ORGANIC MATTER AND MORINGA LEAF EXTRACT'S EFFECTS ON THE PHYSIOLOGY AND FRUIT QUALITY OF RED SEEDLESS WATERMELON (*Citrullus lanatus*)

*EFEITOS DA MATÉRIA ORGÂNICA E DO EXTRATO DA FOLHA DE MORINGA SOBRE A FISIOLOGIA E QUALIDADE DO FRUTO DA MELANCIA VERMELHA SEM SEMENTES (*Citrullus lanatus*)*

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ABSTRACT: This study was designed to assess the effects of different types of organic matter on the quality and biochemical properties of red seedless watermelon. The research was a single factor experiment, which involved six (6) treatments and four (4) replications. Watermelon grown and harvested from five (5) different organic matter sources, namely; vermicompost (VC), poultry manure (PM), cow dung (CD), goat dung (GD), and moringa leaf extract (MLE), at the rates of 10 ton, 20 ton, 30 ton, 30 ton, and 3000 L ha^{-1}, respectively, were used in this study. The results revealed that the treatment of vermicompost improved the chlorophyll content, chlorophyll fluorescence, stomatal conductance, internal carbon dioxide, net photosynthetic rate, fruit weight and mineral nutrient content of watermelon. The application of cow dung reduced the rind thickness and increased the TSS and antioxidant activity of the watermelon. The goat dung treatment significantly affected fruit size, juice content and the pH content of the watermelon's fruit juice. The poultry manure (PM) and moringa extract (MLE) treatments resulted in the highest anthocyanin content of all the watermelon. Although all the organic matter, in their unique ways, improved the quality of red seedless watermelon, the study shows that the vermicompost application had better growth, yield and improvement in the quality of watermelon.

KEYWORDS: Fertilizer. Quality. Biochemical property. Watermelon.

INTRODUCTION

The crop watermelon is a warm season crop. It is a member of the Cucurbitaceae family which belongs to the genus *Citrullus and species Citrullus lanatus* (ROSNAH et al., 2010). Even though watermelon is grown in many different countries, watermelon production is among the top major horticultural crops in Brazil, so that over the years, there has been an increase in the production area of watermelon, especially in the north and northeastern states. From 2001-2014, the area of production of watermelon in Brazil increased by 310% (ANGHINONI, 2014). Watermelons are a rich source of water and, as such, are helpful in averting dehydration. The low-calorie content of watermelon makes it the best choice for diet-conscious people. Watermelon contains mostly water (93.2%) and other nutrients such as sugar, plus many vitamins (Thiamin, riboflavin, and niacin), (IITA, 2013). Potassium, as a macro nutrient, can be found in watermelon which is considered to help in the control of high blood pressure and perhaps avert stroke (IITA, 2013). It has also been reported that potassium helps to reduce high blood pressure and protect against the formation of kidney stones (MCDONOUGH; NGUYEN, 2012).

For proper growth and development, watermelon plants need heavy doses of nitrogen, and therefore, require an application of 200 kg per acre of nitrogen (N). Before sowing, NPK (a mix of Nitrogen, Phosphorous, and Potassium) compound fertilizer is also required to be incorporated, followed by applications of nitrogenous fertilizers at five weeks and with regular intervals up to the anthesis stage (SCHIPPERs, 2000; RICE et al., 1986). Two inches of compost or manure over the garden area increases the growth and development of watermelon. Organic matter such as composted manure, improves nutrients for the soil, enhances structure and drainage, and balances the pH, which indicates either acidic or alkaline conditions. OJO et al. (2014) reported that tropical soils have overwhelming problems of nutrient loss due to

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leaching, acidity, low nutrient deficiency, nutrients disproportion, and soil erosion. Therefore, for better growth and yield of watermelon fruit, it is necessary to supplement the nutrient content of the soil to meet the plant's needs. The use of organic matter such as farmyard manure, green manures, various waste products, as well as the use of compost or with the use of synthetic fertilizers, an increase in the nutrient status of the soil is achieved by boosting the soil's nutrient content (DAUDA et al., 2005).

The quality of a fruit can be categorized by features such as texture, safety, appearance, nutritional value and flavor (ROCHA et al., 2013). The production and management of fruit and vegetables, however, is strongly affected by the pulverization of inorganic fertilizers which can cause health concerns; therefore, there is a need to improve fruit and vegetable production, to give its consumers superior fruit while maintaining quality production practices (STOLZ et al., 2011). There have been serious concerns about the recent stigmatization and health implications of inorganic fertilizers; however, statistical figures (FAO, 2015) indicate that inorganic fertilizers account for more than 90% of fertilizers used by all types of farmers in developing countries. The application of organic fertilizers are essential to enhaced respiration and photosynthesis in crops. Khandaker et al. (2017) reported that the application of organic matter increased the net photosynthetic rate and transpiration of okra plants. Thus, this study aimed to evaluate the effects of organic matter on the quality and the biochemical properties of watermelon.

MATERIAL AND METHODS

Experimental site, plant materials and experimental design

The experiment was conducted at a research plot (5.7471°N, 102.6101°E) at the farm of Faculty of Bioresources and Food industry, Universiti Sultan Zainal Abidin (UniSZA), Besut Campus, 22200 Besut, Terengganu, Malaysia. The area under study has an atmospheric annual temperature of 21-30 °C and relative humidity of 60-90. The experiment was conducted between 2016 and 2017. In this research, watermelon Red Flesh Seedless Variety (F1 hybrid) was used as planting materials and different organic fertilizers viz., well decomposed cowdung, vermicompost, poultry manure, goat dung and moringa leaf extract were used as the sources of plant nutrients. The research was a single factor experiment, which involves six (6) treatments and four (4) replications. Watermelon fruits grown and harvested from different organic sources Viz; vermicompost (VC) at the rate of 10 t ha^{-1}, poultry manure (PM) at the rate of 20 t ha^{-1}, cowdung (CD) at the rate of 30 t ha^{-1}, goatdung (GD) at the rate of 30 t ha^{-1}, moringa leaf extract (MLE) at the rate of 3000 Lha^{-1} (diluted volume) were used in this study. Four fruits from each replication were randomly selected for measurement of growth and fruit quality parameters.

Measurements of physiological properties

The chlorophyll content of the watermelon leaves was determined using a Konica Minolta Chlorophyll Meter (Model: SPAD 502Plus). Three fully matured leaves from the middle of vine randomly selected and were cleaned for data recording. The chlorophyll content was measured around 1 pm and four times during the experimental period. The data was shown as SPAD value index. A portable CI-340 handheld Photosynthesis System (Bio-Science, USA) was used for the measurement of photosynthetic characteristics viz; net photosynthetic rate, transpiration rate, stomatal conductance and internal carbon dioxide concentration ($IntCO_2$) were measured three times during plant growth and development. Photosynthetic characteristics measurements were carried out according to Khandaker et al. (2012). A Plant Efficiency Analyzer (Hansatech Instruments Ltd., England) was used to measure chlorophyll fluorescence and the photosynthetic yield of treated and untreated watermelon plants

Measurement of fruit size, weight and rind thickness

The length and diameter of the watermelon fruit was measured manually by using a flexible tape. Watermelon was positioned vertically at its most stable position and diameter of the fruit was recorded. The length of the fruit was determined by measuring the distance between the top portion and the bottom portion (YAU et al. 2010). The weight of the whole watermelon fruit was recorded using an electronic weighing balance (Model: Mettle PJ3000, Japan). The thickness of the rind was measured with the aid of an electronic digital vernier calipers and the average value was recorded in centimeter (cm).

Measurement of juice contente

The total moisture component of the samples is described as the juice content of the sample. Crucibles were oven dried at 90ºC for 30 min and transferred into desiccators to cool. After cooling, the cubes of watermelon fruit of the diameter 5 mm x 5 mm x 5 mm size. Each sample was weighed in the crucible and oven dried at 110ºC to a constant weight. The percentage juice content of each sample was then calculated as follows:

$$\text{Juice content } (\%) = \frac{w_3 - w_1}{w_2 - w_1} \text{ X } 100$$

where; W1 = Weight of Crucible, W2 = Weight of empty Crucible and Sample before drying, W3 = Weight of Crucible and Sample after drying

Determination of pH and ash

A glass electrode pH meter was used to determine the fruit juice pH after extracting and sieving the juice of watermelon. Buffers of pH 4.0 and 7.0 were being used to calibrate the pH meter. Ash of a biological material is an methodical term for the organic residue that remains after the organic matter has been burnt off (INUWA et al. 2011). The percentage of ash was then calculated using the formula below:

$$\text{Crude Ash} (\%) = \frac{w_3 - w_1}{w_2 - w_1} \text{ X } 100$$

where; W1 = Weight of Crucible , W2 = Weight of Crucible and Sample before ashing , W3 = Weight of Crucible and Sample after ashing

Determination of fruit minerals (K, Fe, Na, Mg, Ca and Cu), TSS and anthocyanin content

In this study, there were six kinds of minerals present in watermelon fruit that were analysed; including Potassium (k), Iron (Fe), Sodium (Na), Magnesium (Mg), Calcium (Ca) and Cupper (Cu). The method used to analyse the mineral content was described by Jackson (1973). The solutions including watermelon flesh were allowed to stand overnight, and then filtered through a dry filter paper to remove excess silica without washing. The solution containing samples were retained and used for the analysis of minerals against the reagent blank by Atomic Absorption Spectrophotometer (AAS). Three replicates of samples from each treatment were used, and the average was computed, results were expressed as mg g^{-1}. A digital hand refractometer (Atago Co. LTD., Tokyo, Japan) was used to evaluate the total soluble solids (TSS) content and the result was expressed as ºBrix. Total anthocyanin contents of watermelon extracts were determined by the pH-differential method (RODRIGUEZ et al. 1999).

Determination of DPPH free-radical scavenging activity

To determine the quantitative measurement of radical scavenging properties, the solution of 50 µl of methanolic extract samples (or 80% MeOH as a blank) and 1 ml of 0.04% (w/v) solution of DPPH in methanol. A standard antioxidant (Quercetin) was used for comparison or as a positive control (BLOIS 1958). Discoloration was determined at 517 nm after incubations for 30 min. The actual decrease in absorption induced by the test compounds was compared with the positive controls.

Statistical analysis

The experiment was carried out according to Randomized Complete Block Design (RCBD) with four replications. The data obtained was analysed using SAS (Version 9.3) software. A one way repeated ANOVA was applied to evaluate any significant differences within the parameters studied in this experiment. Least significant difference (LSD) test was used to compare different treatments whenever ANOVA showed significant differences among means.

RESULTS

Chlorophyll Content, Photosynthetic Characteristics and Photosynthetic Yield of Watermelon

The chlorophyll content of the watermelon crops was measured at intervals of 21, 42, 63, and 84 days (DAT) after transplanting the nursery stock to separate fields with the 5 different organic matter treatments applied. At 21 and 45 days, the different treatments did not produced any significant effect on the chlorophyll content of watermelon leaves (Table 1). The VC shows a greater impact than CD, GD, MLE, and a control application, but, VC is not significantly different from poultry manure. The chlorophyll content of PM, CD, and GD are not significantly different from each other, however, the control treatment and MLE show the lowest values of 41 and 41, respectively, which are not statistically different from GD (47.2 SPAD) at day 84. The different organic matter and MLE produced a significant effect on the net photosynthetic rate of the watermelon at 45 and 75 days. Two weeks after planting, the different treatments did not produce any significant effect on the net photosynthetic rate (Table 1). At 45 days, the plants treated with CD produced the highest net photosynthetic rate (18.65 µm/m^2/s), followed by GD, PM and other treatments, while the control plants showed the lowest net photosynthetic rate (13.92 µm/m^2/s). Subsequently, net photosynthetic rates measured at day 75 indicated that CD was statistically different from the control treatment.

Table 1. Influence of organic matters and moringa leaf extract on the physiological properties of red seedless watermelon

Chlorophyll content				**Net photosynthetic rate**		
Days After Transplanting (DAT)						
21	42	63	84	14	45	75
34.25a	37.05a	40.75cd	41.00c	9.27a	13.92b	20.12c
28.47a	47.92a	57.25a	61.37a	8.52a	16.55ab	20.72bc
35.07a	46.87a	51.75ab	52.40b	8.50a	16.84ab	21.11abc
30.80a	42.30a	45.90bc	54.12b	9.19a	18.65a	22.38a
29.15a	47.30a	45.50c	47.22bc	8.69a	16.50ab	21.68ab
33.22a	37.00a	38.75d	41.00c	8.57a	16.37ab	20.85bc
13.13	16.26	5.90	7.17	1.80	3.73	1.4

Mean values with the same letters within the same column are not significantly different at $p \leq 0.05$. CNT; control, VC; vermicompost, PM; poutry manure, CD; cowdung, GD; Goatdung, MLE; moringa leaves extract, LSD; least significant difference.

The transpiration rate was measured at 14, 45 and 75 days (DAT) with results observed at 14 DAT for all the treatments statistically the same. Results show the VC, PM, GD, and MLE are not statistically different from each other than at 45 DAT. However, CD with the highest value of net transpiration (2.85 mmol/m^2/s) is statistically different from all other organic matter and the control matter which has the least value of net transpiration (1.45 mmol/m^2/s) at 45 DAT. Results recorded at 75 days after transplant indicate that PM, CD, and GD, with values of 1.74, 1.71 and 1.74 mmol/m^2/s, respectively, are significantly different from the control with the lowest transpiration rate value at 1.28 mmol/m^2/s (Table 1). The stomatal conductance of watermelon plants was recorded at 14, 45 and 75 DAT. Results indicate that all of the treatments did not vary significantly at 14 DAT. Vermicompost produced the highest value of stomatal conductance (0.14 mmol/m^2/s) at 45 DAT which is significantly higher than the other treatments and the control. Moreover, results observed at 75 DAT show that stomatal conductance of treated and untreated plants did not vary significantly from each other (Table 2).

Table 2. Influence of organic matters and moringa leaf extract on the stomatal conductance, Internal CO_2 and photosynthetic yield of red seedless watermelon

	Stomatal Conductance			**Internal CO_2**			**Photosynthetic Yield**		
	Days After Transplanting (DAP)								
	14	45	75	14	45	75	14	45	75
CNT	0.03a	0.05c	0.12a	3.79a	7.68c	5.78a	0.809a	0.810a	0.802c
VC	0.03a	0.14a	0.12a	3.45a	8.64abc	7.53a	0.810a	0.815a	0.827a
PM	0.03a	0.07bc	0.07a	3.94a	8.09bc	6.35a	0.815a	0.815a	0.827a
CD	0.03a	0.10ab	0.13a	3.49a	11.33a	7.96a	0.817a	0.815a	0.827a
GD	0.03a	0.07bc	0.07a	4.07a	10.69ab	7.13a	0.815a	0.810a	0.815b
MLE	0.03a	0.06bc	0.08a	3.77a	9.57abc	6.79a	0.812a	0.812a	0.812bc
LSD	0.016	0.49	0.17	2.27	2.73	3.38	0.014	0.015	0.017

Mean values with the same letters within the same column are not significantly different at $p \leq 0.05$. CNT; control, VC; vermicompost, PM; poutry manure, CD; cowdung, GD; Goatdung, MLE; moringa leaves extract, LSD; least significant difference

Recorded results of the internal carbon dioxide (CO_2) concentrations in the watermelon was influenced by different organic matter and MLE at 14, 45 and 75 DAT. Results related to internal CO_2 concentration obtained at 14 DAT are not statistically different from each other. At 45 DAT, CD has the highest value of internal CO_2 (11.33 µm/mol) followed by GD and MLE with internal CO_2 values of 10.69 and 9.57 µm/mol, respectively, which is significantly higher than the control with an internal CO_2 value of 7.68 µm/mol. However, all of the values of internal CO_2 concentration among treatments at 75DAT vary insignificantly. Photosynthetic yield (Fv/Fm) was recorded at 14, 45 and 75 days after transplant, results obtained indicate that at 14 and 45 DAT no significant differences were observed amongst the treatments and control. However at 75 DAT VC, PM, and CD had the highest values at 0.82, 0.82 and 0.82 F_v/F_m, respectively, and are statistically significant when compared to control with the least mean value of 0.80 F_v/F_m. Moreover, GD and MLE are not statistically different from the control at 75 DAT.

Fruit weight and fruit Size

The results show that organic manure and MLE produced a significant effect on watermelon yield. Fruit weight (yield) was highest in plots treated with VC (285t ha^{-1}), followed by PM, and then the other treatments (Figure 1 & Figure 2 A below). The lowest fruit weight was recorded in the control plot (106 t ha^{-1}). The watermelons' size was significantly affected by organic matter and the moringa leaf extract treatments (Figure 1). Results indicate that GD had the highest length to diameter ratio (1.033) followed by MLE (1.032), which were significantly higher than the control ratio (1.024) with the lowest length to diameter ratio.

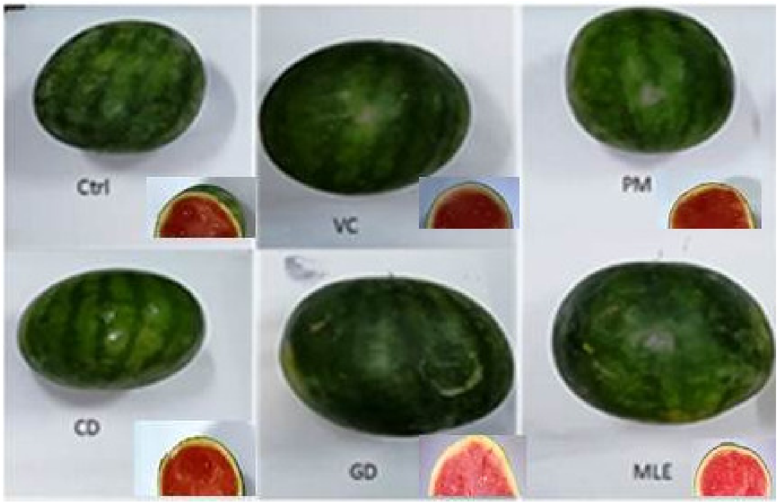

Figure 1. Fruit size and rind thickness of watermelon as affected by organic matters and MLE

Rind thickness and juice contente

The juice content is the percentage of water contained in the watermelon as a percentage (%). From the results obtained, GD had the highest juice content (94.9%) and PM had the lowest juice content (93%) (Figure 1), however, all of the treated and untreated plants are not statistically different from each other at P ≤ 0.05. From the Rind Thickness results shown in Figure 2 (D), it is observed that CD (1.12 cm) has the lowest rind thickness which varies significantly from the Control (1.55 cm). However, VC, PM, GD, and MLE did not vary from either the control or CD at P ≤0.05.

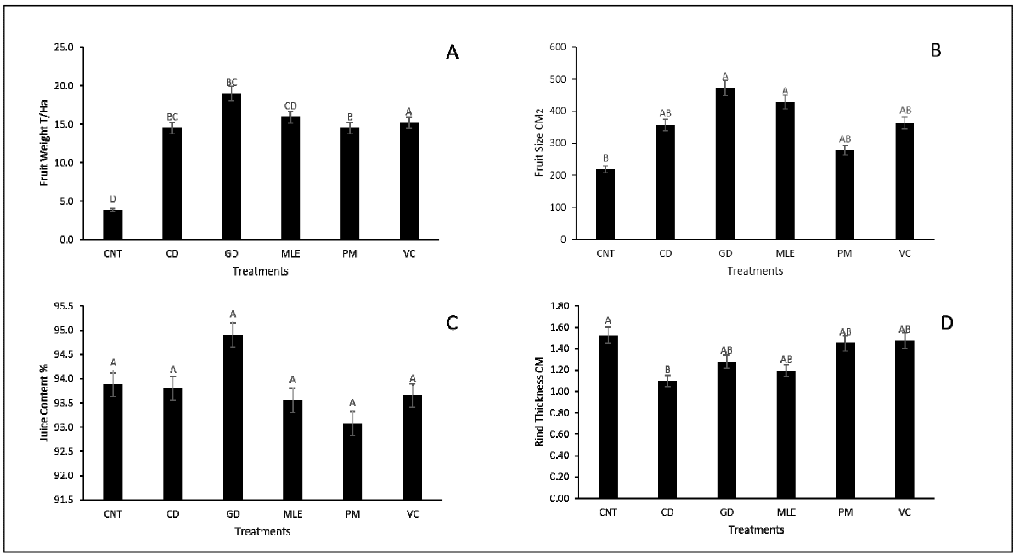

Figure 2. Effects of organic matters on (A) Fruit weight, (B) Fruit size, (C) Juice content, (D) Rind thickness of red-seedless watermelon. Bars indicate ± SE and different letters represent the statistical significance at $p < 0.05$. CNT; control, VC; vermicompost, PM; poutry manure, CD; cowdung, GD; Goatdung, MLE; moringa leaves extract.

Anthocyanin content and pH of the fruit juice

The results obtained for anthocyanin content of watermelon treated with different organic matter shows that poultry manure (PM), and moringa extract (MLE), had the highest anthocyanin content with values of 0.255 mg/g and 0.2544 mg/mg, respectively, which are statistically different ($P \leq 0.05$) from the other treatments, as well as the control. Although (CD) had the lowest anthocyanin content (0.094 mg/g), it is not significantly different from the control, vermicompost (VC) or goat dung (GD) (Figure 3A). Results from figure 3B indicate that the fruit juice pH was highest in GD (5.66) which is significantly higher than the control (5.25) with the lowest pH value. However VC, PM, CD, and MLE are not statistically different from either GD or the control.

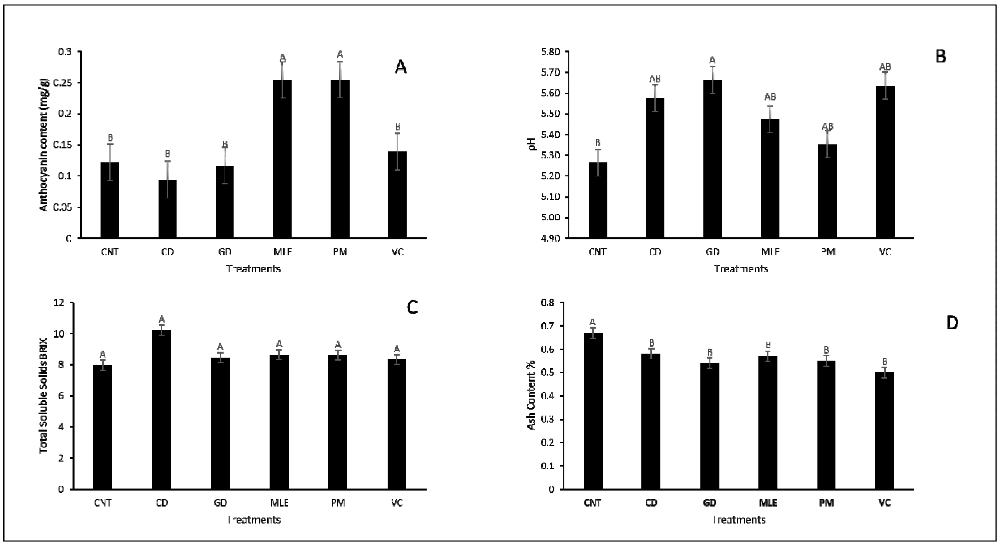

Figure 3. Effects of organic matters on (A) Anthocyanin content, (B) pH, (C) Total soluble solids, (D) Ash content of red-seedless watermelon. Bars indicate ± SE and different letters represent the statistical significance at $p < 0.05$. CNT; control, VC; vermicompost, PM; poutry manure, CD; cowdung, GD; Goatdung, MLE; moringa leaves extract.

Total Soluble Solids (TSS) and Ash contente

Data recorded for TSS did not vary significantly amongst treatments ($P \leq 0.05$), however watermelon grown from the cow dung treatment had the highest TSS content (10.22 ºBrix), and the control had the lowest TSS content (7.9 ºBrix) (Figure 3B). The percentage of ash content in the watermelon was measured and recorded showing that the watermelon from the vermicompost treatment had the least ash content (0.51%) followed by goat dung (0.54%), but the control had the highest ash content percentage with a value of 0.67%, however, there is not a statistical difference between all of the treated plants and the control at P value of < 0.05 (Figure 3D).

Antioxidant activity

The radical scavenging activity of watermelon fruit extract, as shown in Table 3, expresses the percentage of inhibation of the initial DPPH absorption by the tested compound. The reaction mixture contained 50 µl of methanolic extract samples as a blank. The data from the table reports that at concentrations of 50 µg/ml, the control had the least mean value of 31.86, moringa biostimulant at 48.81, and cow dung at 47.72, did not vary statistically from the standard quercetin (51.36). Results of 100 µg/ml concentrations show that all the treatments are significantly different from the lowest control (56.03) and the highest quercetin (82.56), however poultry manure (67.7) did not vary statistically ($p \leq 0.05$) from goat dung (65.48).

Table 3. Effects of organic matters on antioxidant activity values of watermelon fruits at different concentrations (50 and 100 µg/ml)

Treatments	Inhibition (%)	
	50µg/ml	100µg/ml
CNT	31.86±0.72e	56.03±1.28f
VC	46.02±0.43c	62.06±0.74e
PM	47.22±0.45bc	67.7±0.81d
CD	47.72±0.65ab	71.75±0.32c
GD	40.5±0.43d	65.48±0.58d
MLE	48.81±0.58ab	78.3±0.32b
Quercetin (standard)	51.36±0.42a	82.56±0.49a
LSD	2.656	3.309
C.V	2.57	2.08

Mean values with the same letters within the same column are not significantly different at p≤0.05. CNT; control, VC; vermicompost, PM; poutry manure, CD; cowdung, GD; Goatdung, MLE; moringa leaves extract, LSD; least significant difference, CV; coefficient of variability.

Nutrient Content and Its Correlation among Parameters

Results in Table 4, indicate the nutrient content of watermelon pulp. The nutrients measured were Potassium (K), Iron (Fe), Sodium (Na), Magnesium (Mg), Calcium (Ca) and Copper (Cu). Results show that poultry manure had the highest mean value (56.045 mg/g) of potassium which is significantly different from the least performing treatment, which was the control treatment (44.865 mg/g). Iron content did not vary significantly between the treatments. Moringa leaf extract had the highest sodium content (21.338 mg/g), however it differed from cow dung (17.735 mg/g) and goat dung (15.730 mg/g). Moreover, the control treatment recorded the least sodium content (18.720mg/g). The magnesium content measurement showed that vermicompost had the highest mean value (0.211 mg/g) and was statistically different from goat dung which had the least magnesium content (0.183 mg/g). The calcium content measurement shows the control had the highest mean value (0.155mg/g), however, no significant difference was observed between the treated fruits. The analyzed results for copper indicate that moringa extract had the highest copper content (0.234mg/g) followed by goat dung, then vermicompost with mean values of 0.229 and 0.220 mg/g, respectively, and are statistically higher than control (0.161 mg/g).

Table 4. Effects of organic matters and moringa leaf extract on the nutrient content of watermelon fruits

	Nutrients (mg g^{-1} DM)					
Treatments	K	Fe	Na	Mg	Ca	Cu
CNT	44.865bc	0.222a	18.720ab	0.223ab	0.155a	0.161b
VC	51.180ab	0.230a	14.940b	0.211ab	0.114a	0.220a
PM	56.045a	0.218a	14.010b	0.242a	0.141a	0.203ab
CD	50.323ab	0.216a	17.735ab	0.217ab	0.153a	0.199ab
GD	41.133c	0.210a	15.730ab	0.183b	0.140a	0.229a
MLE	32.810d	0.211a	21.338a	0.199ab	0.147a	0.234a
LSD	6.6488	0.048	5.618	0.051	0.1174	0.055
CV	6.4423	9.803	14.640	11.539	36.906	11.847

Mean values with the same letters within the same column are not significantly different at p≤0.05. CNT; control, VC; vermicompost, PM; poutry manure, CD; cowdung, GD; Goatdung, MLE; moringa leaves extract, LSD; least significant difference, CV; coefficient of variability.

From the correlation matrix below, it was reported that the chlorophyll content and transpiration rate have a positive, significant, correlation to net photosynthesis (Table 5). It is furthermore sufficient to report that internal CO_2 had a positive relationship on the net photosynthesis of watermelon plants grown in BRIS soil amended with organic matter and moringa leaf extract. Photosynthetic yield correlates to a transpiration rate at p level of 0.05. The number of fruit statistically correlates to the net photosynthesis, transpiration rate, internal CO_2, and chlorophyll fluorescence. On the other hand, fruit weight significantly correlates to the chlorophyll content of watermelon leaves (Table 5).

Table 5. Correlation between physiological and qualitative properties of watermelon

PARAMETERS	Chlorophyll Content	Net Photosynthesis	Transpiration Rate	Stomatal Conductance	Internal CO2	Photosynthetic Yield	No of Fruits	Fruit Weight	Fruit Size	Juice Content
Chloro. Cont.	1									
Net Phot.	.315	1								
Transp. Rate	.522	.874*	1							
Stomatal Cond.	.647	.135	.041	1						
Internal CO_2	.081	.861*	.760	.060	1					
Photosyn Yield	.754	.796	.865*	.340	.475	1				
No of Fruits	.537	.909*	.893*	.397	.839*	.835*	1			
Fruit Weight	.958**	.287	.555	.633	.140	.717	.586	1		
Fruit size	.067	.471	.663	-.140	.763	.255	.611	.261	1	
Juice Content	-.215	.075	.019	-.040	.490	-.338	.079	-.205	.462	1

DISCUSSION

Chlorophyll content in the leaves of plants correlates to the amount of nutrients absorbed by the crop from its growth medium, which translates into the physiological performance of the plant. The chlorophyll content of the watermelon crops was higher (40 - 60 SPAD value) at 63 and 84 DAT, since the accumulation of chlorophyll on these days was within the required value for watermelon crops (TADMOR et al. 2010) . The chlorophyll content of watermelon crops varies from 30 to 50 SPAD value (INTHICHACK et al. 2014). The chlorophyll content of vegetable crops increases at the peak growth stage (MALGORZATA et al. 2010). The opening and closure of the stomata will affect photosynthetic CO_2 fixation in mesophyll tissues which has also been shown to be affected by organic matter in the soil. In this study, results indicate that vermicompost treatment improves the chlorophyll content in watermelon leaves. Organic matter could significantly increase the cholorophyll content. In spider plant leaves the chlorophyll content was increased with subsequent increments of nitrogen fertilizers (ZHANG et al. 2011). This might be the connection between the efficient assimilation, and absorption, of nitrogen by the plant which serves as a constituent of chlorophyll in the plant tissue. In this study, a significant increase in net photosynthesis and the transpiration rate was observed in all of the organic matter and the moringa leaf extract treated plants. A late decline was recorded in the transpiration rate which is a result of the reduction of CO_2 fixation in leaf mesophyll tissues induced by stomatal closure. A decrease in transpiration rate occurs as a marigold plant advances into its late stage (SINGH et al. 2015). The increased organic matter, which contains magnesium and other nutrient elements, might have helped chlorophyll synthesis which in turn increased the rate of photosynthesis. Organic matter can increase root growth and holds a large quatity of water for use by the plant roots. This improves the root system of watermelon plants which may absorb larger quatities of water and increase transpiration more than the control plants.

Results indicate that stomatal conductance at 45 DAT was higher in vermicompost treatment, then, later declined at 75 DAT which was because of stomatal closure in the leaves' mesophyll, an occurance related to its loss of chlorophyll pigmatations. These observations conform with findings of Efthimiadou et al., (2010), but are contradictory to Selvaraju; Iruthayaraj, 1995. Internal CO_2 assimilation was higher at 45 days which correlates to the chlorophyl content of the crops and translates to higher chemical activity in the leaves of watermelon plants.

Photosynthetic yields are a result of energy absorbed from the sun that was not used for heat dissipation or photosynthetic reactions. The results of this study indicate that photosynthetic yield (fv/fm) was higher in all of the treated plants when compared to the control treated plants during all successive test days after transplant. Similar effects were observed which resulted in an increase in the

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antenna pigment levels and the excitation efficiency of trapping at the centers of active PS-II (MONERUZZAMAN et al., 2013). Both strawberry and apple plants perform better in terms of photosynthetic efficiency when treated with organic manure as compared to chemical fertilizers (BAKER; ROSENQVIST 2004). A decrease in the F_v/F_m ratio is a consistent sign of photoinhibition which shows that these crops are more light sensitive. This is because photosynthetic yield ratios indicate the photochemical efficiency of crops, so that, a greater reduction in this parameter occurs in plants grown in higher O_2 concentration. A minimum level of fluorescence content caused the state of the leaves to remain unchanged in all treatments, indicating that organic matter has an effect on improving the photosynthetic yield of watermelon.

Fruit weight measurements indicate that vermicompost produced the highest weight fruit. Vermicompost at 15 ton ha^{-1} had a higher fruit weight when compared with treatments of organic manure at 15 ton ha^{-1} (RAKESH et al. 2014). The control treatment produced the lowest weight fruit. This is possible because of low nitrogen content which produces poor fruit settings and, as a result, the formation of smaller fruit (JOHN *et al.,* 2004). It is sufficient to report that all of the organic matter performed as expected. These results were also in concordance with similar studies, which reported that olive fruit flesh weight varied greatly according to fertilization with various organic matter (HEGAZI et al. 2007). Incremental changes of average fruit weight could be due to better nutrient content of the amended soils with organic matter. The reason for improved fruit weight could be attributed to the solubilization effect of crop nutrients, with the addition of organic fertilizers, resulting in an increased uptake of essential nutrients (SENDURKUMARAN *et al.,* 1998). These observations are in harmony with those of Silvia et al. (2007).

Results indicate that goat dung, followed by moringa extract, had the biggest fruit sizes and this was significantly different from the control treatments. During the developmental period of the fruit sets, nutrients in organic matter increase carbohydrate availability and photosynthesis which causes cell enlargement. GA_3 stimulates cell expansion during the fruit set and the developmental stages (KHANDAKER et al., 2013). RAPHAEL et al. (2007) reported that exogenous applications of biostimulants raised the carbohydrate levels in fruit and increased fruit size. Moringa biostimulant improves fruit size which could be because moringa extracts have been shown to include zeatin, a cytokinin related hormone (FUGLIE 2000). Poultry manure also increases fruit size because the fruit is positively influenced by adequate supplies of nitrogen (ALABI 2006). Watermelon crops have an indeterminate growth pattern so the fruit develops progressively on the same plant due to continuous flowering. Competition for available nutrients amongst the fruit has a direct effect on the fruit size of the watermelon (ALI; KELLY, 1992).

The watermelon rind is the area of whitish flesh between the colored flesh of the edible fruit and the exterior skin. From the results measured, it is observed that CD has the thinnest rind. Cattle manure applications led to thinner fruit rind in watermelon cultivation (AUDI et al. 2013). But in other studies it was reported that the gene of a watermelon fruit has a direct correlation to the fruit rind thickness (PORTER, 1941). Rind thickness seems to be propotional to the fruit variety since Yellow Crimson resulted in the highest value of rind thickness followed by the Giza hybrid and the thinnest value in the Envy variety (ABDEL-MAWGOUD et al., 2010). A thicker rind in the control treated watermelon could be attributed to a lower nutrient and moisture content in the soil which hinders fruit biomass formation. This argument is in agreement with a similar study which reported that soil amended with organic fertilizers improved fruit biomass accumulation (MALGORZATA et al. 2010).

Results from the current study show that the fruit juice pH was the highest in GD. The improvement of fruit pH quality may be related to an improvement in the production of the plants, which might favor producing better quality fruit. The control treatment performed lowest in regard to fruit pH which might be connected to the stage of ripeness in the fruit since fruit parameters, such as the pH value, are related to the maturity stage of the fruit (JUROSZEK *et al.,* 2009). Higher pH values were recorded (between 6.28 and 6.53), for watermelon when the organic manures varied (MASSRI; LABBAN 2014).

Fruit juice content is an important parameter in processing fruit because it is related to size (MONERUZZAMAN *et al.,* 2011). The juice content is the percentage of water contained in the watermelon fruit. Watermelons are very juicy with a juice content of over 90% (ROSNAH *et al.,* 2010). The control treated fruit measurements show a higher moisture content than some poultry manure and vermicompost treatments, which was because unripe fruit can produce more water than ripe fruit. This observation is in agreement with the reports of

FAO, (1989), that stated unripe watermelon has high moisture content, thus the weight of the fruit is heavier. At a complete maturity stage, the water content of the fruit is reduced, thus the weight of fruit consequently becomes lighter. In a study conducted on watermelon, it was reported that the juice percentage was the highest for sheep manure (92.4%) treated plants followed by poultry manure (91.43%), pigeon manure and control treated plants (90.99% and 90.58% respectively). The average juice content of watermelon fruit was between 93 to 94.5% (Figure 2A). These values were in agreement with that of USDA, (2003).

The colors in fruit and vegetables echo the presence of biologically active substances and antioxidants that have been reported to promote good health (MONERUZZAMAN et al., 2012). Plants treated with moringa extract, as a biostimulant, show high anthocyanin content, which is supported with the findings of Khandaker et al. (2012), who reported that the anthocyanin content was increased in H_2O_2 treated wax apple fruit. Moreover, total anthocyanins were similar for all treatments but tended to increase in the organic treatments (PANICKER; SIMS 2009). A study also reported that treatment with poultry manure had no effect on the presence of anthocyanins in the leaves of *Ocimum gratissimum (*OSUAGWU; EDEOGA 2012).

The total soluble solids determine the maturity standards and affect consumer acceptability (KHANDAKER et al., 2011). Fruit sweetness, is the most important quality factor in watermelon fruit and is related to the level of total soluble solids (TSS) (MAYNARD 2001). Data recorded for TSS did not vary amongst treatments statistically ($P \leq 0.05$), however, cow dung had the highest value of TSS and the control treatment had the least value. These observations, to some extent, are in agreement with the arguments of some studies where they verified that applying nitrogen rich organic fertilizers provided significant increases in the TSS content of melon plant fruit (SRINIVAS; PRABHAKAR 1984). All of the plants treated with organic matter had TSS ranges of 8.32-10.24 ^{o}BRIX. These results indicate that organic matter improves the quality of watermelon fruit. This observation is based on the United States Standards of Watermelons grades (USDA, 1978) which indicate that watermelons with 8 ^{o}BRIX TSS are good quality fruit. The ash percentages in this study range between 0.51-0.58 % in treated plants and were noted since watermelon fruit is made up of 0.5% Ash (Slavery, 1974). The results of this study are not in agreement with the findings of other reports which stated that ash content was not significantly affected by organic fertilizers tested on *Chloris gayana* (YOSSIF; IBRAHIM 2013),Results in Table 3 show that antioxidant scavenging activities increased with the application of different organic matter. Other research had similar findings about this higher antioxidant activity which was recorded when organic fertilization was compared to mineral fertilization in fresh jujubes (WU et al. 2013). The best radical inhibited activity percentages were found at 100ug/ml and 50ug/ml in plants treated with moringa extract, when compared with the standard used (Quercetin), which might be in connection with the effects of phenolic compound derivatives in moringa extract as a precursor for the synthesis of flavonoid structures and, as such, related to the increased antioxidant activity. OTHMAN et al. (2007) reported that reaction mixtures (fruit extract) consisting of 20 µg/ml – 100 µg/ml showed better antioxidant activity. Flavonoids enhanced antioxidant activity (ABDALAH, 2013). The lowest levels of antioxidant scavenging activity were observed in the absence of organic matter. Therefore, it is sufficient to suggest that elements in the organic matter correlate to an increase in the scavenging activities of watermelon fruit. These results are not in agreement with several findings from other researchers who reported that mineral nutrition has little or no effect on the improvement of the polyphenols and antioxidants in some plants (PAVLA; POKLUDA, 2008).

It has been established that watermelon fruit contain high amounts of minerals such as Mg, K, Zn Ca, P, and Fe, and other nutrients (OYOLU, 1977). The results revealed that all organic matter used in this study resulted in an improvement of the nutrient content of the watermelon fruit. This might be due to the organic material used which increased the soil's available macro and micro nutrient status. Poultry manure and vermicompost, as reported, have high NPK (AGBEDE et al., 2008) which stands out from other treatments in improving Potassium, Magnesium and Iron content in the soil. Organic material added to the soil increases the nutrient content of radish plants due to the beneficial effects of organic matter in improving soil's nutrition status, particularly the formation of nitrogen in the soil (WAFAA et al., 2015). Plants treated with moringa extract increase the sodium and copper content of watermelon fruit. This is supported by previous research that reported moringa extract is comprised of a high combination of important minerals, vitamins, beta-carotene, essential amino acids and many phenolics which provide a rare and rich combination of flavonoid pigments with several zeatin (ANWAR et al., 2007). There is a positive correlation between flavonoids and antioxidant activity in fruit (KHANDAKER et al. 2011).

CONCLUSIONS

Watermelon crops treated with vermicompost improve chlorophyll content, chlorophyll fluorescence and stomatal conductance.

Vermicompost also enhances fruit weight and nutrient content.

Cow dung improves internal carbon dioxide, rind thickness and TSS.

Fruit juice content and the juice's pH were significantly improved with the application of goat dung.

Moringa leaves extract improves the antioxidant scavenging activities of plants. However, it has been proved that the application of vermicompost significantly improves growth, yield and the quality of watermelon.

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RESUMO: Este estudo foi desenhado para avaliar os efeitos de diferentes tipos de matéria orgânica sobre a qualidade e propriedades bioquímicas da melancia vermelha sem sementes. A pesquisa foi um experimento de fator único, que envolveu seis (6) tratamentos e quatro (4) repetições. Melancia cultivada e colhida de cinco (5) diferentes fontes de matéria orgânica, nomeadamente; vermicomposto (VC), esterco de galinha (PM), estrume de vaca (CD), esterco de cabra (GD) e extrato de folhas de moringa (MLE), nas doses de 10 ton, 20 ton, 30 ton, 30 ton e 3000 L ha-1, respectivamente, foram utilizados neste estudo. Os resultados revelaram que o tratamento do vermicomposto melhorou o teor de clorofila, a fluorescência da clorofila, a condutância estomática, o dióxido de carbono interno, a taxa fotossintética líquida, o peso do fruto e o teor de nutrientes minerais da melancia. A aplicação de esterco bovino reduziu a espessura da casca e aumentou o TSS e a atividade antioxidante da melancia. O tratamento com esterco de cabra afetou significativamente o tamanho do fruto, o teor de suco e o teor de pH do suco de fruta da melancia. Os tratamentos com esterco de galinha (PM) e extrato de moringa (MLE) resultaram no maior teor de antocianina de todas as melancias. Apesar de toda a matéria orgânica, em seus meios únicos, melhorar a qualidade da melancia vermelha sem sementes, o estudo mostra que a aplicação do vermicomposto apresentou melhor crescimento, rendimento e melhora na qualidade da melancia.

PALAVRAS CHAVE: Adubo. Qualidade. Propriedade bioquímica. Melancia.

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