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Impacts of vermicomposting rates on growth, yield and qualities of red seedless watermelon

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Abstract

A study was conducted at the teaching and research farm of the Faculty of Bioresources and Food Industry at Universiti Sultan Zainal Abidin (UniSZA) with an objective of determining the best rates for vermicompost application on red seedless watermelon var. Crimson sweet. In this research, watermelon crimson red flesh seedless variety was used as planting materials and different application rates of vermicompost were the major factor of the experiment. The research was a potted layout experiment in a completely randomized design (CRD). Sixteen (16) pots were randomly arranged in a nursery and 10 kg of BRIS soil was added into each pot until 10 cm of soil furrow slice was achieved. Application of vermicompost at the rates of 5, 10, 15, 20 t ha^{-1} and untreated control were applied, with four replications each, single plant was taken as an experimental unit from each replicate. Vermicompost treatment at the rate of 15 t ha^{-1} increased stomatal conductance, transpiration rate and the least days required to 50% flowering was significantly different compared with other treatments and control. The vermicompost application at the rate of 20 t ha^{-1} positively influences leaf area, net photosynthetic rate, internal carbon dioxide, number of flowers and fruits weight of watermelon. This findings also revealed that quality properties of watermelon like rind thickeness, TSS, pH, anthocyanin, juice and ash contents were improved with the application rate of 20 t ha^{-1}. Vermicompost application rate of 15-20 t ha^{-1} is recommended for watermelon production.

Keywords: watermelon, vermicompost, rates, growth, yield, qualities.
Abbreviations: CRD_completely randomized design, BRIS_ beach ridges interspersed with swales, t ha^{-1}_ton per hectare, DAT_days after transplant, C: N_carbihydrates: nitrogen, VC_vermicompost, *Pn*_net photosynthetic rate, TSS_total soluble solids, SE_standard error, QA_quantification of anthocyanin, µM_micro mole, Ta_air temperature, ANOVA_analysis of variance

Introduction

Watermelon plant is a native of Southern Sahara of Africa, it belongs to the family cucurbitacea and botanically identified as Citrulus lanatus. Watermelon adapts well to a wide range of climatic conditions, it now cultivated in all the tropics and subtropical countries of the world with China been its largest producer (Adeoye et al., 2007). Watermelon mostly contains water (93.2%) and other nutrients such as sugar and many vitamins such as thiamin, riboflavin, and niacin. Macronutrient potassium is also available in watermelon fruits, which is considered to help in the control of high blood pressure and perhaps avert strokes (IITA, 2013). It has been also reported that potassium helps in reducing high blood pressure and protect formation of stone in kidney.

The third world's better means of achieving soil fertility improvement and better crop production is from the use of organic fertilizer, been it inexpensive and readily accessible to the dwellers, of which animal dropping is largely available (Odedina et al., 2011). The use of organic fertilizers has enlightened farmers from the use and total reliance on synthetic fertilizers on soil fertility improvement (Schelge, 2000). Vermicompost are formed with the activities by epigeic earthworms, such as Red Wigglers (Eisenia fetida) to decompose farm, food and animal wastes. The resulting compost is high in available nitrogen and has C:N ratios of about 15:1 rendering organic matter more mineralizable than thermophilic compost by pretreating organic wastes at temperatures between 43-63°C, organic standards of pathogens and weed seeds suppression can be met. Like thermophilic compost, vermicompost has high organic matter, water holding capacity and nutrient retention but it differs in that it has faster mineralization rates, and thus greater nutrient supply rates owning to its lower C:N ratio. Apart from the nutrients in organic, its effects on the enhancement of soil organic content, soil texture and the biological life of the soil are well documented particularly at high rates of application in on field trials. Some evidence suggested that it may contain other growth-promoting substances like natural hormones and B vitamins (Leonard, 2006). The incorporation of vermicompost increased soil organic matter and total nitrogen improved the efficiency of soil phosphorus, soil organisms population increment, especially bacterias, and activity increase of soil enzymes like urease. Boyhan, (2000) reported that organic manures increased soil organic matter content and thus total nitrogen. In trying to make the world green and free of inorganic sources of plant nutrients, the available nutrients of organic source has to be renewed for proper soil fertility management (King, 1990). There are many research studies carried out that indicate the benefits derived by vermicompost which improves the performance of plants (Jeffries, 1987), is known to improve phosphorus nutrition by accessing large surface area of soil (Stancheva et al., 2004), improvement of soil acidity (Li et al., 1991) and making phosphate available to plants (Tarafdar and Marschner, 1994). The watermelon has no exception from other plants, it requires nutrients and an idle soil condition to thrive best. Inorganic fertilizers are expensive and problematic when applied in excess than organic fertilizers and hence the need for more sources of organic fertilizers and application rates of organic fertilizers is paramount to investigation for proper soil-plant utilization and farm inputs economy. Thus, the objective of this research was to identify the best application rate of vermicompost on red seedless watermelon.

Results

Vine length and leaf area of watermelonDifferent rates of vermicompost applied to watermelon at fourteen (14) days after transplant showed that rates of 5, 10, 15 t ha-1 with vine length values of 12.45, 12.54 and 11.20 cm respectively are significantly different with the control which has the least value of 9.41 cm (Fig. 1). At forty-five (45) days after transplant 5 and 10 t ha-1 produces the longest vine length (270 and 260 cm) which is statistically different with control (64 cm), 15 t ha-1 and 20 t ha-1 are statistically different from each other but different with the least control and other treatments. Application rates at 5, 10, 15 and 20 t ha-1with values of 436.25 cm, 437.5 cm, 392 cm and 409.5 cm at 65 days after transplant are significantly different with the control with the lest mean value of 192.5 cm (Fig. 1).

The results showed that vermicompost application rates significantly affect the leaf area of watermelon crops (Fig. 2). Leaf area at fourteen days after transplant was the highest at 20 t ha-1 with a value of 20.5 cm2, and it is significantly different with 5, 10 and 15 t ha-1 with mean values of 24, 25, 26 cm2. The control at 14 DAT had the lowest leaf area (20.5 cm2) and it is statistically different with the other treated watermelon plants. No significant difference was observed amongst treated plants at 45 DAT but there are significantly different with the control (Fig 2). Leaf area at 75 DAT was the least in the control with the value of 52.25 cm2 and it significantly differs with 5, 10, 15 and 20 t ha-1 at 82, 86, 87 and 89 cm2, respectively.

Net photosynthetic rate

Net photosynthetic rate measured at 14 DAT recorded 20 t ha-1 of vermicompost to be of the highest mean value (10.05 µm/m2/s), the control, 5, and 10 t ha-1 are significantly different from application rate of 20 t ha-1 (Fig. 3A). However, 15 t ha-1 (9.41 µm/m2/s) is not statistically different from 20 t ha-1. Means recorded at 45 DAT indicated that at application rate at 10, 15 and 20 t ha-1 does not differ statistically ($p \leq 0.05$). However, the control (19.95 µm/m2/s) had significant difference with all the application rates. At 75 DAT, 20 t ha-1 had the highest mean value (24.35 µm/m2/s) amongst the treatment, moreso it differs statistically with the least control treatment (19.53 µm/m2/s) (Fig. 3A).

Internal carbondioxide

Data recorded at 14 DAT shows that application rate of 15 and 20 t ha-1 of vermicompost had the highest internal CO2 values of 5.24 and 5.1 µm/mol respectively and does not vary statistically (Fig. 3B). The control with the least internal CO2 (2.54 µm/mol) varies significantly with all the treatments. Similarly, at 45 DAT 15 and 20 t ha-1 are the highest treatments with mean values of 11.88 and 12.31 µm/mol respectively as compared with the control with the least internal CO2 value (6.2 µm/mol). At 75 DAT, plant treated with 20 t ha-1 produced the highest internal CO2 concentration (8.13 µm/mol), whereas control produced the lowest internal CO2 concentration (5.78 µm/mol) and their difference was statistically significant (Fig. 3B).

Stomatal conductance

Data recorded for stomatal conductance reveals that, application rates of vermicompost at 14 DAT shows a significant difference between the control (0.03 mmol/m2/s) and 10 t ha-1 application rate with the higher value of stomatal conductance (0.04 mmol/m2/s) (Fig. 3C). However, at 45 DAT 10, 15 and 20 t ha-1 with stomatal conductance values of 17, 19 and 16 mmol/m2/s, respectively does not differ significantly between each other, but varies significantly with the control with the lowest stomatal conductance value (0.04 mmol/m2/s) at $p \leq 0.05$ (Fig. 3C). At 75 DAT, no significant differences were recorded amongst the treatment at $p \leq 0.05$.

Transpiration rate

Transpiration rate at 14 DAT showed no significant differences between application rate of 10, 15 and 20 t ha-1 (1.85, 1.9 and 1.84 mmol/m2/s, respectively) (Fig. 3D). The control and 5 t ha-1 does not differ significantly, however they are statistically different from the former. At 45 DAT, 15 and 20 t ha-1 had the highest rate transpiration rate and does not differ statistically moreso, they differ significantly from the control which has the least mean value (1.55 mmol/m2/s). Data recorded at 75 DAT has no significant difference amongst the treatment and transpiration rate decreases with harvesting stage (Fig. 3D).

Days to 50% flowering and number of flowers

The Table below shows recorded number of flowers according to watermelon flower's sex. Data for male flower indicates that 20 t ha-1 had the highest mean value (35), followed by 15 t ha-1 (33) which do not vary statistically at $p \leq 0.05$ (Table 2). However, the control with the least value (13) has significant difference with all the treatments. Similarly, 20 t ha-1 produces the highest female flower mean value (20) and is significantly different with all the treatments including the control which denotes the least female flower number (8) (Table 2). From the results, it was

Table 1. Physiochemical properties of vermicompost used in the experiment.

Parameters of vermicompost	Content
pH	7.83 ± 0.05
Total C (g/kg)	285.6 ± 1.77
Total N (g/kg)	24.20 ± 1.0
Available P (g/kg)	9.82 ± 0.11
Organic matter (g/kg)	494.4 ± 2.6
Exchangeable C/N ratio	12.2 ± 0.12
Exchangeable K (g/kg)	14.6 ± 0.16
Exchangeable Ca (g/kg)	22.4 ± 2.88
Exchangeable Mg (g/kg)	5.96 ± 0.10
Exchangeable Na (g/kg)	6.22 ± 0.03
Exchangeable Cu (g/kg)	0.92 ± 0.03
Exchangeable Fe (g/kg)	7.92 ± 0.13
Exchangeable Mn (g/kg)	12.86 ± 0.15
Exchangeable Zn (g/kg)	13.7 ± 0.13

All the data are mean of three replication.

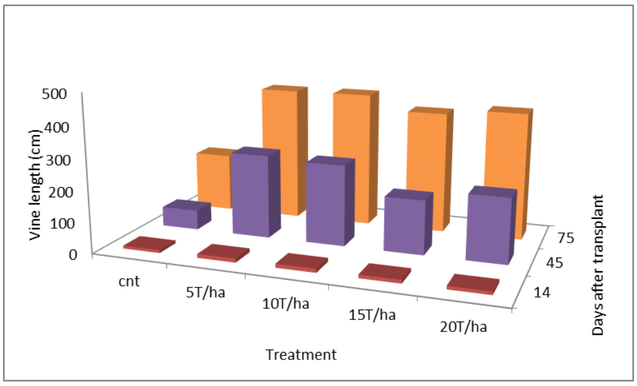

Fig 1. Effects of vermicompost application rates on the vine length watermelon. Bars indicate ± SE and different letters represent the statistical significance at p < 0.05.

Table 2. Effects of vermicomposting rates on the flowers and fruit production of watermelon.

Treatment	Parameters			
	Flowers production		Days to 50% flowering	Fruits weight (t ha^{-1})
	Male	Female		
Control	12.83 d	5.38 e	51.23 a	1200.06 d
5 t ha^{-1}	21.5 c	8.50 d	42.21 b	2016.67 c
10 t ha^{-1}	26.03 b	11.67 c	41.37 b	2191.67 b
15 tha^{-1}	32.8 a	16.5 b	40.43 b	2566.68 a
20 t ha^{-1}	35.25 a	19.5 a	48.15 a	2650.50 a
LSD	3.58	2.4	3.16	162.43
CV	6.38	9.08	3.24	3.5

Mean values with the same letters within the same column are not significantly different at p ≤ 0.05.

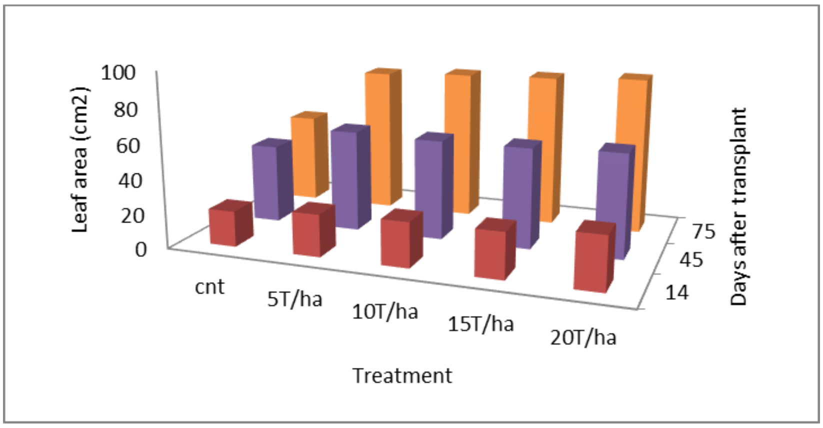

Fig 2. Effects of vermicompost application rates on the leaf area. Bars indicate ± SE and different letters represent the statistical significance at p < 0.05.

Table 3. Effects of vermicomposting rates on quality of fruits of red seedless watermelon.

Treatment	Rind (cm)	TSS (^{o}BRIX)	Ash Cnt (%)	Juice Cnt (%)	pH	Anthocynin
0 t ha^{-1}	1.55 a	7.95 b	8.65 a	91.13 c	5.26 b	0.13 c
5 t ha^{-1}	1.43 ab	8.33 b	8.03 ab	93.65 b	5.64 a	0.13 c
10 t ha^{-1}	1.35 bc	8.10 b	7.90 b	94.08 ab	5.35 ab	0.16 b
15 t ha^{-1}	1.18 cd	10.23 a	7.93 b	94.55 ab	5.58 ab	0.18 ab
20 t ha^{-1}	1.13 d	11.13 a	6.93 c	95.90 a	5.66 a	0.20 a
LSD	0.18	1.44	0.65	1.90	0.36	0.025
CV	6.09	3.77	3.77	0.93	3.07	7.17

Mean values with the same letters within the same column are not significantly different at $p \leq 0.05$

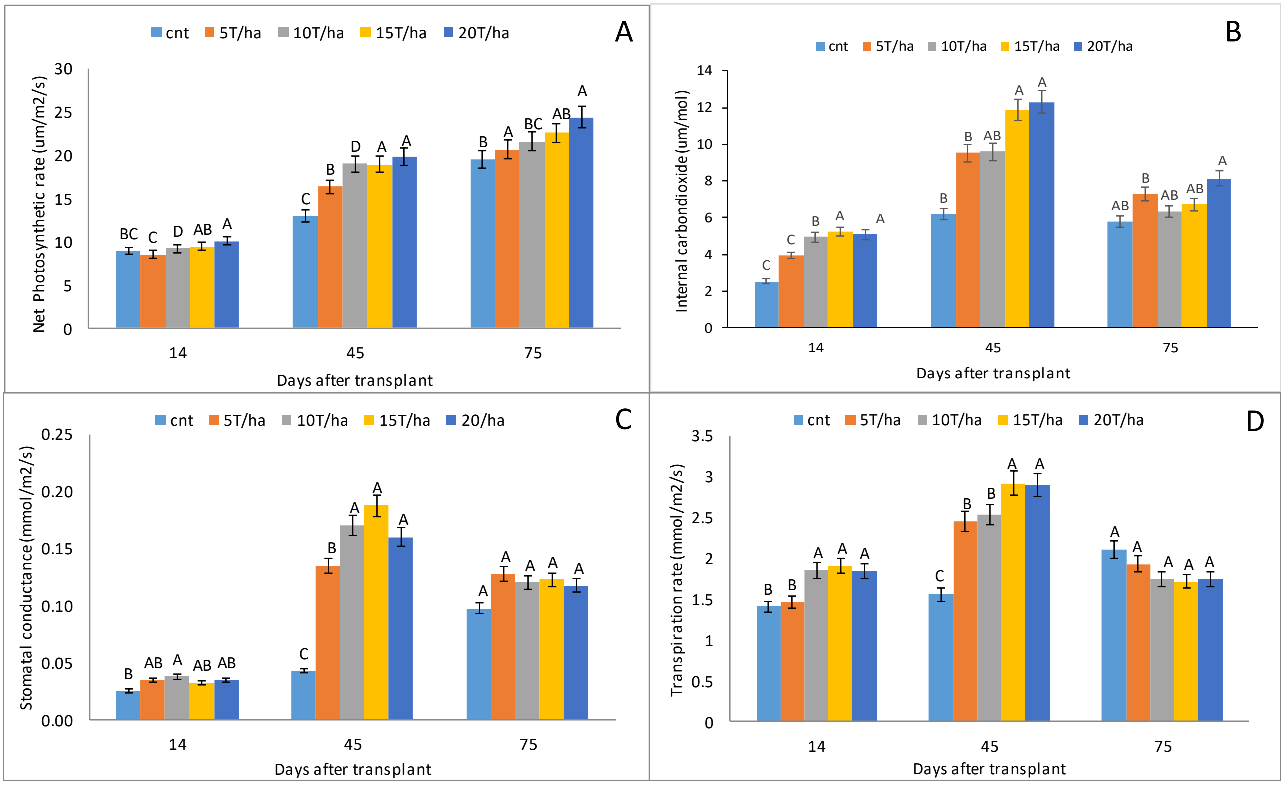

Fig 3. Effects of vermicompost application rates on the (A) Net photosynthetic rate, (B) Internal carbondioxide, (C) Stomatal conductance, (D) Transpiration rate of watermelon. Bars indicate ± SE and different letters represent the statistical significance at $p < 0.05$

Table 4. Correlation of between physiological and yield parameters of watermelon grown under vermicompost treatment.

Parameters	Vine len.	Leaf area	Net photos	Stomat cond.	Int. co2	Transrate	Days to 50% Flw	MF	FF	Fruit weight
Vine length	1									
Leaf area	0.894*	1								
Net photosyn.	0.606	0.880*	1							
Stomatal cond.	0.901*	0.938**	0.767	1						
Int. CO_2	0.707	0.948**	0.947**	0.829*	1					
Transpiration rate	0.695	0.934*	0.950**	0.888*	0.973**	1				
Days to 50% Flw	0.756	-0.650	-0.353	-0.858*	-0.476	0.589	1			
M. flower	0.589	0.886*	0.979**	0.788	0.975**	0.981**	0.422	1		
F. flower	0.445	0.795	0.969**	0.655	0.934*	0.926*	0.244	0.981**	1	
Fruit weight	0.718	0.952**	0.955**	0.876*	0.991**	0.995**	0.552	0.983**	0.931*	1

** Correlation is significant at the 0.01 level, *Correlation is significant at the $p<0.05$ level. MF-male flower, FF-female flower.

recorded that the control and 20 t ha-1 had the highest mean value for the days to 50% flowering of watermelon (51.23 and 48.15 days respectively). Results indicated that 5, 10 and 15 t ha-1 application rates were not significantly different from each other; however the later has significant differences with the former (Table 2).

Fruit weight recorded was converted to a standard of total fruits weight in kilo gram per hectare (kg ha-1). Data collected reveals that 15 and 20 t ha-1 of vermicompost application rates do not vary statistically with the highest fruit weight of 2566 and 2650 (kg ha-1) respectively. The control on the other hand had the least fruit weight (1200 kg ha-1) and it varies significantly with all the treatments tested at $p \leqslant 0.05$ (Table 2).

Fruit qualities

Watermelon rind measured showed that vermicompost application rate at 20 t ha-1 (1.13 cm) had the thinnest rind followed by 15 t ha-1 (1.18 cm) which are significantly different from the control (1.55 cm) with the thickest watermelon rind (Table 3). Results on the total soluble solids from the table 3 presented above indicates that vermicompost application rate at 20 and 15 t ha-1 had the value of TSS, 11.13 and 10.23 respectively, which varies significantly with the other treatments. Treatments of 10, 15 and 20 t ha-1 vary significantly with the others in watermelon ash content with values of 7.9, 7.93, 6.93 %, respectively, the control has the highest amount of ash content (8.65%) (Table 3). As can be seen from Table 3 the highest juice content was recorded in vermicompost application rate of 20 t ha-1 (95.5%) followed by 15 and 20 t ha-1 at 94.5 and 94.08 % respectively, the control varies statistically with all the treated crops and has the least juice content (91.13%). The pH values measured reveals that the control is significantly different with 5 t ha-1 and 20 t ha-1 application rates of vermicomposting, other treatments do not vary statistically with the former (Table 3). The amount of anthocyanin content measured reveals that vermicompost at application rate of 20 t ha-1 had the highest amount of anthocyanin which is significantly different with least control (0.13) and 5 t/ha (0.13) (Table 3).

Correlation of the physiological properties

Results from the correlation matrix reveals that vine length is positively correlated to leaf and stomatal conductance (Table 4). Leaf area is significantly correlated to net photosynthesis, transpiration rate and number of male flowers at p level of 0.05, hence it is highly related with stomatal conductance, internal carbondioxide and fruit weight at p level of 0.05 (Table 4). Results indicates that net photosynthetic rate has significant positive correlation with internal CO2, transpiration rate, male and female flowers production and fruit weight. It can be observed from the results that stomatal conductance is positively correlated with internal CO2, transpiration rate and fruit weight, moreso it has significant negative correlation with days to 50% flowering (Table 4). However, days to 50% flowering have negative correlations with flowers production and fruit weight. However, male flower significant relates with female flowers production and fruit weight (Table 4).

Discussion

Vermicompost application rates at 5 and 10 t ha-1 significantly increases the length of vines of watermelon at early stage of the plant growth cycle, in this stage the higher rate did not performed as anticipated, this might be so because high rates of vermicompost produces high dose of Ca which can cause retard growth of shoots, this observation is in concordance with the findings of Aggelides and Londra (1999), whom reported that decline in growth of tomato with adding vermicompost was probably due to increase in Ca uptake. In the late vegetative stage of the crops life all the application rates performed more way than the control and this might be so because at the that stage a complete mineralization and integrations of the vermicompost has took place. Higher rate of manure improves moisture availability which inturn enhances and release more nutrient elements for increased vine growth (Enujeke, 2013).

Leaf area of watermelon increases as application rates of vermicompost increases, these was so because higher rates of vermicompost improves the soil physical and chemical properties and gives crop optimum conditions for growth and development. This results tallies with the findings of Aliyu (2000), which indicated that higher rates of manure improves soil properties and increases the growth and development of tomato crop. Arancon et al. (2004) reported positive effects of vermicompost in increasing leaf area of tomato, pepper and strawberry plants. Leaf area aslo increased by growth regulators application and phloemic stress (Saifuddin et al., 2009). A higher rate of vermicompost gives higher net photosynthetic rate in watermelon. Nutrients such as N, P, K, Mg, Fe and Cu, are abundantly found in vermicompost which are used in the formation of chlorophyll which is required for synthesizing of light and subsequent conversion into chemical energy via photo-assimilation (Tanaka et al., 1998). Vermicompost at different application rates enhanced the production of chlorophyll and improves photosynthetic activity in some selected horticultural crops. This improved photosynthesis may increased the carbohydrates availability in the plant parts. Moneruzzaman et al. (2010a) reported that exogenous application of sugar to the plant parts improved the quality of deatached plant parts. Theunissen et al. (2010) and also Ali (2014) reported that increased vermicompost at 30%, enhances total leaf chlorophyll content of marigold plant. Results from this experiment shows that higher rate of vermicompost enhanced the stomatal conductance of watermelon crops. According to Khandaker et al. (2017), the highest value of stomatal conductivity of chilli was recorded with the application of vermicompost. It was also observed from the results the higher the net photosynthetic rate the higher the stomatal conductance. Stomatal conductance improves the net photosynthetic rate by regulating CO2 fixation in the leaf mesophyll tissue and is positively correlated with photosynthesis (Khandaker et al., 2013a). Transpiration rates increases as plant growth with increase in vermicompost rate, this was so probably because the increase rate of NPK has effects on internal CO2, and this findings is in conflict with that of Zhu et al. (2010), who reported that increase in NPK rate reduces the transpiration rate of tomato plant. Berova and Karanatsidis (2009) reported that increase photosynthetic pigments and leaf gas exchange in Capsicum annum due to application of vermicompost. At the fruit maturation stage of the crop's life the lesser rate out-performs the higher rates; this might be so because the chlorophyll content and other pigment lost from the leaf mesophyll tissue. Days required to 50% flowering were enhanced with application of high rates of vermicompost in this current study. Haruna et al. (2011) reported that increasing poultry dung rates significantly increases number of days to 50% flowering. However, the highest rate of 20 t ha-1 does not vary significantly with the control, this might be so because the high dose of vermicompost may distort the soil microbial and physical properties as the experiment was conducted in a pot. From this study, significant minimum days were recorded for flower formation in pots treated with 5, 10 15 t ha-1 of vermicompost. Prasad et al. (2009) similarly reported some results in Momordica charantia and Cucumis sativus. In this research, it was observed that number of flowers increases asymmetrically as vermicompost rates increases geometrically. Marc et al. (2015) reported that increased vermicompost improves the number of flowers. A research conducted by Ali (2014) on Calendula officinalis reveals that the highest number of flower bud and open floret was achieved in 60% vermicompost treatment. Some other agricultural practices like as removal of young leaves and growth regulators application stimulates the flowering and improve the flower quality (Moneruzzaman et al., 2010b). Increase in flower number has to with increases in photosynthetic activities and carbohydrate accumulation within the plant (Khaderker et al., 2017). The results are in concordance with those of Roychaudhury et al. (1995) who reported that number of fruit per plant increases with increasing nitrogen application and assimilation rate. It was also reported that carbohydrate accumulation is high in the girdle branch which increase the number of fruits (khandaker et al., 2011). Our results showed that numbers of male flowers outweighs that of the opposite sex, this was so because; the male flowers are initially produced in a watermelon crop. This is supported with the findings of Thriveni (2015), who stated that the female flowers of melon initiates 10 days after the production of the male flowers. Similarly, it was also observed that different rate of vermicompost on Chrysanthemum chinensis produces high fresh weight of flowers and number of flowers per plant (Nethra et al., 1999).

Results from the study conducted shows that fruit weight was enhanced as vermicompost application rate was increasing. Increase in vermicompost rate had significant effect on fruit yield and weight this was because the vermicompost improves moisture retention in the soil and improves soil chemical and microbiological activities. This is supported by Edwards and Burrows 1988; Canellas et al. 2002. Application of organic manures increases fresh weights of the fruits per plant (Khandaker et al., 2017). In a similar research conducted by Thriveni (2015), he reported that bitter gourd produces 4000 kg ha-1 of fruit weight with increased rate of vermicompost. Vermicompost applied at a rate of 5 t ha-1 have also been reported to significantly increase yield of tomato (5.8 t ha-1) in farmers' fields compared with control (3.5 t ha-1) (Nagavallemma et al., 2004). Crop growth regulators and other plant growth influencing substances produced by microorganisms are also present in vermicompost (Tomati et al., 1988), higher rates of VC influences the rind thickness of watermelons, this might in relation of the growth regulators in VC. Fruit juice and total soluble solids content in fruits are impotant parameters that strongly affect consumer acceptability (Moneruzzaman et al., 2011).

It has been reported that growth regulators increased fruit juice, TSS content and produced better quality fruits (Khandaker et al., 2013b). Moreso, there direct correlation of increasing VC rates with ripening of fruits thus the TSS content, juice content and percentage of ash of watermelon fruits can be attributed higher rates of vermicomposting, this agrees with the findings of Gutrierrez et al. (2007). The pH value of influences the ability of minerals to dissolve in water, continues increment in VC rates increases the pH of watermelon fruits. Accumulation of anthocyanin content in fruits varied with the growing condition and growth regulators application (Khandaker et al., 2012). Fruit quality trait like the anthocyanin content was enhanced in this study, and it suffice to suggest that high rates of VC positively influences the anthocyanin content in a watermelon, different rates of vermicompost might have favored the cultivation of firmer, better colored and quality fruit (Singh et al. 2008).

Materials and methods

Plant materials

A potted research was conducted at the teaching and research farm of the Faculty of Bioresources and Food Industry at Universiti Sultan Zainal Abidin (UniSZA), Besut Campus, Besut, Terengganu, Malaysia, with atmospheric annual temperature of 21-30 °C and relative humidity of 60-90%. Located at 5.7471°N, 102.6101°E. In this research, watermelon Red Flesh Seedless Variety (Crimson sweet F1 hybrid) was used as planting materials and different application rates of vermicompost was the major factor of the experiment. Application rates of 5, 10, 15, 20 t ha-1 and untreated control were applied with four replications each, single plant was taken as an experimental unit from each replicate.

Experimental design and treatment application

The research was a potted layout experiment in a Completely Randomized Design (CRD). Sixteen (16) pots were randomly arranged in a nursery and 10 kg of soil was added into each pot until 10 cm of soil furrow slice was achieved. Vermicompost was analyzed before the treatment application (Table 1). Vermicompost application rate was converted from the standard t ha-1 and applied to the pots in g/pot, using the following formular:10,000 m2 in one hectare x 0.1 m soil depth x 1.5 g/cm3 bulk density = 1500 t ha-1 of soil.

Furrow slice = 1 ha has 1500000 kg of soil.
If 1 t ha-1 is used for 10 kg soil (pot soil),
Then, ton is converted into kg,
=(1000kg (VC @ 1 t/ha))/(1500000 kg) = 0.00067 / kg-1 soil
Convert kg to = 0.67 g of VC/ kg-1
= 0.067 X 10 (soil in pot)
= 6.7 g/pot @ 1 t ha-1

Measurement of vine length and leaf area

Vine length was measured from the base of randomly selected five plants/plot to the growing tip of a main vine using a flexible measuring tape as per methods used by Grant and Todd (2001) . The main vine was chosen from those beginning close to the base of the plant and extending the farthest from the base, vine length was measured at intervals. Fresh leaves from watermelon branches are randomly collected washed, clean and flattened beforehand from each plot and measured by using the Leaf Area Meter (Model Portable Laser CI-202, CID Bio-science, USA) with replicate data recorded.

Photosynthetical characteristics

Data for net photosynthetic rate (Pn) was recorded as µm/m2/s .Transpiration rate (E) data was read as mmol/m2/s. Stomatal conductance (C) was read as mmol/m2/s. Finally, internal carbon dioxide concentration (IntCO2) was recorded as µm/mol. Data were collected using same equipment, C1-340 Handheld Photosynthesis System (CID Bio-Science, USA). All the necessary setup and calibaration were followed according to manual of C1-340 Handled Photosynthesis System (CID Bio-Science, USA) given. Photosynthesis rate was determined by measuring the rate at which a known leaf area assimilates the CO2 concentration in a given time. The calculation for net photosynthetic rate was determined as below:

Pn = -W x (Co – Ci) = -2005.39 x ((V x P)/(Ta x A)) x (Co – Ci)

Where Pn: Net photosynthesis rate (µmol/m2/s), W: mass flow rate, Co (Ci): outlet (inlet) CO2 concentration (ppm or µmol/mol), P: atmospheric pressure (bar), Ta: air temperature, A: leaf area (cm2).

While, the rate of transpiration was determined by the water vapour flux accumulates per one sided leaf in a given times. The calculation used to get the transpiration rate as below:

E = ((eo – ei)/(P – eo)) x W x 103

eo = hro x es/100 ei = hri x es/100

es = 6.13753 x 10-3x e Ta x (18.564 - T / 254.4)/ (Ta+ 255.57)

Where eo (ei): outlet (inlet) water vapour (bar), P: atmospheric pressure (bar), es: saturated water vapour at air temperature (bar), Ta: air temperature (oC), hro (hri): outlet (inlet) relative humidity (%).

Flower production and number of fruits produced

From the initial planting of the seedlings to the flowering of 50% of crops on each plot, the number of flowers and buds on crops are recorded and presented as days to 50% flowering. Male and female flowers are also counted separately and recorded in the log book. Ripe fruits were determine by observing the tendril (dried and brown tendril signifies ripe fruits) or the watermelon fruits were gently hit and metallic or hollow sound is an indication of ripe fruits. Total number of fruits at harvest per treatment were counted and recorded as total yield per hectare.

Determination of fruit qualities

Fruit rind was measured with the aid of digital vernier calipers and recorded in cm. The total moisture and ash component of the samples were determined by methods describe by Inuwa et al. (2011). Crucibles were oven dried at 90oC for 30 min and transferred into desiccators to cool. After cooling, watermelon flesh was diced into cubes of 5 mm x 5 mm x 5 mm size. Each sample was weighed in the crucible and oven dried at 110 oC to a constant weight. The percentage juice and ash content of each sample were then calculated. Total soluble solids was determined with use of handheld refractometer. And juice pH was measured with using a glass electrode pH meter after extracting the juice and sieving the pulp. Photometric determination of anthocyanins was performed, spectrometer was used to determine the absorptions of samples. Absorption of the extracts at 530- and 657-nm wavelength was determined photometrically.Quantification of anthocyanins was performed using the following equation: QAnthocyanins =(A530 – 0.25* A657) X M-1, where QAnthocyanins is a corrected absorption value linearly correlatedwith the amount of anthocyanins, A530 and A657 is the absorption at the indicated wavelengths and M is the weight of the plant material used for extraction (g).

Statistical analysis

Data were analyzed for the differences in the mean value among the treatments by using one way repeated ANOVA procedure and means were separated using Duncan's Multiple Range Test (DMRT) with SAS 9.4. Differences at $P \leqslant 0.05$ were considered as significant

Conclusion

From the results above on the effects of different application rate of vermicompost on red seedless watermelon growth and yield, all the rates are superior to the control but higher rates of 15 and 20 t ha-1 gave the best result in growth and yield of watermelon. Application of vermicompost at the rate of 15 t ha-1 increased stomatal conductance, transpiration rate and the least days required to 50% flowering was significantly different compared with other treatments and control. Vermicompost application at the rate of 20 t ha-1 positively influences leaf area, net photosynthetic rate, internal carbon dioxide, number of flowers and fruits weight of watermelon. This findings also reveals that quality properties of watermelon like rind thickeness, TSS, pH, Anthocyanin, Juice and ash contents were improved with the application rate of 15-20 t ha-1. Vermicompost application rate of 15-20 t ha-1 is recommended for watermelon production.

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