed by neighboring countries in regions close to the borders of countries. By reducing intermediaries in agriculture, affordable high quality products should be offered to the consumer.

Making arrangements to increase animal supply and meat supply will have positive contributions to increase country welfare.

Since agriculture provides raw materials to the industry sector, the development of the agriculture sector will also improve the industry sector. Sustainable growth occurs with the growth of the industry sector along with agriculture. Instead of growing directly in the industry sector, the growth of the industry sector together with the agriculture sector will have a positive effect on ensuring balance in income distribution. In order to reduce the dependence on imports in agricultural products, plans can be made according to the needs of sectors that provide raw materials from agriculture. By growing the agricultural products necessary for raw materials in areas close to industrial areas, the increase in the speed of conversion of agricultural areas into industrial areas can be slowed down.

A controlled structure is required in the use of herbicides and pesticides. Herbicide and pesticide users should be obliged to provide the seller with the information for which product and for how much area. The seller must also process this information into the herbicide and pesticide control program to be created on the computer. Traceability of agricultural products will positively contribute to achieving price stability in agricultural products.

All the rings of the value chain in agricultural products are responsible for access to food. The traceability of the value chain will have positive effects on the prevention of informality in agriculture. Agricultural products, agricultural lands and agricultural infrastructure should be considered as holistic in every project to be prepared for food traceability.

Yield, quality, harvest time price in agricultural products and the prices it takes in every activity after harvest are the parameters that play a role in shaping the international competitiveness. Every study to be made in order to be the country that invests in other countries in agriculture and evaluates the production potential together with its land assets will serve the welfare of our country. In order to increase the traceability of the food market, "every product grown is a brand" approach should be adopted by the agricultural sector.

The countries of the world should prepare a new production planning in order to ensure food security, taking into account the increase or decrease in the production of climate change and world agricultural products, or the products that will remain at the same level.

Countries should develop varieties with low production costs, high quality and different characteristics. Compulsory agricultural insurance should be made to farmers and the cost of this insurance should be covered by the supports given to agricultural products. A new agricultural management system should be prepared in which the size of agricultural holdings is increased by decreasing the number of parcels.

All things considered the source of digital technologies is information. With the use of digital technologies in agriculture, a successful food marketing management system can be established. In the near future, all activities in agriculture will be managed and monitored. What should be considered here is not to stay away from individual field observations while benefiting from technology. Because agricultural products consist of different varieties, the phenology of all of them is different. Care should be taken to ensure that the information storage capacity of the digital technologies to be used is high. The food marketing management system depends on the modernization of agriculture and the global value chain. The new value chain studies to be created will have positive contributions to the sustainability of agriculture.

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Assessment on the Nutrient Status of Lowland Rice Soil Using Minus One Element Technique (MOET)

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Abstract

Laboratory soil analysis is one of the effective way of knowing the nutrient content of the soil. However, it is expensive and difficult to avail from the government facilities for free laboratory soil analysis. Minus one element technique (MOET) is a friendly and less expensive way of knowing the nutrient status of the soil. This study aimed to determine the nutrient status of the lowland soil in Central Luzon State University (CLSU) rice farm. Minus one element technique (MOET) was used through observation of growing rice (NSIC Rc216) variety planted in a container. The fertilizer formulations considered as the treatments included the following without nitrogen (-N), without phosphorus (-P), without potassium (-K), without sulfur (-S), without copper (-Cu), and without zinc (-Zn). Rice plants receiving complete nutrient elements served as the control. Results revealed that no visible deficiency symptoms in the growing rice except on minus nitrogen and minus sulfur treatments. This result suggested that the soil in CLSU rice farms still have sufficient nutrient elements except on nitrogen and sulfur. Plants in minus N element showed yellowing of the leaves starting at the older leaves and moves along to the middle leaves two weeks after planting. This treatment show less number of tillers and foliage as compared to the treatment receiving complete nutrients. Plants in minus sulfur appears a pale green to pale yellow leaves starting in the younger leaves. Thus, soil in CLSU rice farm needs Nitrogen and Sulfur nutrient elements and need to be addressed.

Keywords: Deficiency symptoms, minus one element technique (MOET), nutrient elements and productive soil

Research article

INTRODUCTION

Rice (*Oryza zativa* L.) is a staple food for nearly half of the world's population, most of which live in developing countries. It occupies one-third of the world's total area planted to cereals and provides 35-60 percent of the calories consumed by 2.7 billion people in Asia. According to Rescalsota, et. al, (2005), one of the major crop production problems that will affect rice yield is the deficiency of important soil nutrients needed by the plant for its growth and development. Moreover, (Sanchez et al. 1997; Shepherd and Soule, 1998) stated that, soil fertility depletion in smallholder farms is the fundamental cause of declining food production. An inadequate supply of one of these important nutrients can cause metabolic disorders in plants (Kirkby and Bergmann, 1992).

To have efficiently supply the needed amount of nutrients to the plants it is necessary to have our soil analyzed for chemical analysis. However, soil analyses are very expensive and farmers seldom have access to soil laboratories and other practical soil testing procedures that could accurately determine their soil nutrient status. Thus, PhilRice developed the Minus One Element Technique (MOET), this is a crop diagnostic tool that determines soil nutrient deficiency under lowland rice condition. Despite the application of appropriate rates of nitrogen (N), phosphorus (P), and potassium (K) fertilizers accompanied with new technologies and management strategies on rice production, yields of most rice farmers are still below the potential yield of improved and high yielding varieties. Multi-nutrient imbalance could be one of the reasons for the gaps in yield.

It is therefore imperative that farmers fully assess the nutritional status of their low-yielding farms. According to (Castillo and Mamaril, 2008) the minus-one element technique (MOET) of diagnosing nutrient limitations of lowland rice soils is one promising technique because it is farmer-friendly, simple, cheap, and sensitive as a good diagnostic tool. Moreover, the basic principle of MOET is based from the "law of the minimum" which states that the level of crop production can be no greater than that allowed by the most limiting of the essential plant growth factors. It is a biological technique wherein the plant itself extracts the elements from the soil and the amount they absorb from the soil is reflected by its relative growth. Thus, the test can show farmers the limiting nutrient(s) that needs to be applied. Results from MOET test are obtained faster; hence farmers can make the necessary adjustment and amelioration to their standing crop. The test is likewise more economical than the soil chemical analysis method.

This study was conducted to determine the nutrient deficiency symptoms of lowland rice (NSIC Rc216) variety grown in a container with soils from CLSU rice farm using minus one element technique.

MATERIAL and METHOD

The first step in doing the MOET is to buy the kit from PhilRice, Maligaya, Munoz, Nueva, Ecija, Philippines. Aside from the fertilizer formulation, the kit also contained seven plastic bags and the instruction booklet. The fertilizer formulations served as the treatments for the study. These formulations are complete fertilizer, minus nitrogen (N), minus phosphorous (P), minus potassium (K), minus sulfur (S), minus zinc (Zn), minus copper (Cu). The soil samples collected from the CLSU rice production area in Sawmill farm, Munoz, Nueva Ecija. Organic debris that was not well decomposed was removed leaving uniform soil samples. Soil samples were submerged in water for one week to soften and pulverize the soil medium.

The soil samples were placed in plastic container (25cm wide x 35cm long) with 10 kg wet soil thoroughly mixed with the fertilizer formulation. A 20 day old seedlings (NSIC Rc216) rice variety was transplanted at 2 seedlings per pot. The rice plants were taken cared and the water supply was maintained in the pots until the experiment was terminated. The vegetative parts of rice plants were cut, weighed and placed in the oven 70 ^{0}C until constant weight was attained. Agronomic and dry matter yield (%) were gathered such as; plant height (cm) and number of tillers per pot were recorded weekly starting 14 days from transplanting until the experiment was terminated at 50 days after planting. The growth of the plants in the pots under minus certain elements such as (-P, -K, -S, -Cu and –Zn) was compared to that of plants receiving the complete nutrient formulation. Observations on plant growth patterns and the occurrence of deficiency symptoms were noted until the experiment was terminated.

RESULTS and DISCUSSION

To determine the basis for the deficiency of specific elements in the lowland soil, agronomic data from the rice plants receiving complete elements was multiplied to 80% as shown in Table 1. If the value from the agronomic data is below than the amount computed (80%) of the value from the plants receiving complete elements, it means that the element is deficient. Plants in minus N and minus S elements exhibited nutrient deficiency symptoms which include few number of tillers, yellowing of the leaves, thinner stems and lower fresh and dry weights of biomass as compared to plants receiving complete nutrients. These results suggested that the soil tested still had sufficient amount of some nutrient elements except on the nitrogen and sulfur.

Table 1. Growth parameters (49 DAP) of NSIC Rc216 rice variety under the minus one element technique (MOET).

Treatment	Final Number of tillers plant^{-1}	Final Plant height (cm)	Biomass fresh weight (g)	Biomass dry weight (g)	Moisture content (%)	Dry matter yield (%)
Complete	28	60.22	76.45	18.75	75.47	24
-N	10	60.24	23.90	5.60	76.57	23
-P	25	65.51	73.00	17.05	76.64	23
-K	23	65.50	49.00	16.80	77.96	22
-S	13	61.65	30.55	6.55	78.56	21
-Cu	26	64.52	61.15	15.90	77.27	23
-Zn	26	61.00	63.80	15.00	76.49	24
80% value from the complete elements	28 x 0.80 = **22.48**	60.22 x 0.80 = **48.16**	76.45 x 0.80 = **61.16 g**	18.75 x 0.80 = **15.0 g**		24 x 0.80 =**19.0**

On the other hand, red numbers in Table 1 signify the deficiency of nutrient elements in the said parameters. Nitrogen and Sulfur are the 2 elements that are insufficient thus, it reduces the number of tillers per plant and the weight of fresh and dry biomass. However, the dry matter yield produced by the plants applied with minus elements (N, -P, -K, -S, -Cu and –Zn) showed a comparable weights (g) to the plants applied with complete fertilizer.

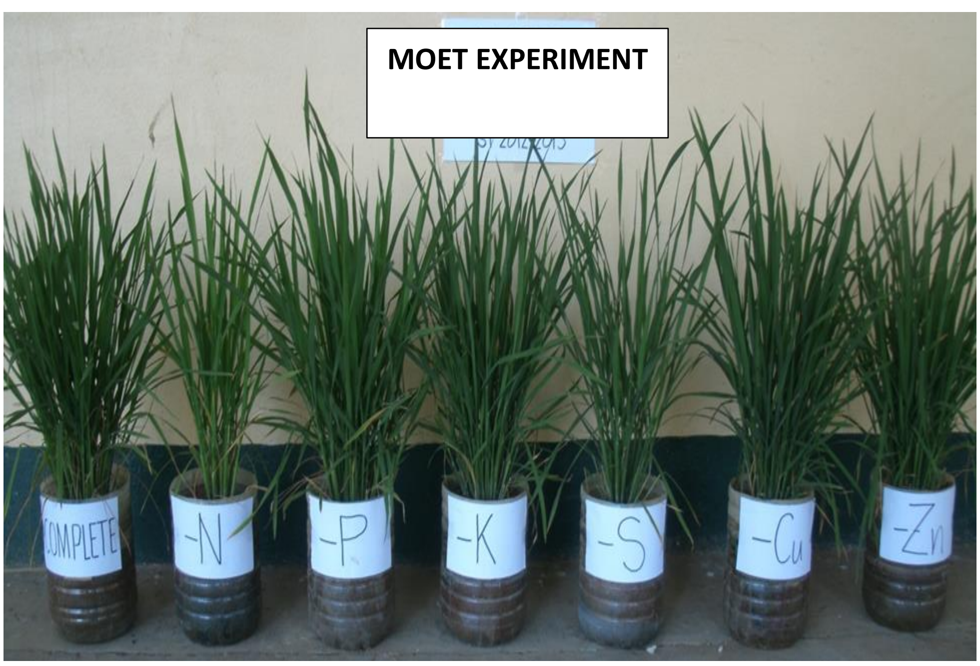

Figure 1. Fertilizer formulations used in the study

Visual Description of Deficiency Symptoms Observed in the Rice Plants

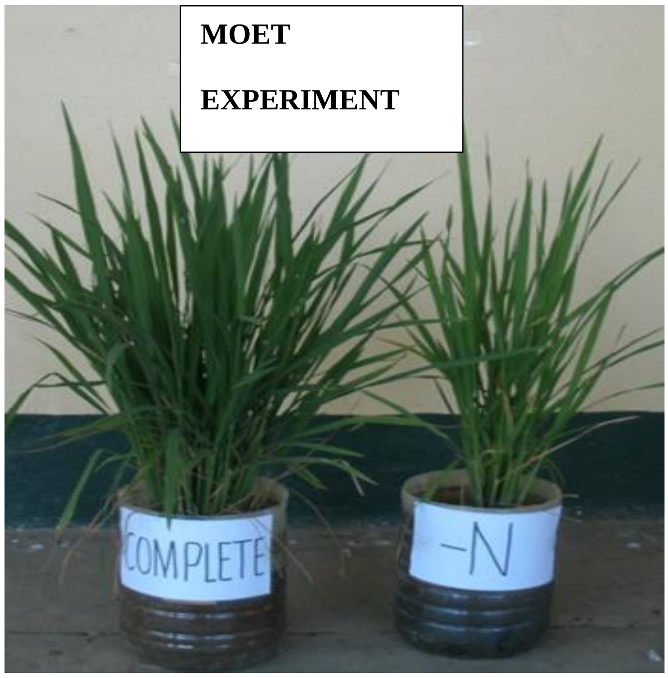

Figure 2. Observation comparing the complete (check) and the – N element

Nitrogen deficiency symptoms usually affect starting in older leaves and to younger leaves as severe deficiency progresses. The symptom is very evident in the plant shoots which exhibited by stunted growth and generally smaller leaf sizes as compared to the plants receiving complete nutrient elements. In this study, the minus N element showed a yellowing of the leaves starting at the older leaves and moves along to the middle leaves two weeks after planting. These treatments showed less number of tillers and thin foliage as compared to the treatment receiving complete nutrients. The deficiency symptoms revealed by the rice plant signals that the soil in sawmill rice production area is now deficient in this particular elements (N and S). Thus, the soil can`t be able to supply nutrients needed by the rice plant.

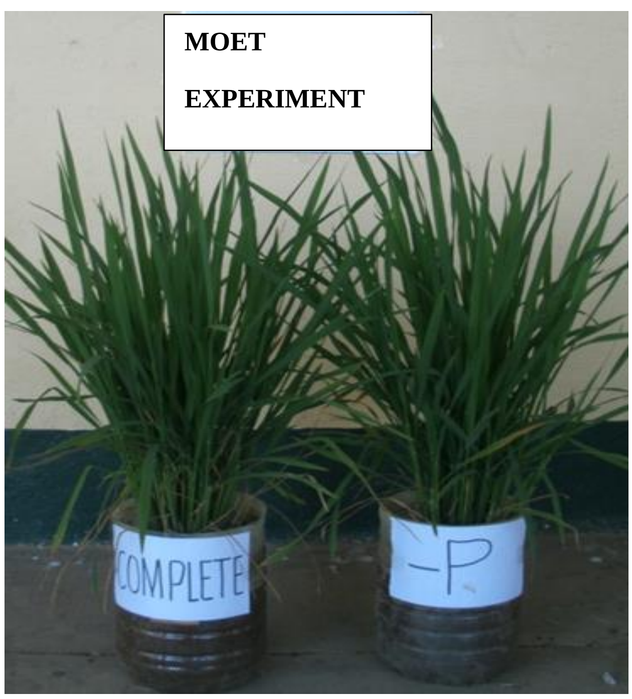

Figure 3. Observation comparing the complete (check) and the - P

The general symptoms of rice that deficient in phosphorus, the leaves are dark green with erect leaves. There was also an interveinal spotting of drying up of basal leaves, localized yellowing of older leaves with interveinal chlorosis. Also, there was intense brown coloration of the tips or edges of the plant leaves and reduced leaf area as compared to the treatment receiving the complete nutrients. However, in this study, the above deficiency symptoms did not occur significantly, only a very slight drying of the older leaves along the tips and edges of greener and erect young leaves. This result suggested that the soil tested in Sawmill area revealed that the P element sill sufficient for rice growth and development.

Figure 4. Observation comparing the complete (check) and the – K

The appearance of potassium deficiency symptoms occur mainly on the older leaves and the general symptoms exhibited by rice leaves include brown necrotic lesions or spots which developed within the chlorotic zones of the leaves, severe yellow chlorosis in the interveinal zones and in extreme cases the leaves will turn whitish or completely lost its green coloration . However, in this study the visible deficiency symptoms did not appear, this result suggests that the potassium content in the area tested was still sufficient.

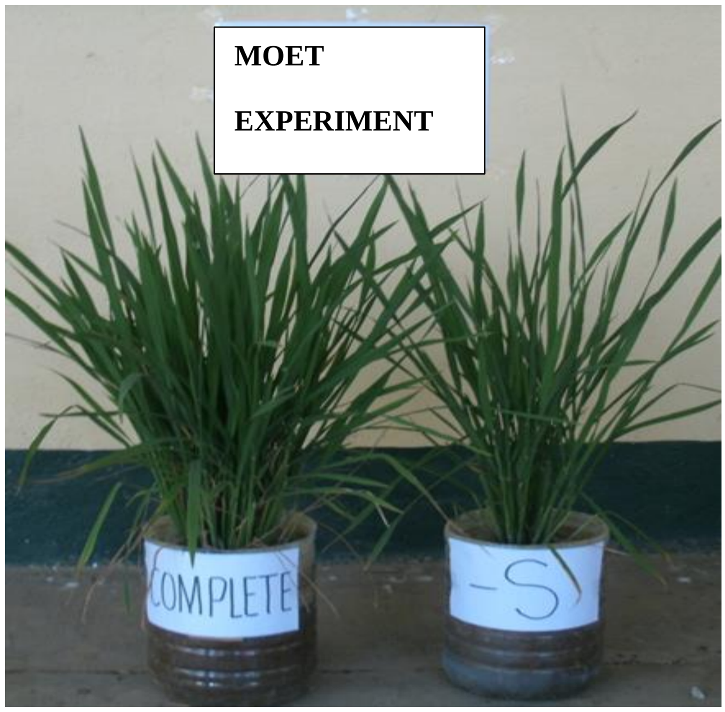

Figure 5. Observation comparing the complete (check) and the – S

The general description of the sulfur deficiency symptoms is comparable to the nitrogen deficient soil. It appears a uniform pale green to yellow leaf but the difference is sulfur deficiency starts in the new leaves whereas nitrogen deficiency starts in the older leaves. In this study, treatment minus sulfur appears yellow leaves with less number of tillers with thinner leaves.

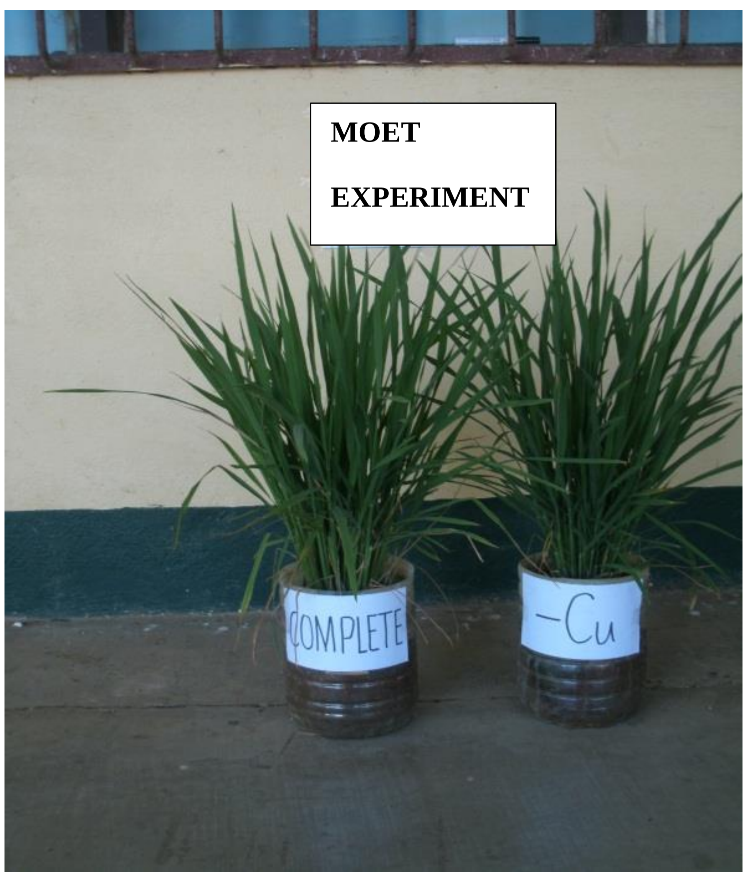

Figure 6. Observation comparing the complete (check) and the - Cu

The appearance of potassium deficiency symptoms occur mainly on the older leaves and the general symptoms exhibited by rice leaves include marginal chlorosis of young leaves sometimes necrotic tips (if severe), twig dieback, sometimes necrotic and brown spots over leaf surface thus, reduces the growth and yields. However, in this study a slight yellowing of leaves observed at the late stage (3 weeks after planting) thus, reduces its fresh and dry biomass production.

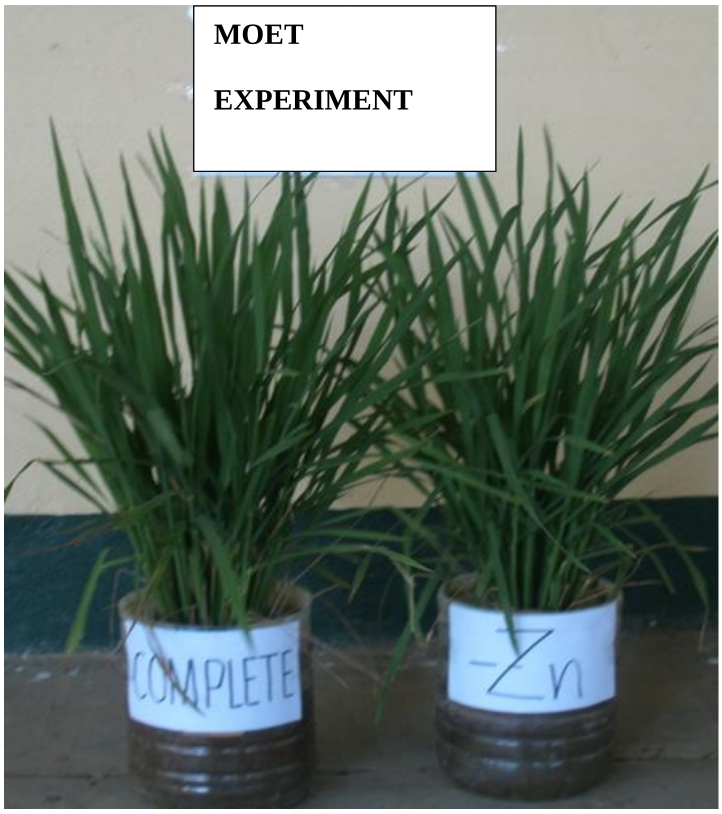

Figure 7. Observation comparing the complete (check) and the –Zn

The general symptoms of zinc deficiency were also chlorosis and necrosis of the younger leaves. As zinc stimulates the production of auxin, a characteristics symptom that the plant becomes dense with small leaves and short distance internodes. However, these deficiency symptoms did not appear in our experiment. The actual appearance shown is comparable to the treatment receiving complete nutrients. This result suggested that the soil tested still have sufficient amount of zinc element.

CONCLUSION

MOET is a farmer`s friendly technology in assessing the nutrient status of the soil as manifested in the growth of the plant, it is very practical, easy to follow and less expensive. Likewise, identification of visible symptoms of nutrient deficiency can be a useful tool to guide farmers and researchers in managing rice plant for optimum production. Moreover, soil in the rice farm of CLSU revealed that it has still enough amounts of secondary macronutrient elements except on nitrogen and sulfur.

RECOMMENDATION

Before planting the field, assessment of the nutritional status of the soil should be done through a practical and low cost process the minus one element technique (MOET). For more accurate results, at least 2 replications will be recommended in this technique. Also studies on the different level of N and S will be conducted in this area.

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