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IMPACT OF ORGANIC AND MINERAL FERTILIZER ON SOME PHYSICAL AND MECHANICAL CHARACTERISTICS OF POTATO TUBERS DURING STORAGE PERIOD

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ABSTRACT: This study was concerned with potato tubers in the experimental farm of Faculty of Agriculture, Menoufia University during the season 2020. The main objective of this work is to study the effect of with organic fertilizers comparing with using mineral fertilizers on some physical and mechanical properties of potato tubers during storage period. The experiments were conducted on two varieties of potatoes, (Diamond and Arizona). Two types of fertilizers were used in the cultivation of potato tubers, which were organic fertilizers and mineral fertilizers. The experimental treatments were divided into five treatments as follows: Control (without fertilizers) (T1) - 100% mineral fertilizer (T2) - 50% mineral fertilizer and 50% organic fertilizer (T3) - 25% mineral fertilizer and 75% organic fertilizer (T4) - 100% organic fertilizer (T5). The potato tubers stored at 4°C for 45 days. The reported results showed that, the best physical characteristics of potato tuber were found with fertilization treatment of (50% organic 50% mineral). Significantly found best among all treatments successive growth stages in term of maximum average weight (114 g), Shape index (331.30 %) and coefficient of friction with wood after 45 days of storage (.561). Where, the highest average value potato tubers firmness treatment (75% organic 25% mineral) is (114N).

Key words: Physical characteristics, potato tubers, fertilizer types.

INTRODUCTION

Potato is one of the World's most important food crops in terms of human consumption, particularly in Egypt. It is grown in more developing countries than any other tuber crop. It is a tuber, not a root, and belongs to the morning-glory family. Many parts of the plant are edible, including leaves, tubers, and vines, and varieties exist with a wide range of skin and flesh color, from white to yellow to orange and deep purple. Potato belongs to family Solanaceae, and it is one of the important vegetables in the world and in Egypt (Potato yield was 5215.905 thousand tons, with an area of 178608 hectares in Egypt (FAO, 2020). The potato is the third most consumed crop globally behind rice and wheat, according Kammlade (2015). Modern agriculture degrades soil health and affects the environment, while alternative agriculture, such as organic farming, regenerates the ecosystem, making it possible to keep the soil alive and the water unpolluted. In organic farming, the non-use of chemical inputs combined with good farming practices protects sustainably the environment against pollution. The control of fertilization, especially nitrogen fertilization, represents a key to this preservation (Harraq *et al.*, 2022).

Organic potato farming minimizes the application of pesticides and inorganic fertilizers. Manure, green manure, and compost are applied to replace or minimize the use of artificial inorganic fertilizers. Organic fertilizer is needed quite a lot, so it should be supplied from other regions. Organic fertilizer is beneficial to plant growth and tuber formation of potatoes, improving soil structure so it facilitates roots penetration into the soil, so that the tuber development is better. The effect of organic fertilizer application on potato yield are very significant (Sugiarto *et al.*, 2013).

Physical characteristics of agricultural products are the most important parameters for the designing of grading, conveying, processing, and packaging systems. Among these physical characteristics, mass, volume, projected area, and

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center of gravity are the most important in sizing systems (Malcolm *et al.*, 1986). Other important parameters are width, length, and thickness (Mohsenin 1987).

Ahmed *et al.* (2019), reported that tuber size significantly increased in organic manure added plot compared to control. It means organic manures have effect for tuber production of potato. The small size tuber in control plant might be due to lower tuber growth rate. Furthermore, the effect of Rangpur Dinajpur Rural Service (RDRS) and Northern organic fertilizer on tuber size was statistically nonsignificant with each other and these two organic fertilizers influenced lesser on tuber production than chicken manure (CM) and cow dung (CD). The differential response among four organic fertilizers for tuber size might be due to the fact that compost chicken and cow dung manure has capacity to release more nutrients than RDRS and Northern fertilizers.

Adeyeye *et al.* (2016), found that there was no significant difference between the weight of tuber and tuber yield in the study, but application of urea produced higher mean value of (4000kg/ha) of tuber yield followed by poultry and cow dung and the least mean value from the control application (0kg/ha) of fertilizers.

Németh and Bonn (2004), mentioned that the demands of the consumers with regard to food quality are growing. The environmental compatibility of a cultivation technique is considered an additional quality criterion. Firmness and texture of agricultural products are suitable criteria for the evaluation of their quality. Pendulum, penetrometer, and plate tests are used to assess potato tubers on the basis of their mechanical properties.

Abedi *et al.* (2019), regarded that, the effect of the class and interaction between it and the surface type on the rolling resistance of the tuber was significant. The abrasion surface and variety significantly affected both the static and dynamic coefficient of friction, as well as, among all the abrasion surfaces, the court fabric had the highest and the galvanized sheet had the lowest value of the static coefficients of friction, the latter one causes less risk of damage for the potato. Regarding the rolling resistance of the tubers, it can be found that commonly for two varieties in the first two classes, this property was the highest and lowest on the galvanized iron sheet and the rubber and the wood surface, respectively.

Wibowo *et al.*, (2021), mentioned that the brightness level of Atlantic potato tuber flour produced was relatively high, ranged from 67.9 to 76.38. The higher the L-value means the brighter the color of the flour. The brightness level of the flour is influenced by the color of the potato tubers, Atlantic potato tubers have a white color so that it can produce a relatively high brightness level of flour. Moreover, this characteristic also contributes to the color of the product. The difference in tuber color is caused by differences in the carotene pigment content in each variety.

Due to limited of published information on the effect of organic and mineral fertilizers on the physical and engineering properties of potato tuber.

MATERIALS AND METHODS

1. Potato tubers

Two varieties of potato tubers (Diamond - Arizona) were planted in an area of 12 m^2, which were divided into lines of 60 cm width and 90m length, and the planting distances were 25 cm. Potato tubers were grown in the summer season 2020 and stored at a temperature of 4 °C. Five fertilizer treatments were used during cultivation potato plant.

2. Fertilizer treatment

Two types of fertilizer were used in cultivation of potato tuber (organic – mineral), in five treatments as follows: T1, Control (without fertilizers), T2, 100% mineral, T3, 50% mineral and 50% organic , T4, 25% mineral and 75% organic, T5, 100% organic.

The organic fertilizer was a compost of mixture of animal manure and plant residual produced by Shora Co, a rate of (8 tons/Feddan). The mineral fertilizer for potato was ammonium nitrate with a concentration of 33% a rate of (360 kg/ Feddan). The component analysis of the used organic fertilizer (compost) as shown in Table (1).

3. Experimental site description

Samples were randomly collected from experimental soil before sowing at depth of 0-30cm to estimate the mechanical and chemical properties of soil as presented in Table (2) for experimental farm of Agricultural Faculty.

4. Physical and mechanical measurements of potato tubers

a. Weight of potato tuber

The digital balance was used in the present investigation, it was used for determining the weight of particles and large samples of potato tubers. The specification of the digital balance was as follows: Source of manufacture: Germany; Type: GP4102; Power source: Electricity; Maximum measurement, Kg: 5 kg; Accuracy, g.: ±0.01 g.

Table (1): Physical and chemical characteristics of used compost (organic fertilizer) in the study.

Component	Unit	Values
Weight of m^3	Kg	650
Moisture content	%	25
pH (1:10)		7.44
EC (1:10)	dS/m	8.13
Total N	%	1.6
Ammonium N	ppm	136
Nitrate N	ppm	85
Organic matter	%	38.92
Organic Carbon	%	22.57
Ash	%	61.07
C:N ratio		14:1
Total phosphor	%	1.02
Total Ca	%	0.83

Table (2): Soil mechanical and chemical properties of experimental site during season 2020 for experimental farm of Agricultural Faculty.

Texture	O.M. (%)	*EC (dS/m)	pH	Available N (ppm)	Available P (ppm)	Available K (ppm)	Soluble ions meq. / L in soil						
							HCO_3^-	CL^-	SO_4^{2-}	K^+	Na^+	Ca^{++}	Mg^{++}
Clay loam	1.72	0.68	7.63	31.02	11.53	283.21	0.4	0.33	4.66	2.66	2.16	0.43	0.33

*EC Electrical conductivity in soil 1:2.5 soil/water suspension
OM organic material percentage

b. Dimensions of potato tuber

A random sample of five tubers from each variety in each group was selected. The dimensions of major (L), intermediate (W), and minor (T), diameter of all particles in the sample, which means length, width, and thickness respectively, were measured using digital caliber.

Electronic digital caliper Vernier. An ideal tool digital Vernier caliper for a broad range of industrial and automotive applications made of hardened stainless steel. Internal, external and height dimensions can be easily and accurately measured by a linear capacitive measuring system. Zero setting in any position with a small locking thumb screw which locks the jaws in place. With
easy to read large display handy conversion chart at the back.

c. Geometric main diameter of potato tuber

The obtained data of samples were studied in terms of geometric mean diameter (D_g), percent of roundness of samples (R %) and sphericity (S%), for individual potato tuber. The geometric mean diameter, D_g is given by Sreenarayana *et al.* (1985) as:

$D_g = (LWT)^{1/3}$ …………………...(1).

d. Volume of potato tuber

One volume graduated Nessler cylinder was used in the present investigation; it was used for measuring the volume of samples submersed in solution of sodium nitrite.

e. Shape index (SI) of potato tuber

The SI for each potato cultivar was calculated using the equation given by Singh *et al.* (2004):

$SI = \frac{L^2}{WT} \times 100$ …………………………...(2).

According to the SI, potato tubers were characterized as round (SI = 100-160), oval (SI = 161-240), and long (SI = 241-340), respectively, and for each SI group, 5 tubers from each cultivar were characterized (Singh *et al.* 2004).

f. Projected area of potato tuber

The projected area of tuber was measured by placing it under a transparent paper and using planimeter to measure the area of shadow.

g. Surface area of potato tuber

Surface area was defined as the total area over outside of the tuber. The surface area was measured by wrapping aluminum foil around the seed and then cutting the foil into small pieces. These pieces were then passed through an area meter to find the area of the foil, which represented the surface area of the tuber. The area meter was measured only the apparent area of foil submitted and was not affected by creases in the foil. (Essa and Gamea, 2003).

According to Mohsenin (1987), surface area, can be expressed as follows:

$S_{a.c} = \pi D_g^{\,2}$ ………………………………..(3).

h. Roundness of potato tuber

According to Mohsenin (1987), the degree of roundness can be expressed as equation (4).

$R = \frac{A_P}{A_C}$ ……………………………………(4).

Where A_P: the largest projected area,
A_C : the smallest circumscribing circle

i. Sphericity of potato tuber

According to Mohsenin (1987), the degree of sphericity can be expressed as equation:

$S = \frac{(LWT)^{1/3}}{L}$ ……………………………...(5).

Where L is fruit or tuber length, W width, and T thickness.

j. Coefficient of friction of potato tuber

Potato tuber friction angle was measured for each treatment on three surfaces (rubber, wood, and galvanized steel) using a manual measuring device. Tubers samples were placed in a tray over the tested surface, At the operating, the tested surface, which has the tubers sample, the device plate, which the tested surface and, tuber and sample placed on it was tilted up around its side pivot, the angle of frication was recorded when 75% of the tubers reached the bottom on the device. The static coefficient of friction for the mentioned samples was obtained from the equation (6). The friction angle of the seed samples was an average of five replications.

According to Singh and Gowswami (1996), static coefficient of friction (μ) was calculated as the following formula:

$\mu = \tan \Phi$……………………………..…(6).

Where:

Φ = The angle of tilt.

The device was designed and fabricated in the Agricultural and Biosystems Engineering department, Faculty of Agricultural, Menoufia University, with dimensions 14 x 31.5 cm, according to Abdallah (2005).

k. Firmness of potato tuber

The device is used to measure the firmness and penetration of the potato tubers in N. The follows are the specification of this device: Source of manufacture: Effe- Gi, Ravenna, Italy; Type: MT; Force: manual; Measuring range, Kg: 1-11kg; Accuracy, Kg: 0.1 kg; Readout: gauge.

The device was used to measure the firmness and penetration of the potato tubers. Firmness was measured using a digital penetrometer (model FHT-1122 hardness tester CT3, China), fitted with a 5 mm probe. The maximum force necessary to penetrate 3.5 mm into the pulp was recorded and expressed in Newton (N). Firmness was measured in each cucumber fruit and potato tube at each storage period and fertilizing treatment according to Elsisi *et al.* (2020).

l. Color index of potato tuber

The total color difference (ΔE)

$$\Delta E = \sqrt{\Delta(L)^2 + \Delta(a)^2 + \Delta(b)^2} \text{ ……………(7).}$$

The lightness L, a and b values. L value refers to lightness of the color of the sample fruit and ranges from black = 0 to white = 100.

m. Chemical analysis of potato tuber

Chemical analysis was conducted in the central laboratory at the Faculty of Agriculture, Menoufia University, for samples of potato tubers from each treatment to determine sugar, carbohydrates, protein, and ash.

5. Statistical analysis

Data were computerized and analyzed according to the following model by SPSS Program (2004). Also, significant differences among means were detected by Duncan (1955).

Program (2004). Also, significant differences among means were detected by Duncan (1955).

RESULTS AND DISCUSSIONS

1. Weight of potato tubers

Fig. (1) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the average weight of potato tubers was recorded at 50% organic and 50% mineral treatment (114.00±32.98, g) for fresh diamond potato tubers, and the highest value of the average weight of potato tubers were at the same treatment (111.15±32.15, g), after 45 days of storage. While the highest value of the average weight of potato tubers were at 50% organic and 50% mineral treatment (105.77±15.69, g) for diamond potato tubers.

From the results, the highest decrease in weight due to storage period was 7.3% for 50% organic and 50% mineral in diamond and the lowest decreased was 6.1% for control treatment in Arizona.

The results showed significant differences in the average weight of potato tubers affected by the potato tuber variety at $P \leq 0.05$, while there were no significant differences in the effect of both the type of fertilization and storage period on the weight of potato tubers, while there were significant differences in the interaction between the potato tuber variety and the type of fertilization at $P \leq 0.05$. The results also showed that there were no significant differences in the interaction between the potato tuber variety, the type of fertilization and the storage period in the average weight of potato tubers.

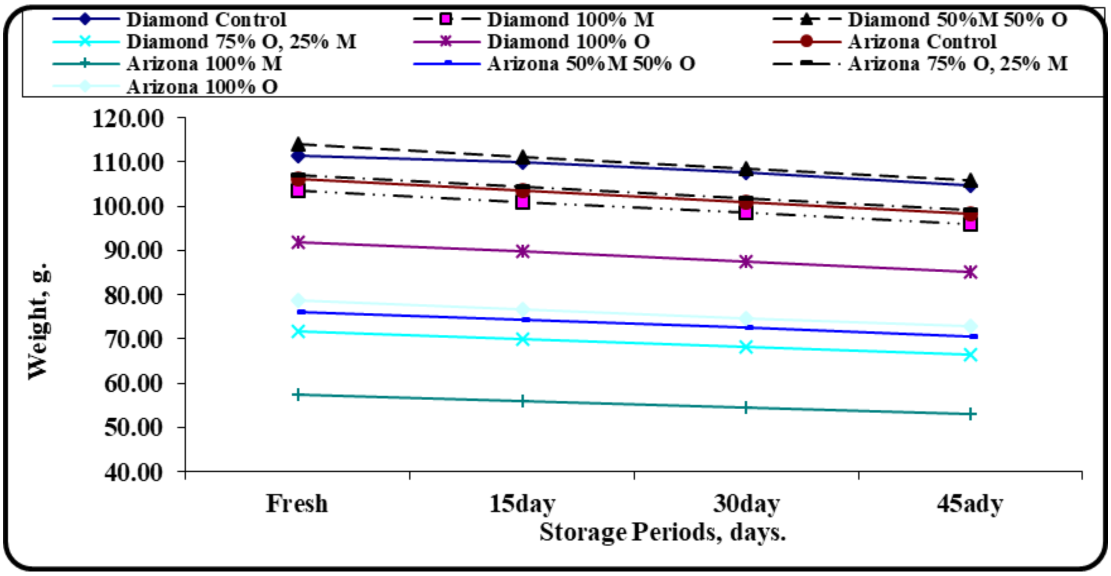

Fig (1): Average weight (g) of potato tubers as affected by variety, type of fertlization and storage period.

Results showed that there were significant and positive correlations between potato tuber weight and potato tuber length, width, thickness, projected area, volume and 1cm slice firmness at $P \leq 0.01$, and at $P \leq 0.05$ with surface area in the first experiment.

This result was in agreement with the finding of Al-Hmoudi *et al.* (2015).

2. Dimensions of potato tubers

Figs. (2), (3), (4) and (5) illustrated that the effect of both fertilization and storage period on two varieties of potato tubers .The result showed that, the highest value of the average length of potato tubers was recorded at 50% organic 50% mineral treatment (66.51±5.48, mm) for fresh diamond potato tubers, the highest value of the average width of potato tubers was recorded at 75% organic 25% mineral treatment (50.40±7.66, mm) for fresh Arizona potato tubers, the highest value of the average thickness of potato tubers was recorded at 50% organic 50% mineral treatment (38.65±3.05, mm) for fresh diamond potato tubers, the highest value of the average geometric main diameter of potato tubers was recorded at 100% mineral treatment (48.21±3.17, mm) for fresh diamond potato tubers, and the highest value of the average length of potato tubers were at the 50% organic 50% mineral treatment (65.95±5.40, mm), after 45 days of storage the highest value of the average length of potato tubers were at 50% organic 50% mineral treatment (64.36±5.21, mm) for diamond potato tubers, the highest value of the average width of potato tubers were at 75% organic 25% mineral treatment (48.17±7.32, mm) for Arizona potato tubers, the highest value of the average thickness of potato tubers were at 50% organic 50% mineral treatment (37.26±2.84, mm) for diamond potato tubers, the highest value of the average geometric main diameter of potato tubers were at 100% mineral treatment (45.69±3.00, mm) for diamond potato tubers.

The results showed significant differences in the average length, width, thickness and geometric main diameter of potato tubers affected by the potato tuber variety at $P \leq 0.01$, while there were no significant differences in the effect of both the type of fertilization and storage period on the length and thickness of potato tubers, but there were significant differences in width at $P \leq 0.05$, and geometric main diameter at $P \leq 0.01$. While there was the interaction between the potato tuber variety and the type of fertilization at P≤0.01 for length, width, thickness, and geometric main diameter of potato tubers. The results also showed that there were significant differences in the interaction between the potato tuber variety, the type of fertilization and the storage period in the average length of potato tubers at P≤0.05 and P≤0.01 for width, thickness, and geometric main diameter of potato tubers.

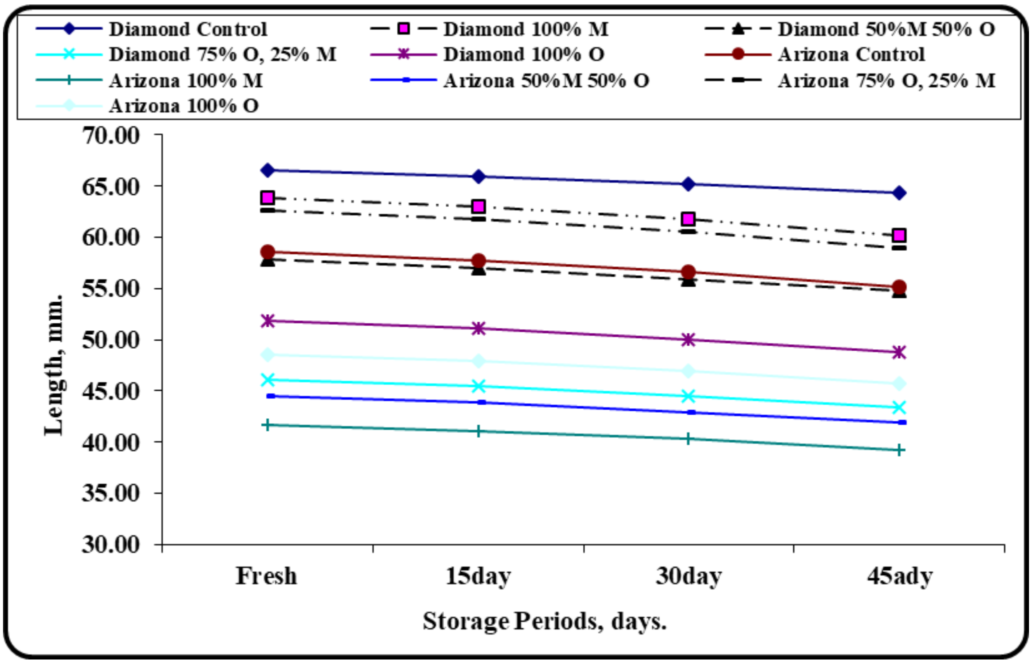

Fig (2): Average length (mm) of potato tubers as affected by variety, type of fertlization and storage period

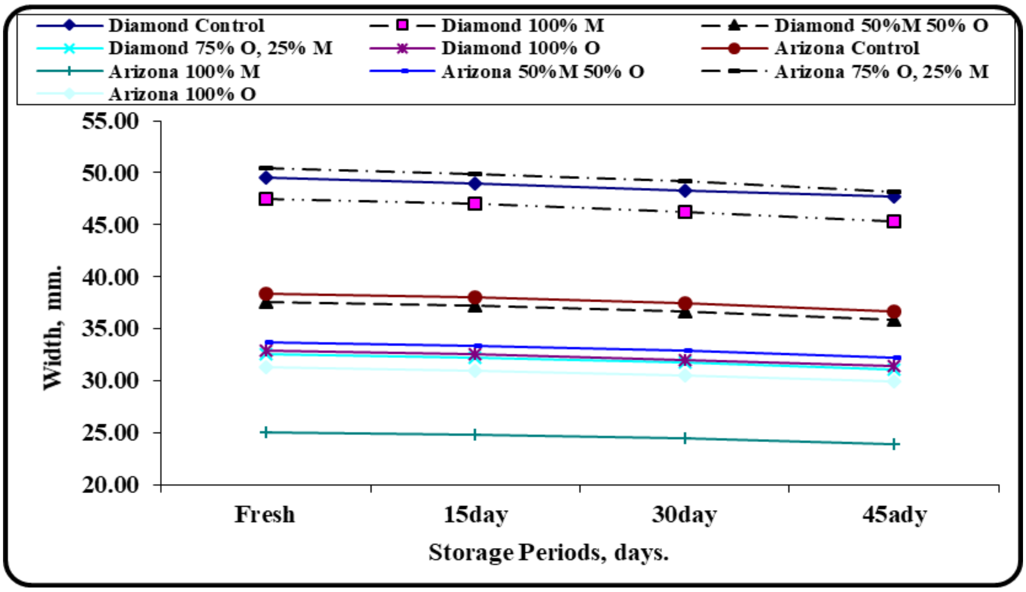

Fig (3): Average width (mm) of potato tubers as affected by variety, type of fertlization and storage period.

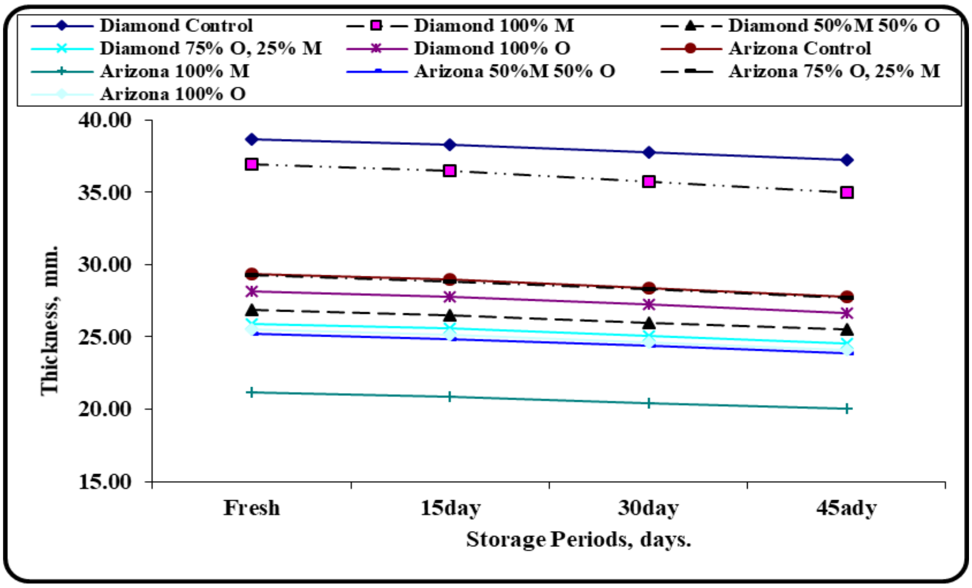

Fig (4): Average thickness (mm) potato tubers as affected by variety, type of fertlization and storage period.

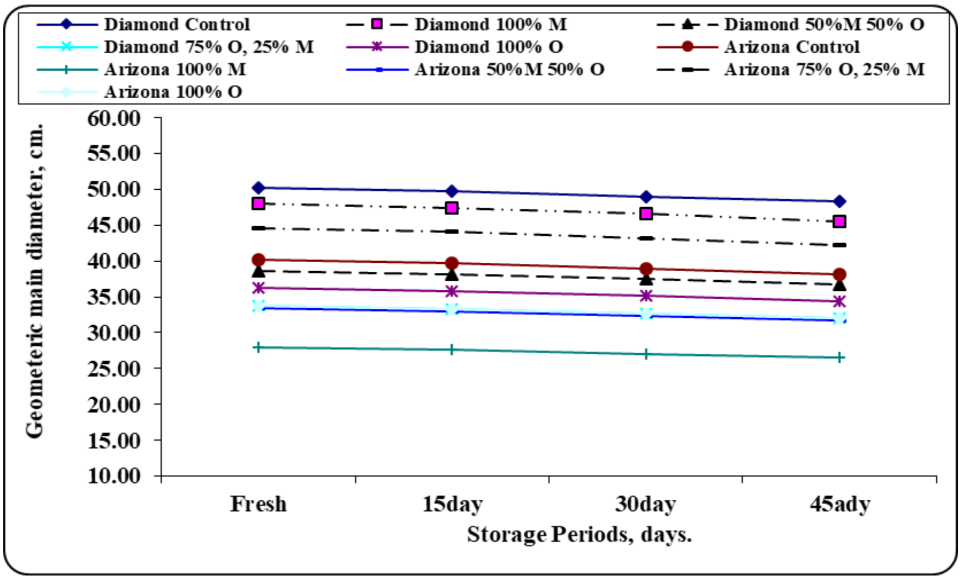

Fig (5): Average geometric main diameter (mm) of potato tubers as affected by variety, type of fertlization and storage period.

From the results, the highest decrease in length due to storage period was 5.8% and the lowest decreased was 3.2%, And the highest decreased in width due to storage period was 4.4% and the lowest decreased was 3.8%.

Results showed that there were significant and positive correlations between potato tuber length and potato tuber width, thickness, projected area, volume, and surface area at $P \leq 0.01$, and at $P \leq 0.05$ with roundness and 1cm slice firmness. The statistical analysis showed that there were significant and positive correlations between potato tuber width and potato tuber thickness, projected area, roundness, sphericity, and volume at $P \leq 0.01$, and at $P \leq 0.05$

with surface area. Also, results showed that there were significant and positive correlations between potato tuber width and potato tuber projected area, volume, surface area and firmness at $P \leq 0.01$, and at $P \leq 0.05$ with slice 1, 1.5 and 2cm firmness. results showed that there were significant and positive correlations between potato tuber thickness and potato tuber projected area, sphericity, volume, and surface area at $P \leq 0.01$, and at $P \leq 0.05$ with roundness in experiment.

This result was in agreement with the finding of Kang (2004), Singh *et al.* (2017), and Law 3. Volume, projected area, and surface area of potato tubers and Osaigbovo (2018).

3. Volume, projected area, and surface area of potato tubers

Figs. (6), (7), (8) and (9) illustrated that the effect of both fertilization and storage period on two varieties of potato tubers .The result showed that, the highest value of the average volume of potato tubers was recorded at 50% organic 50% mineral treatment (74.60±11.80, cm^3) for fresh diamond potato tubers, the highest value of the average projected area of potato tubers was recorded at 75% organic 25% mineral treatment (28.84±6.90, cm^2) for fresh Arizona potato tubers, the highest value of the average measured surface area of potato tubers was recorded at 50% organic 50% mineral treatment (546.95±27.01, cm^2) for fresh diamond potato tubers, and the highest value of the average calculated surface area of potato tubers was recorded at 100% mineral treatment (72.98±0.43, cm^2) for fresh diamond potato tubers, after 45 days of storage the highest value of the average volume of potato tubers were at 50% organic 50% mineral treatment (67.00±10.50, cm^3) for diamond potato tubers, the highest value of the average projected area of potato tubers were at 50% organic 50% mineral treatment (27.66±4.21, cm^2) for diamond potato tubers, the highest value of the average measured surface area of potato tubers were at 50% organic 50% mineral treatment (141.16±16.50, cm^2) for diamond potato tubers, the highest value of the average calculated surface area of potato tubers were at 50% organic 50% mineral treatment (65.55±0.39, cm^2) for diamond potato tubers.

The results showed significant differences in the average volume, projected area and surface area of potato tubers affected by the potato tuber variety at $P \leq 0.01$, while there were no significant differences in the effect of fertilization on volume, projected area and surface area of potato tubers, but there were significant differences in width at $P \leq 0.05$ for surface area as affected by storage period. The results also showed that there were significant differences in the interaction between the potato tuber variety, the type of fertilization and the storage period in the average volume, projected area, and surface area of potato tubers at $P \leq 0.01$.

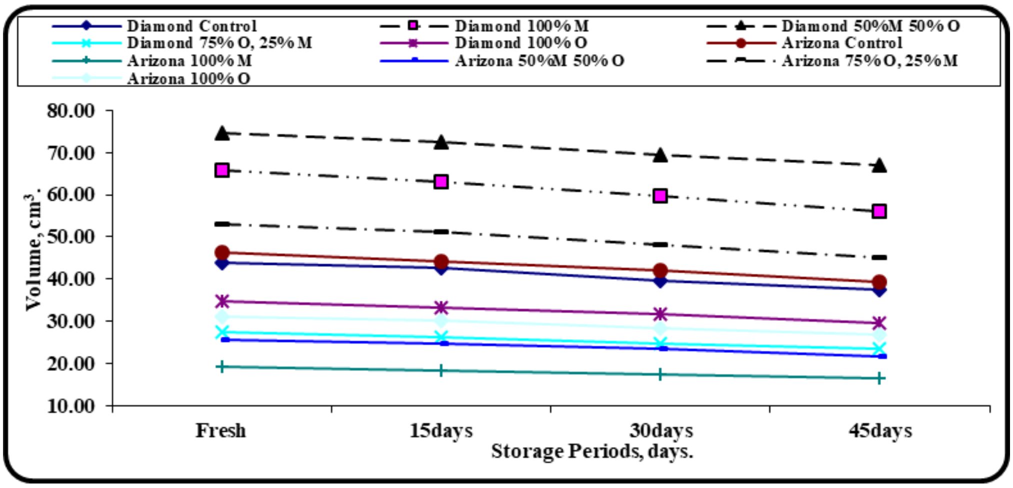

Fig (6): Average volume (cm^3) of potato tubers as affected by variety, type of fertlization and storage period.

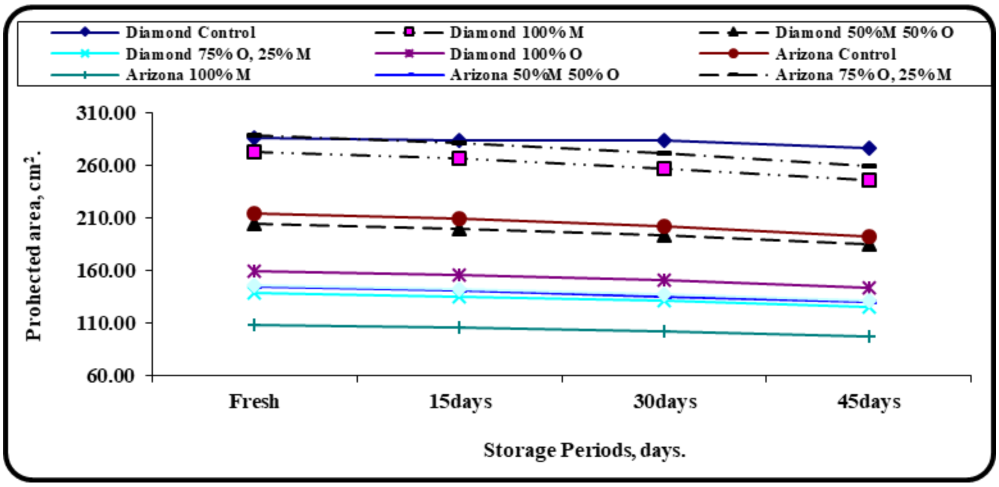

Fig (7): Average projected area (cm^2) of potato tubers as affected by variety, type of fertlization and storage period.

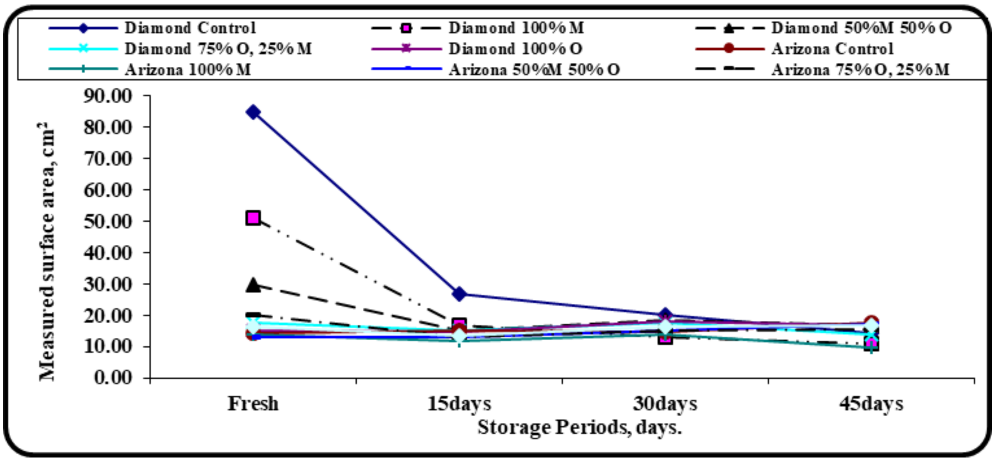

Fig (8): Average measured surface area (cm^2) of potato tubers as affected by variety, type of fertlization and storage period.

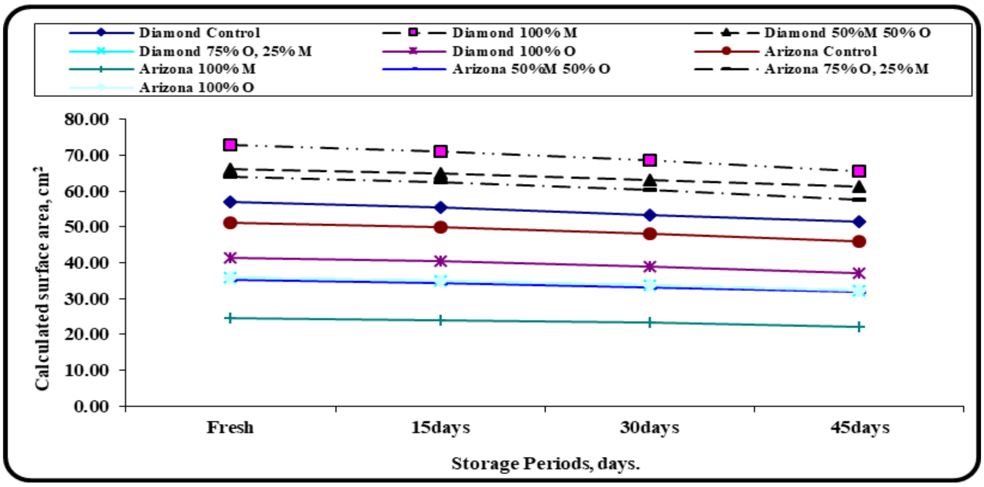

Fig (9): Average calculated surface area (cm^2) of potato tubers as affected by variety, type of fertlization and storage period.

4. Roundness, sphericity, and shape index of potato tubers

Figs. (10) and (11) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the average roundness of potato tubers was recorded at 75% organic and 25% mineral treatment (89.89±9.43, %) for fresh Arizona potato tubers, the highest value of the average sphericity of potato tubers was recorded at 50% organic 50% mineral treatment (75.89±3.97, %) for fresh Arizona potato tubers, after 45 days of storage the highest value of the average roundness of potato tubers were at 75% organic 25% mineral treatment (91.23±9.57, %) for Arizona potato tubers, the highest value of the average projected area of potato tubers were at 50% organic 50% mineral treatment (76.38±3.99, %) for Arizona potato tubers.

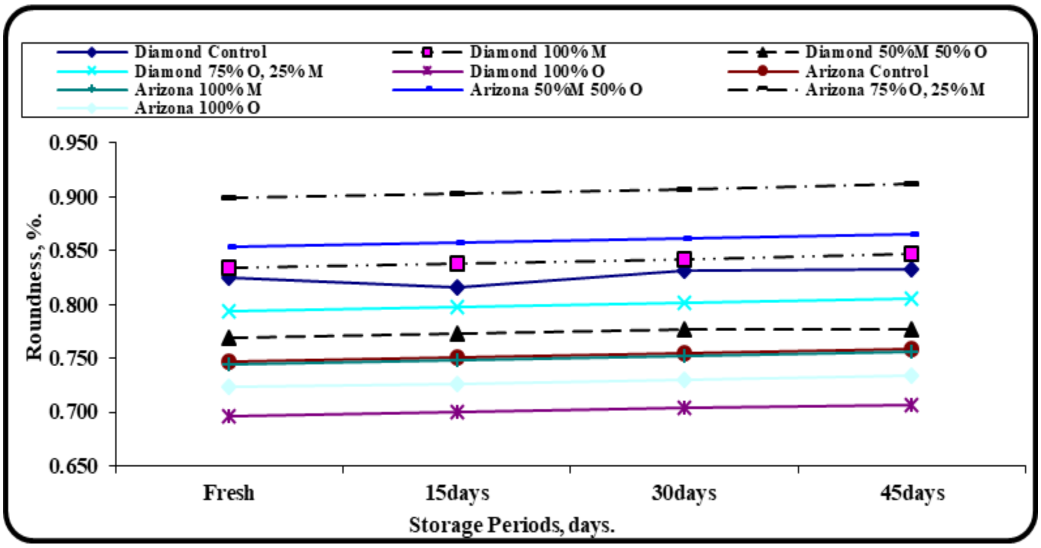

Fig (10): Average roundness (%) of potato tubers as affected by variety, type of fertlization and storage period.

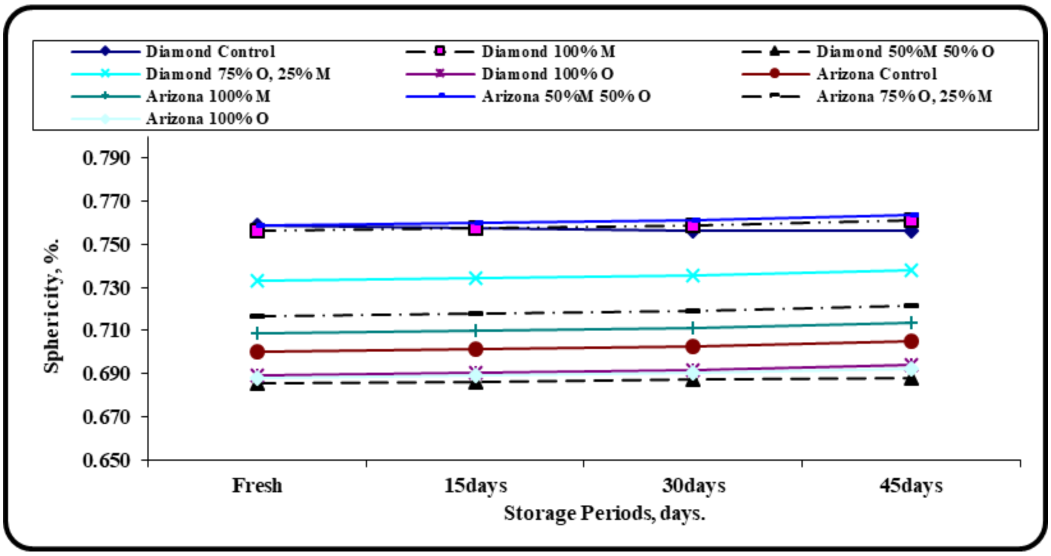

Fig (11): Average sphericity (%) of potato tubers as affected by variety, type of fertlization and storage period.

Fig. (12) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the average shape index of potato tubers was recorded at 50% organic 50% mineral treatment (331.30±43.53, %) for fresh diamond potato tubers, after 45 days of storage the highest value of the average shape index of potato tubers was recorded at 50% organic 50% mineral treatment (327.62±37.31%) for diamond potato tubers.

From results of potato tuber shape index appeared oval shape (161-240) in diamond with control and 100% mineral treatments and Arizona with 50% mineral and 50% organic treatment, whereas, all other treatments appeared long shape (241-340), according to (Singh *et al.* 2004).

The results showed highly significant differences in the average roundness and sphericity of potato tubers affected by the potato tuber variety at P≤0.01, and there were highly significant differences in the effect of fertilization on roundness, sphericity and shape index of potato tubers at P≤0.01, but there were non-significant differences in roundness and sphericity as affected by storage period. The results also showed that there were non-significant differences in the interaction between the potato tuber variety, the type of fertilization and the storage period in the average roundness and sphericity, but there were highly significant differences at P≤0.01in shape index.

Results showed that there were significant and negative correlations between potato tuber shape index SI and potato tuber roundness, sphericity, and volume at P≤0.01, and at P≤0.05 with coefficient of friction with stainless steel CFS.

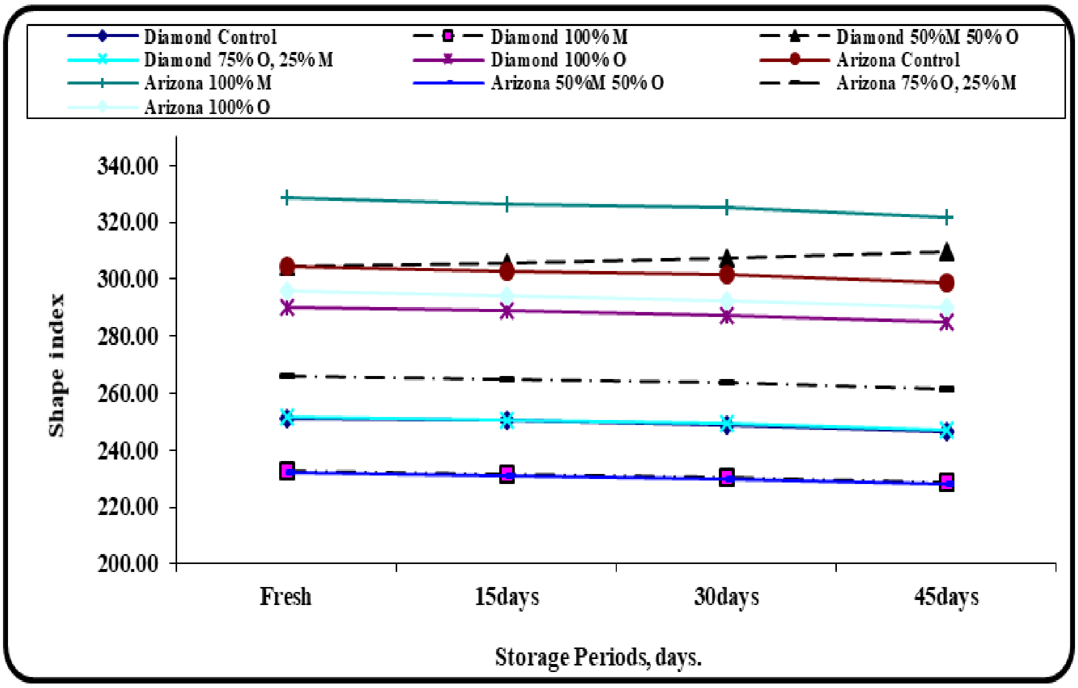

Fig (12): Average shape index (%) of potato tubers as affected by variety, type of fertlization and storage period.

5. Coefficient of friction with rubber, wood, and galvanized steel of potato tubers

Fig. (13) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the average coefficient of fraction with rubber of potato tubers was recorded at control treatment (0.587±0.042) for fresh Arizona potato tubers, after 45 days of storage the highest value of the average coefficient of fraction with rubber of potato tubers was recorded at control treatment (0.600±0.049) for Arizona potato tubers.

Fig. (14) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the average coefficient of fraction with wood of potato tubers was recorded at 50% organic and 50% mineral treatment (0.504±0.028) for fresh Arizona potato tubers, after 45 days of storage the highest value of the average coefficient of fraction with wood of potato tubers was recorded at 50% organic and 50% mineral treatment (0.561±0.021) for diamond potato tubers.

Fig. (15) illustrated that the effect of both fertilization and storage period on two varieties of potato tubers .The result showed that, the highest value of the average coefficient of fraction with galvanized steel of potato tubers was recorded at 75% organic and 25% mineral treatment (0.408±0.027) for fresh diamond potato tubers, after 45 days of storage the highest value of the average coefficient of fraction with galvanized steel of potato tubers was recorded at 75% organic and 25% mineral treatment (0.423±0.038) for diamond potato tubers.

The results showed non-signification differences in the average coefficient of friction with rubber, wood and galvanized steel of potato tubers affected by the potato tuber variety, types of fertilization and storage periods. The results also showed that there were non-signification differences in the interaction between the potato tuber variety, the type of fertilization and the storage period in the average coefficient of friction with rubber, wood, and galvanized steel. The result was in agreement with the finding of Abedi *et al.* (2019).

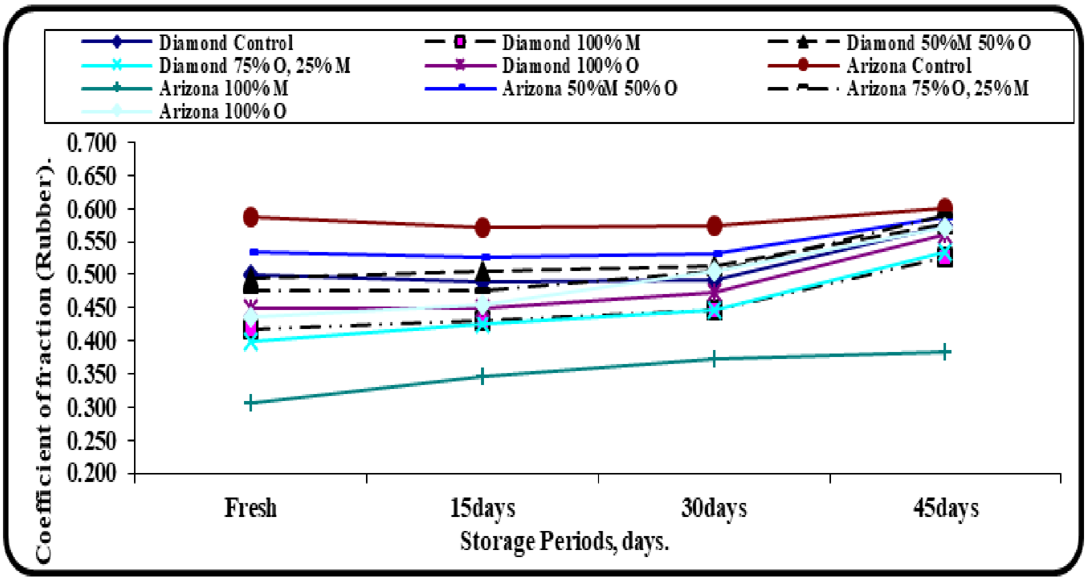

Fig. (13): Average coefficient of fraction with rubber of potato tubers as affected by variety, type of fertlization and storage period.

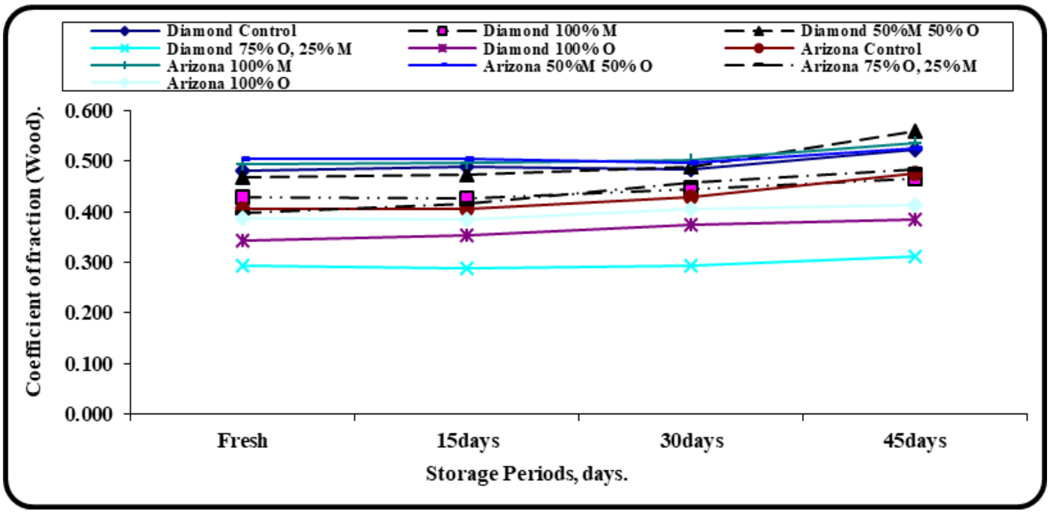

Fig. (14): Average coefficient of fraction with wood of potato tubers as affected by variety, type of fertlization and storage period.

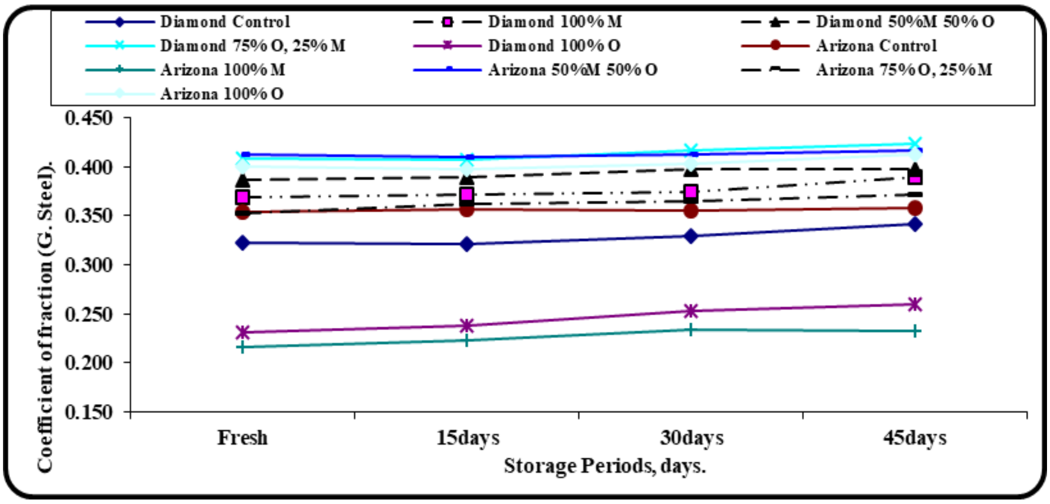

Fig. (15): Average coefficient of fraction with galvanized steel of potato tubers as affected by variety, type of fertlization and storage period.

6. Both of inside and outside color index potato tubers

Fig. (16) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the of inside color index of potato tubers was recorded at 50% organic and 50% mineral treatment (1376.0±1.48) for fresh diamond potato tubers, after 45 days of storage the highest value inside color index of potato tubers was recorded at 75% organic and 25% mineral treatment (1423.3±1.48) for Arizona potato tubers.

Fig. (17) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the of outside color index of potato tubers was recorded at 100% mineral treatment (10631.6±265.38) for fresh diamond potato tubers, after 45 days of storage the highest value outside color index of potato tubers was recorded at 100% mineral treatment (10827.5±1265.38) for diamond potato tubers.

The results showed highly significant differences in the inside color index of potato tubers as affected by the potato tuber variety, types of fertilization and storage periods at

P≤0.01. The results also showed that there were highly significant differences in the interaction between the potato tuber variety, the type of fertilization and the storage period inside color index of potato tubers at P≤0.01. But there were non-signification differences in the outside color index of potato tubers as affected by the types of fertilization and storage periods and its interaction, whereas there were highly significant differences in the interaction between the potato tuber variety at P≤0.01.

The result was in agreement with the finding of Wibowo *et al.*, (2021) they mentioned that the difference in tuber color is caused by differences in the carotene pigment content in each variety.

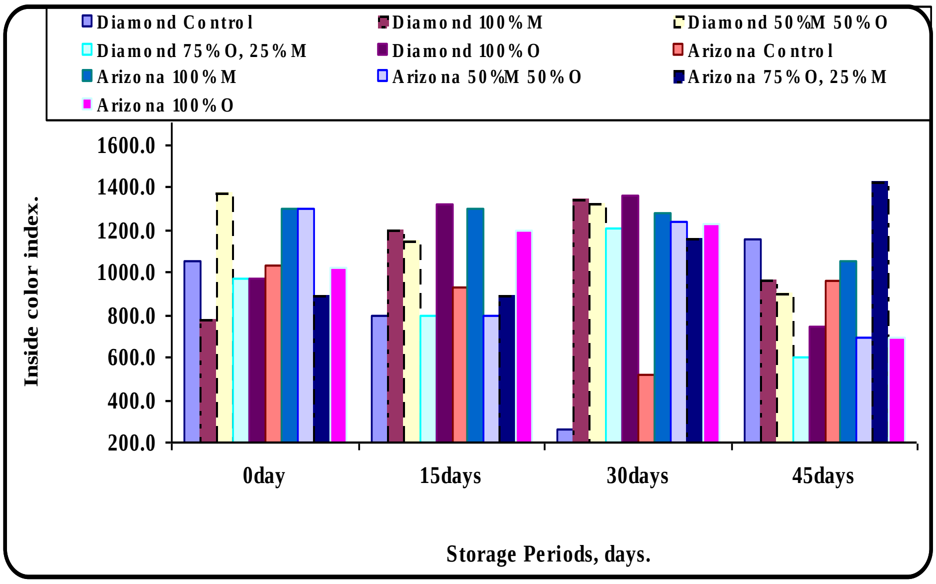

Fig. (16): Inside color index of potato tubers as affected by variety, type of fertlization and storage period.

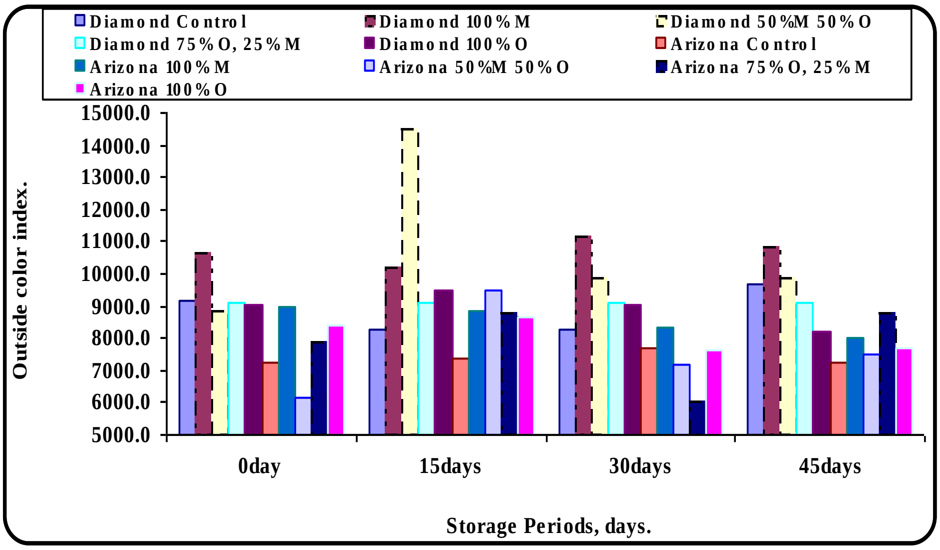

Fig. (17): Outside color index of potato tubers as affected by variety, type of fertlization and storage period.

7. Firmness of potato tubers

Fig. (18) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the of potato tubers firmness was recorded at 75% organic and 25% mineral treatment (114.60±0.24, N) for fresh diamond potato tubers, after 45 days of storage the highest value of potato tubers firmness was recorded at 75% organic and 25% mineral treatment (100.45±0.24, N) for diamond potato tubers.

Fig. (19) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the of potato tubers slices 1cm firmness was recorded at 75% organic and 25% mineral treatment (114.60±0.24, N) for fresh diamond potato tubers, after 45 days of storage the highest value of potato tubers slices 1cm firmness was recorded at 75% organic and 25% mineral treatment (100.45±0.24, N) for Arizona potato tubers.

Fig. (20) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the of potato tubers slices 1.5cm firmness was recorded at 75% organic and 25% mineral treatment (115.60±0.13, N) for fresh diamond potato tubers, after 45 days of storage the highest value of potato tubers slices 1.5cm firmness was recorded at 75% organic and 25% mineral treatment (89.60±0.27, N) for diamond potato tubers.

Fig. (21) illustrated the effect of both fertilization and storage period on two varieties of potato tubers. The result showed that, the highest value of the of potato tubers slices 2cm firmness was recorded at 50% organic and 50% mineral treatment (114.30±0.40, N) for fresh diamond potato tubers, after 45 days of storage the highest value of potato tubers slices 2cm firmness was recorded at 50% organic and 50% mineral treatment (103.70±0.31, N) for Arizona potato tubers.

The results showed highly significant differences in the of potato tubers firmness and firmness of slice 1, 1.5 and 2cm thickness as affected by the potato tuber variety, types of fertilization and storage periods at $P \leq 0.01$. The results also showed that there were highly significant differences in the interaction between the potato tuber variety, the type of fertilization and the storage period potato tubers firmness and firmness of slice 1, 1.5 and 2cm thickness at $P \leq 0.01$.

From results, 100% mineral treatment effected firmness. The result was in agreement with finding of Allela *et al.* (2022).

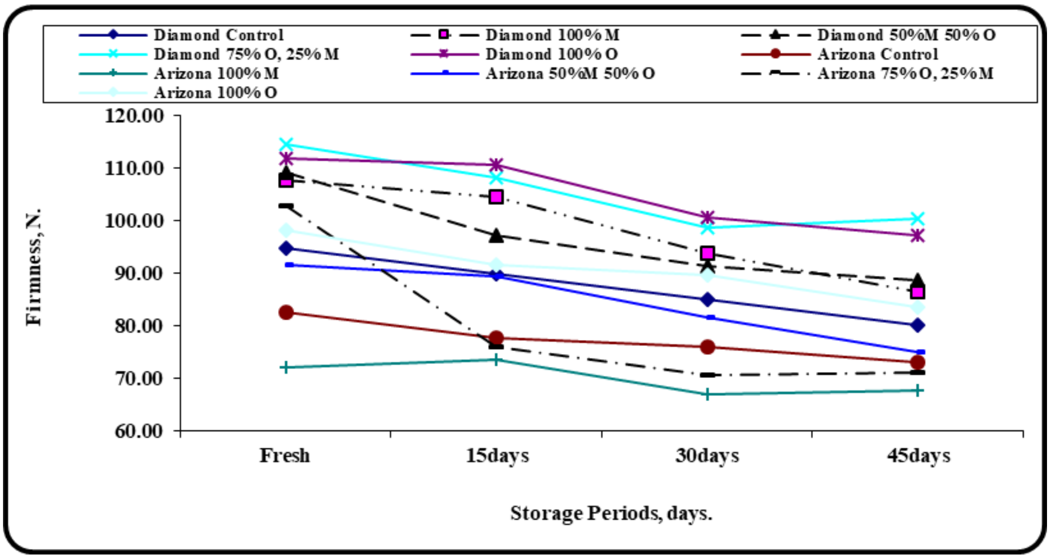

Fig. (18): Firmness of potato tubers as affected by variety, type of fertlization and storage period.

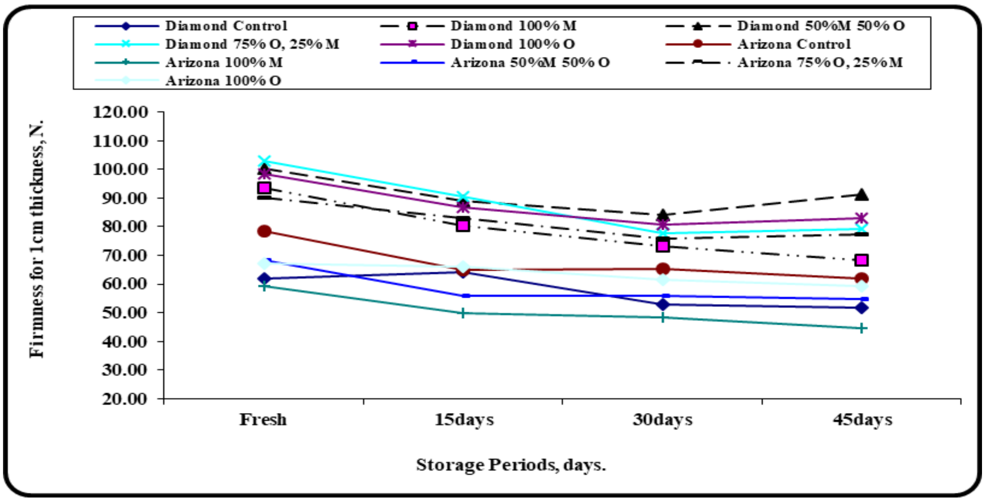

Fig. (19): Firmness for 1cm thickness of potato tubers as affected by variety, type of fertlization and storage period.

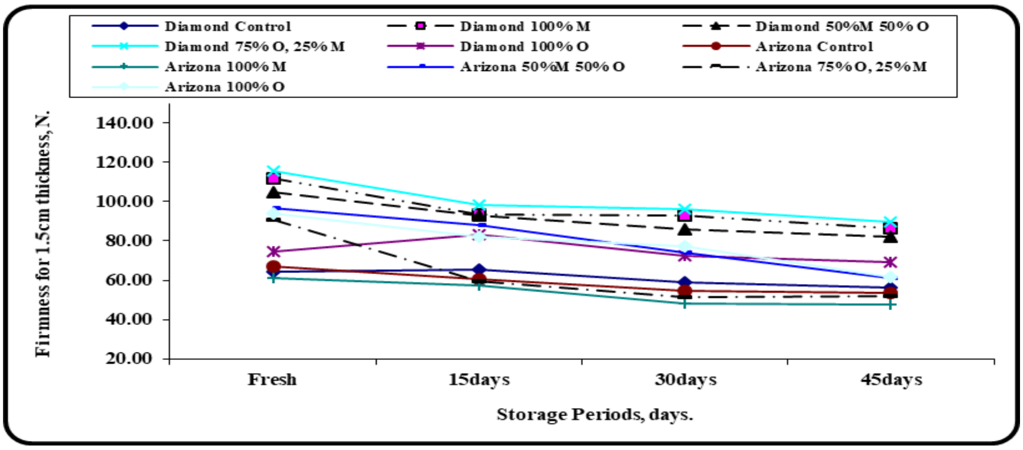

Fig. (20): Firmness for 1.5cm thickness of potato tubers as affected by variety, type of fertlization and storage period.

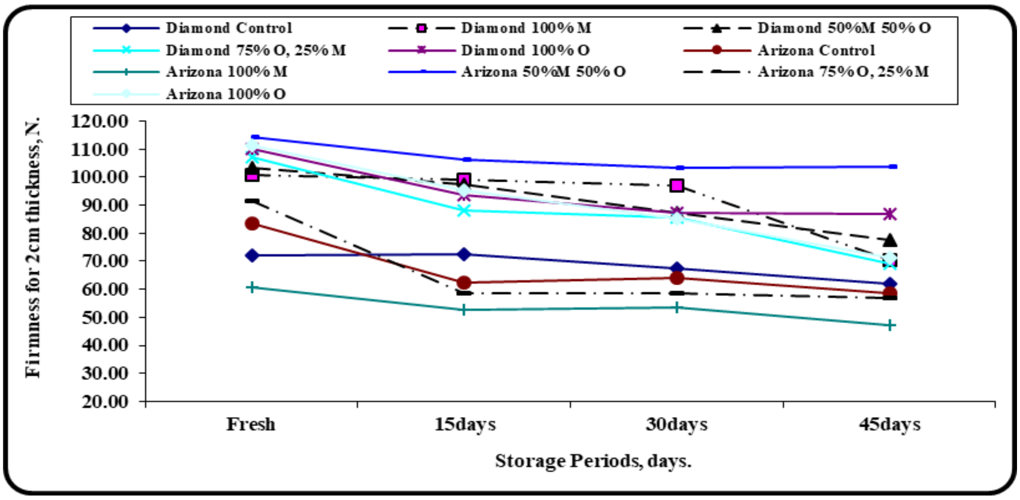

Fig. (21): Firmness for 2cm thickness of potato tubers as affected by variety, type of fertlization and storage period.

8. Chemical analysis of potato tubers as affected by storage periods

8.1. Sugar content

Fig. (22) illustrated the effect of both varieties and storage period on sugar content of potato tubers, the highest value of the of sugar content of potato tubers was recorded (0.506±0.011, mg/g) for diamond potato tubers after 45 days of storage. But the lowest value of the sugar content of potato tubers was recorded (0.323±0.028, mg/g) for fresh diamond potato tubers.

The results showed nonsignificant differences in sugar content of potato tubers as affected by the potato tuber variety. The results also showed that there were highly significant differences in the interaction between the potato tuber variety, and the storage period on sugar content of potato tubers at $P \leq 0.01$. And there were highly significant differences in sugar content of potato tubers as affected by storage periods at $P \leq 0.01$. The results also showed that there were highly significant differences in the interaction between the potato tuber variety, and the storage period on sugar content of potato tubers at $P \leq 0.01$.

results showed that there were significant and negative correlations between potato tuber sugar content and potato tuber carbohydrates, protein, and ash at $P \leq 0.01$ in the experiment.

This result seemed to agree with the finding of Mirdad (2010), who concerned the sugars content, the best interaction effect that gave the lowest value of this parameter was the combination among cultivar Diamont and application of organic manure.

8.2. Carbohydrates content

Fig. (23) illustrated the effect of both varieties and storage period on Carbohydrates content of potato tubers. The result showed that the highest value of the of Carbohydrates content of potato tubers was recorded (1.638±0.100, mg/g) for fresh diamond potato tubers. But the lowest value of Carbohydrates content of potato tubers was recorded (0.752±0.015, mg/g) for Arizona potato tubers.

The results showed significant differences in Carbohydrates content of potato tubers as affected by the potato tuber variety at $P \leq 0.05$. But there were highly significant differences in Carbohydrates content of potato tubers as affected by storage periods at $P \leq 0.01$. The results also showed that there were highly significant differences in the interaction between the potato tuber variety, and the storage period on Carbohydrates content of potato tubers at $P \leq 0.01$.

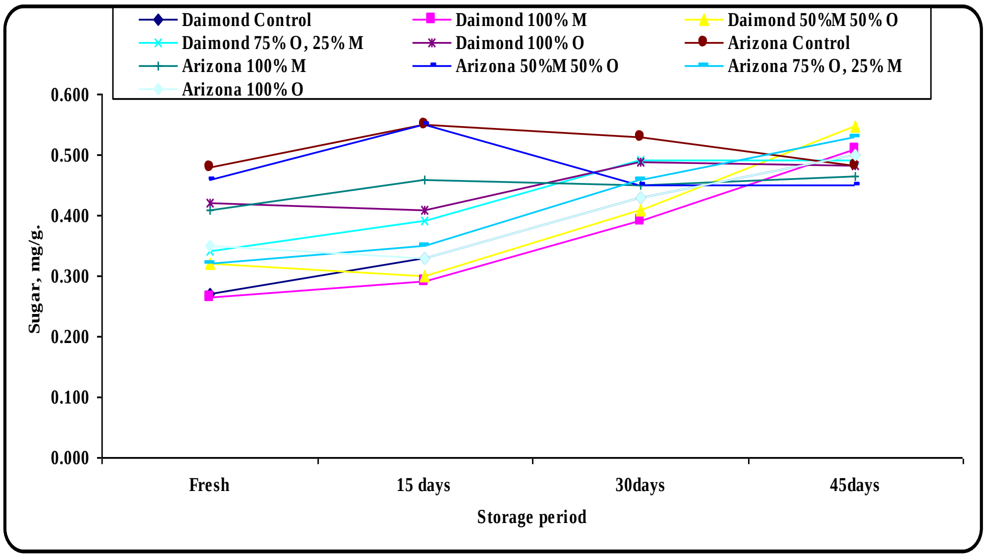

Fig. (22): Content of suger (mg/g) of potato tubers as affected by variety, storage period.

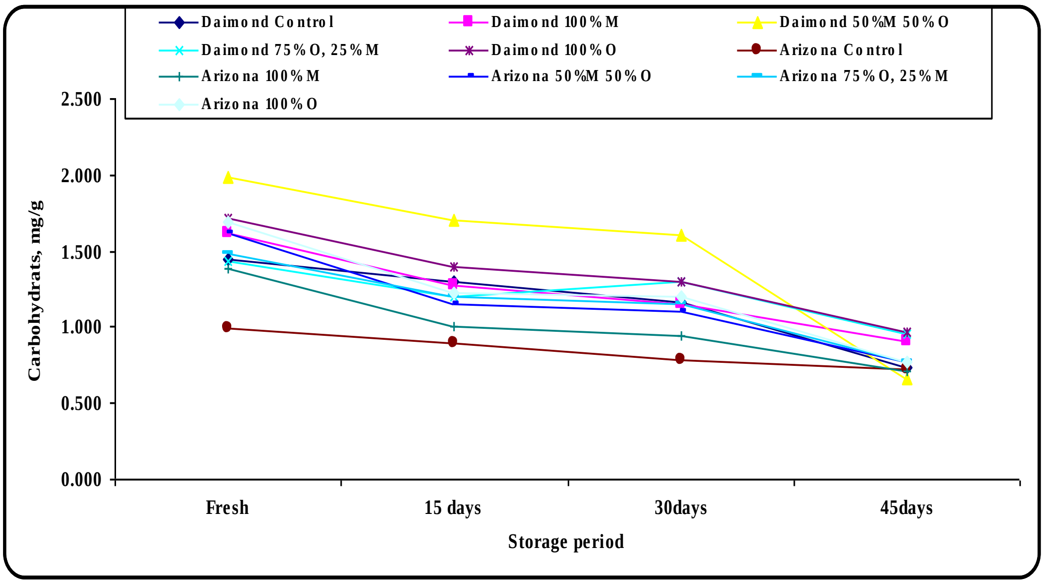

Fig (23): Content of carbohydrates(mg/g) of potato tubers as affected by variety, storage period.

This result seemed to agree with the finding of Mirdad (2010), who found that the highest value of carbohydrates% was given by the interaction among the cultivar Nicola combined with the application of organic manure.

8.3. Protein content

Fig. (24) illustrated the effect of both varieties and storage period on protein content of potato tubers. The result showed that, the highest value of the of protein content of potato tubers was recorded (5.950±0.429, %) for fresh diamond potato tubers i. But the lowest value of protein content of potato tubers was recorded (2.232±0.100, %) for diamond potato tubers in 1st experiment after 30 days of storage.

The results showed non-signification differences in protein content of potato tubers as affected by the potato tuber variety. But there were highly significant differences in protein content of potato tubers as affected by storage periods at $P \leq 0.01$. The results also showed that there were highly significant differences in the interaction between the potato tuber variety, and the storage period on protein content of potato tubers at $P \leq 0.01$.

These results were in agreement with that reported with Kareem *et al.* (2020), they achieved that the highest crude protein percentage in tuber was from the control plants followed by organic fertilizer treatment plants while inorganic fertilizer treatment plants had the lowest percentage.

The highest protein percentage was recorded in case of using seaweed extract (10%), during the first month stored 12.48% and reached 8.48% after four months followed by yeast extract, during the first month stored 10.76% and reached 6.48% after four months (Zaki *et al.*, 2021).

8.4. Ash content

Fig. (25) illustrated the effect of both varieties and storage period on Ash content of potato tubers. The result showed that the highest value of the Ash content of potato tubers was recorded at 100% organic treatment (10.60±0.03, %) for fresh Arizona potato tubers for fresh Arizona potato tubers. But the lowest value of Ash content of potato tubers was recorded at 50% organic and 50% mineral (1.200±0.033, %) for Arizona potato tubers after 45 days of storage.

The results showed significant differences in Ash content of potato tubers as affected by the potato tuber variety at $P \leq 0.05$. But there were highly significant differences in the Ash content of potato tubers as affected by storage periods at P≤0.01. The results also showed that there were highly significant differences in the interaction between the potato tuber variety, and the storage period on Ash content of potato tubers at P≤0.01.

These results were in agreement with that reported with Kareem *et al.* (2020), they achieved that the highest ash content in the tubers was from both the control and organic fertilizer treatment plants followed by inorganic fertilizer treatment plants while the least was from plants treatment with organo-mineral fertilizer.

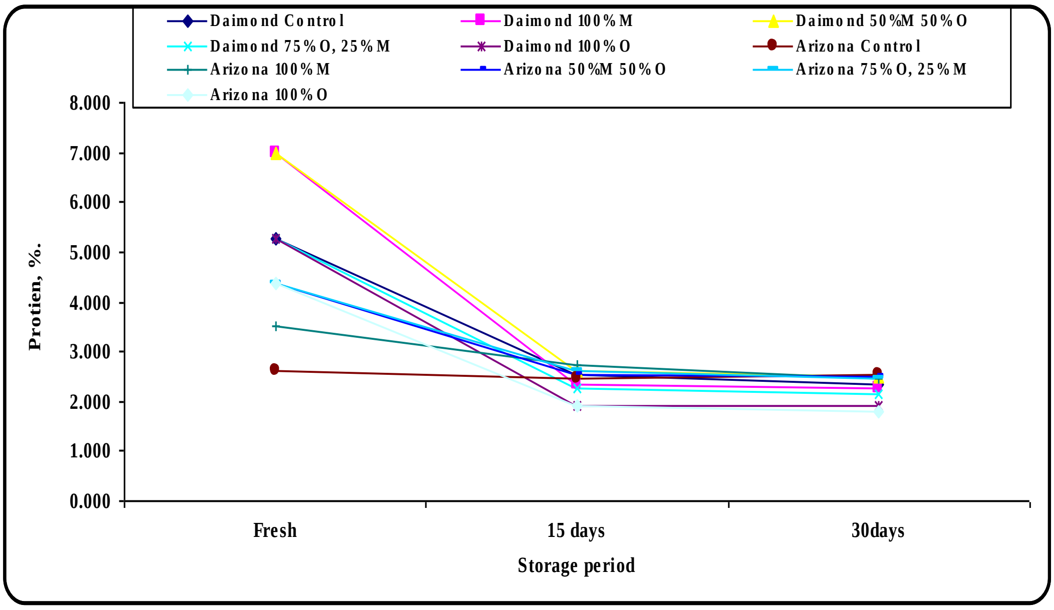

Fig (24): Content of protein (%)of potato tubers as affected by variety, storage period.

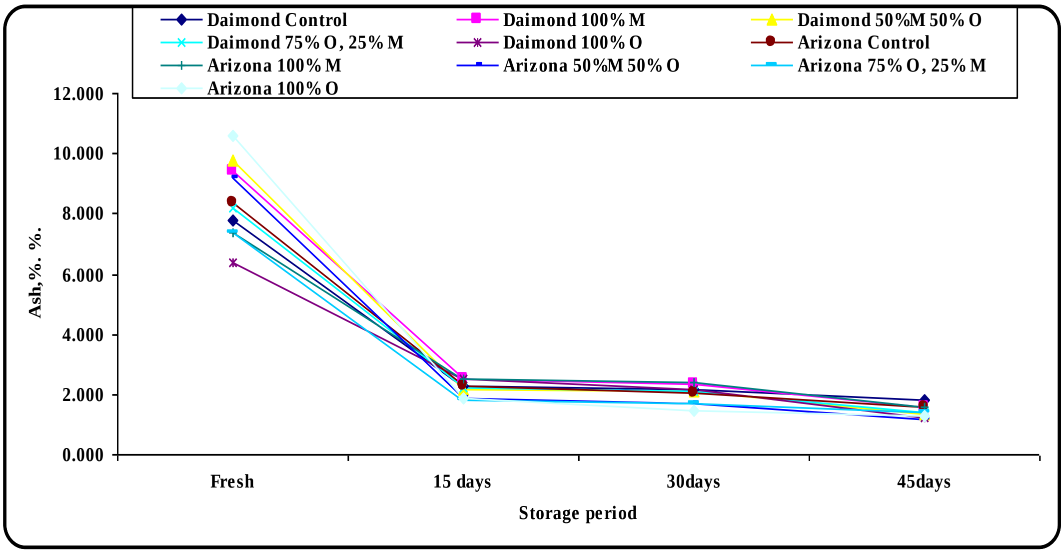

Fig (25): Content of Ash (%) of potato tubers as affected by variety, storage period.

Conculusions

- The best fertilization treatment (50% organic 50% mineral) gave the best results in the physical characteristics of potato tubers. Where, the treatment of (75% organic 25% mineral) fertilization gave the highest value for the firmness of potato tubers.
- Organic fertilization is more effective in achieving tuber quality.
- The best fertilization treatment (50% organic 50% mineral) gave the best carbohydrates and protein contents.
- Organic fertilizers have a significant effect on improving product quality soil, physical properties, and biological activity.
- The highest shape index was achieved with 100% mineral treatment.

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تأثير السماد العضوى والكميائي على بعض الخصائص الطبيعية والميكانيكية لدرنات البطاطس أثناء فترة التخزين

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الملخص العربي

تم إجراء هذه الدراسة علي محصول البطاطس والذي تم زراعته في مزارع كلية الزراعة – جامعة المنوفية خلال موسم الزراعة ٢٠٢٠ وذلك بهدف دراسة تأثير استخدام الأسمدة العضوية مقارنة باستخدام الأسمدة المعدنية على بعض الخواص الفيزيائية لدرنات البطاطس. ولقد أجريت التجارب علي صنفين من البطاطس هما دياموند وأريزونا. تم استخدام نوعين من السماد في زراعة درنة البطاطس وهما سماد عضوي وسماد معدني، وتم تقسيمها إلي خمسة معاملات كما يلي: الكنترول (بدون أسمدة) (T1)، ١٠٠٪ سماد معدني (T2)، ٥٠٪ سماد معدني و ٥٠٪ سماد عضوي (T3)، ٢٥٪ سماد معدني و ٧٥٪ سماد عضوي (T4)، ١٠٠٪ سماد عضوي(T5). وتم تخزين درنات البطاطس في ثلاجات علي درجة حرارة ٤ ^{o} درجة مئوية وكانت فترة التخزين للبطاطس ٤٥ يوماً

وكانت أفضل معاملة تسميد (٥٠% عضوي ٥٠% معدني) حيث أعطت أفضل نتائج في الخصائص الطبيعية لدرنات البطاطس. كما أعطت معاملة تسميد (٧٥% عضوي ٢٥% معدني) عضوي أعلي قيم لصلابة درنات البطاطس ٠