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IMPACT OF ORGANIC FERTILIZATIONS IN IMPROVING BRIS SOIL CONDITIONS AND GROWTH OF WATERMELON (*CITRULLUS LANATUS*)

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Abstract

Dalorima, T., M. M. Khandaker, A. J. Zakaria and M. Hasbullah, 2018. Impact of organic fertilizations in improving bris soil conditions and growth of watermelon (*Citrullus lanatus*). *Bulg. J. Agric. Sci.*, 24 (1): 112–118

Watermelon has been an important and demanding vegetable crop worldwide; however its production is limited by poor soil conditions. An open field experimental research was conducted at the research farm of the faculty of bioresources and food industry at Universiti Sultan Zainal Abidin (UniSZA). With the aim to find out the impact of different organic matters fertilization in amending the BRIS soil and to ascertain the growth and development of watermelon under these organic matters. The experiment was set up in randomized complete block design (RCBD) with four replications. The factors taken for the experiment were five different organic matters, viz., poultry manure, vermicompost, cowdung, goat dung, and moringa leave extract at the rate of 20 t/ha, 10 t/ha, 30 t/ha, 30 t/ha and 300L/ha respectively. Soils chemical properties especially the pH, nitrogen, phosphorus and potassium were improved in plots were vermicompost and poultry manure were applied. Watermelon crops grown on BRIS soil treated with vermicompost significantly improves physiological properties such as vine lengths, number of leaves, number branches, leaf area and chlorophyll content. Furthermore, highest number of fruits per hectare was obtained in plants treated with vermicompost. Cowdung improves internal carbondioxide, transpiration rate and net photosynthetic rates. The application of vermicompost as an organic manure on the BRIS is thus recommended for better growth and yield of watermelon. More so, these manures can be used as a source of organic soil amender on the sandy BRIS.

Key words: BRIS soil; organic; growth; quality; watermelon

Introduction

The incorpration of organic matters as fertilizers increases soil organic matter content, total nitrogen, phosphorus, soil organisms pollulation, especially bacterias and their activities increseses soil enzymes like urease (Boyhan et al., 2000). Organic matters have been reported by many researchers to give significant improvement in crop growth and yield. Organic matters are a reservoir of nutrients and these nutrients are released during mineralization and humification, thus supplying the necessary elements for plant growth (Chiezey and Odunze, 2009). The application of organic manure has been observed to consistently increase the yields of horticultural crops such as eggplant (*Solanum melongena*), pepper (*Capsicum annum L.*) and tomatoes (*Lycopersicon esculentus*). According to Aliyu (2000), the increase in nitrogen as found in organic manures has its effect on the vegetative improvement of crops and ensures healthy and vigorous growth. Barreto and Dynia (1988) reported that the use of several organic matters were economically beneficial to horticultural crops. Organic matter contributed to improvement in soil physical properties, therefore organic matter stabilized soil structure thereby reducing soil bulk density and increasing porosity (Obi and Ebo, 1995). Akanni (2005) reported that soil physical prop-

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erties such as bulk density and total porosity were improved by amending the soil with organic matters. Beach Ridges Interspersed with Swales commonly abbreviated as BRIS originates in peninsular Malaysia. These BRIS soils are very common along the east coast states Kelantan and Mersing in Johor. BRIS soil is composed of more than 95% sand with less than 3% silt and clay (Aminah et al., 2006). The application of various organic matter amendments has proven to improve the fertility of BRIS soils (Othman et al., 1992). The BRIS Soil is a challenging soil for agronomy, it lacks in many aspects, previous studies shows it to be sandy, weakly structured, nutrient deficient, having low water holding capacity, limited ability to support plant growth, having a relatively high soil temperature, low organic matter contents, excessive nutrient leaching and the soil harbors serious infestation of nematodes on crops. Thus, the objective of this research is to determine the chemical characteristic and nematode population of BRIS soil after amendments with organic matters and to ascertain the effectiveness of different organic matters on the growth and yield of watermelon.

Materials and Methods

Experimental site and plant material

The experiment was an open field research conducted at the teaching and research farm of the faculty of bioresources and food industry at Universiti Sultan Zainal Abidin (UniSZA), kampus Tembila, Besut Malaysia, with atmospheric annual temperature of 21-30 °C and relative humidity of 60-90%. Located at 5.7471°N, 102.6101°E, the study continues through the raining season of 2016/2017. In this research, watermelon Red Flesh Seedless Variety (F1 hybrid) was used as planting materials and different organic manures viz., well decomposed cowdung, vermicompost, poultry manure, goat dung and moringa leaf extract were used as the sources of plant nutrients. The seeds of watermelon and the organic manures were collected from AGROPOLIS, UniSZA.

Experimental design

The research is a single factor experiment, which involves six (6) treatments. Recommended rates of organic matter were used for treatment application. Viz; vermicompost (VC) @ 10t ha^{-1}, poultry manure (PM) @ 20t ha^{-1}, cowdung (CD) @ 30t ha^{-1}, goatdung (GD) @ 30t ha^{-1}, moringa leaf extract (MLE) @ 3000L ha^{-1} (diluted volume) and control. The experiment consisting of 6 treatments which were laid out in randomized complete block design (RCBD) with four replications. The whole field was first divided into four blocks each containing 6 plots. In total, there were 24 unit plots. The treatments were randomly assigned to each unit plot so as to allot one treatment in each block. The size of each unit plot was 1 m x 15 m. The distance between the blocks was 2 m and between the plots was 0.5 m.

Soil samples and analysis

The soil samples were air-dried and sieved through a ≤2.0 mm sieve in the laboratory. The following physicochemical properties of the soil were determined; soil texture by pipette method (Day, 1965), total organic carbon by LECO carbon analyzer (model CR-412; LECO Corp., St. Joseph, Mich.), total N by Kjeldahl method (Bremner, 1960), extractable P by Bray and Kurtz no. 2 procedure (Bray and Kurtz, 1945), pH in water at soil: water of 1:5. The concentrations of nitrogen (N), phosphorus (P) and potassium (K) in the solution were determined using an autoanalyzer (QuikChem, Series 8000, Lachat Instruments Inc., USA). The initial physical and chemical properties of the soil are presented in Table 1.

Table 1
The initial physio-chemical properties of BRIS soil used in the experiment

Variables	Content
Sand (%)	95.4
Silt (%)	2.3
Clay (%)	1.5
pH (H2O)	4.8
Organic carbon (%)	0.45
N (g kg^{-1})	0.23
P (g kg^{-1})	0.07
K (g kg^{-1})	0.09

Growth measurements

Vine length was measured from the base of randomly selected five plants/plot to the growing point of a main vine using a flexible metric tape as per methods used by Grant and Todd (2001). Leaves area was measured with the aid of Leaf Area Meter (Model Portable Laser CI-202, CID Bio-science, USA). Chlorophyll fluorescence measurements were performed using the Handy-PEA (Plant Efficiency Analyser, Hansatech Instruments Ltd, UK). Konica Minolta Chlorophyll Meter (Model: SPAD 502Plus) was deployed to measure chlorophyll content. Number of fruits produced were manually counted and logged.

Statistical analysis

Data on crop growth were subjected to statistical analysis (ANOVA) using SAS statistical package (SAS, 2007). Mean comparisons were performed by Duncan's multiple range test (DMRT) at P≤0.05.

Results

Effects of organic matters on the chemical properties of BRIS Soil

Results in Table 2 shows that, soil amended with moringa leaves extract measured the least pH value (4.35), while the soils amended with vermicompost had the highest pH value 6.78. Total nitrogen percentage was highest in poultry manure treatment (0.147%) and lowest in the control, however the other treatments had higher total nitrogen percentage as compared with the Control. Poultry manure (1.8%) had the highest total carbon percent followed by vermicompost (1.34%) then goat dung (1.13%), the control (0.61%) had the least measured total carbon percentage. Potassium content was highest in poultry manure (0.77) followed by vermicompost (0.75), moringa leaves extract measured 0.06 cmol/kg of potassium while the control had the lowest potassium content (0.04 cmol/kg).

Available Phosphorus measured indicates that the soil samples collected from plots amended with vermicompost had the highest available phosphorus (76.54 ppm), followed by the treatments by poultry manure (65.23 ppm), other treatments used had shown some promises excluding the control which had the least available phosphorus content (3.23).

Vine length

The vine length of the crop was measured at 10 days, 32 days 54 days, 76 days and 87 days after transplanting (DAT) (Figure 1). It was observed that at 10DAT vermicompost and poultry manure had significantly longer vines of mean value 12.4 and 12.5 cm respectively than the control treatment, the control had the lowest mean value in term of vine length (9.4cm). However, cow dung, goat dung and moringa leave extract are not significantly different from all the treatments. In other observation of 32DAT, VC and PM had the significant higher vine length of 76 and 62cm, goat dung at 32days after transplant is different from all the treatments, CD and MLE are not statistically significant from the control with the least vine length of 21cm. At 54DAT, it was recorded that vermicompost and poultry manure are statistically higher than all the treatments with the vine length of 270 and 260cm respectively.

Cowdung and goat dung are significantly different from the other treatments, moreover, MLE is not different from the control. Similarly, VC and PM performed significantly higher than the other treatments at 76DAT with vine length of 480 and 416cm respectively; from the results obtained CD is not significantly different from GD. The control gave the lowest vine length of the mean value of 194cm at 76days which is not statistically different from MLE. Results measured from 87DAT indicated that VC had the higher vine length which is statistically significant with all the treatments, MLE with recorded mean value of 248 cm is also significantly different with the rest of the treatments, however, PM, CD, GD and the control treatment are not statistically different from each other.

Number of leaves

The results on the number of leaves of watermelon treated with different organic matters are presented in Figure 2 below. Results obtained from 21DAT showed no significant differences amongst one another. Number of leaves recorded at 42DAT showed that the control has the least significant mean value from the rest of the treatment. VC at 63DAT gave the highest mean value of 41.2 leaves which is not statistically different from poultry manure; the control has the least mean value of 25 leaves however it is not statistically different from MLE. Results obtain from 84DAT indicated that the control and vermicompost are significantly different from each another, however PM, GD and MLE are not statistically different from CD and the Control.

Number of branches

The numbers of branches of the study crop watermelon were recorded at 14, 45, and 75DAT (Figure 3). Results indicated that number of branches between the treatments at 10DAT were not statistically significant from each other, similarly was it recorded in 45DAT. Results observed from 45DAT gave a turn around, VC had the highest mean value of number branches (5.5) which is not significant different from PM, CD and GD, however MLE and control are also not statistically different from PM, CD and GD.

Leaf area

Results obtain on leaf area of watermelon as treated with different organic matters indicated that, they were no any significant difference amongst the treatments at 10DAT and 45DAT (Figure 4). However, it was recorded that at 75DAT the control obtain the least mean value of 45.2 (cm^2) which was significantly different from VC, PM, CD, GD and MLE with the mean values of 83.7, 69.7, 78.2, 74.2, and 82.7 (cm^2) respectively.

Chlorophyll content

The chlorophyll content of watermelon crops was measured at intervals of 21, 42, 63, and 84 days after Transplanting (Figure 5). The chlorophyll content at 21DAT between the treatments has no significant differences from one another, like no statistical difference was recorded between treatments at 42DAT. Vermicompost varies significantly with cow dung, goat dung, moringa extract and control, moreover it is not significantly different from poultry manure, the mean

values of PM CD and GD are not significantly different from each order however control and MLE with least mean value of 41 and 41 respectively are not statistically different from GD (47.2SPAD) at 84DAT.

Chlorophyll fluorescence

Chlorophyll fluorescence was recorded at 14, 45 and 75 days after transplant (Figure 6), results obtain indicated that at 14 and 45DAT no significant differences was observed amongst the treatment, however at 75DAT VC, PM and CD had the highest mean values of 0.82, 0.82 and 0.82 F_v/F_m respectively and are statistically significant as compared with control with the least mean value of 0.80 F_v/F_m. Moreover, GD and MLE are not statistically different from the control.

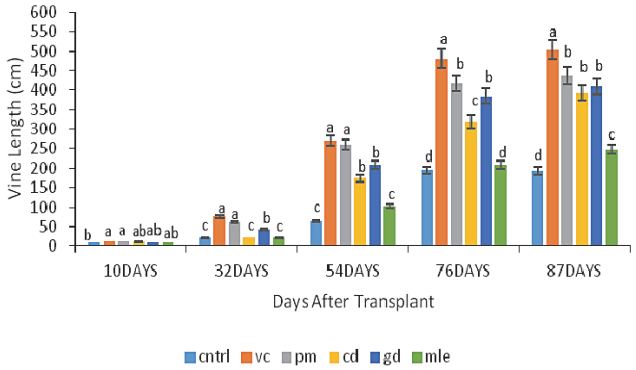

Fig. 1. Effects of organic matters on the vine length of watermelon

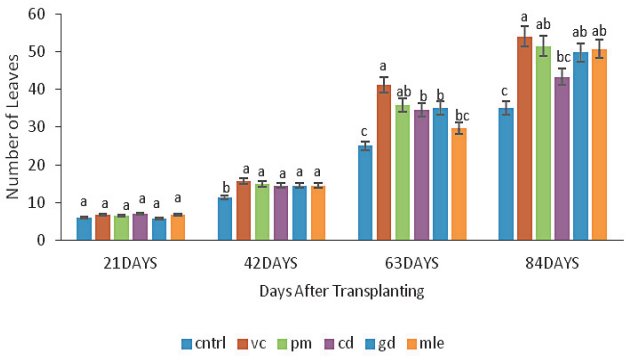

Fig. 2. Effects of organic matters on the number of leaves of watermelon

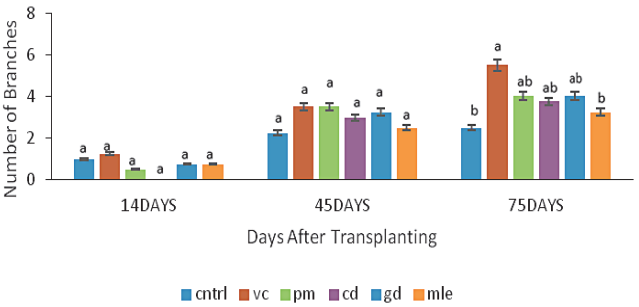

Fig. 3. Effects of organic matters on the number of branches of watermelon

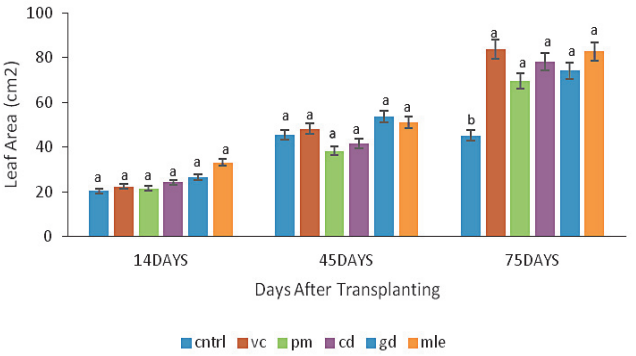

Fig. 4. Effect of organic matters on leaf area of watermelon

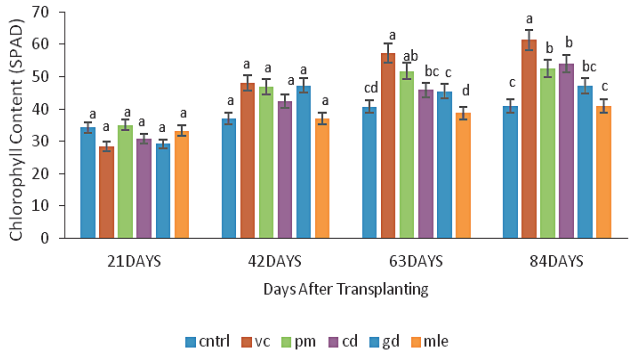

Fig. 5. Effects of organic matters on the chlorophyll content of watermelon

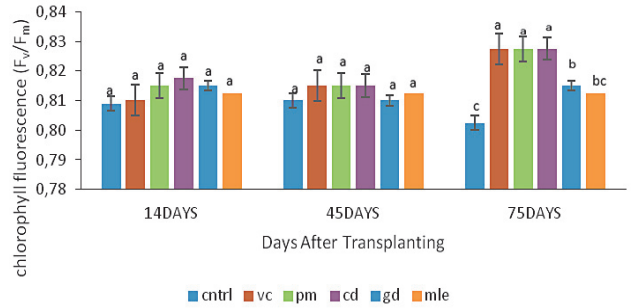

Fig. 6. Effects of organic matter on chlorophyll fluorescence of watermelon

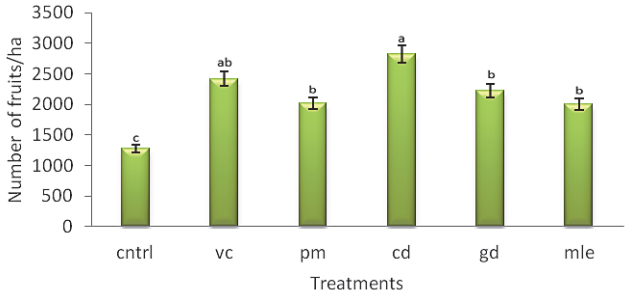

Fig. 7. Effects of organic matters on the number of fruits Ha-1 of watermelon (*Citrulus lanatus*)

Number of fruits Ha^{-1}

Produced number of fruits per hectare, CD (2816.68), PM (2016.67), GD (2225) and MLE (2000) (Figure 7) are all significantly different from the Control, which has the least mean value of 1275.06.

Discussions

Effects of organic matters on chemical properties of BRIS Soil

The application of organic matters as soil amendments as the major treatment of the study necessitated the chemical characterization of the soil with organic materials used. The results of some selected chemical properties of amended BRIS (Table 2), shows that all the organic matters applied as soil amended improved the soil pH as compared with the control. Total nitrogen and total carbon were as well improved in soils treated organic fertilizers especially in in poultry manure and vermicompost, soils treated with moringa extract does not deposit much carbon content, this was because moringa extract is a biostimulant not a manure.

Exchangeable bases (K, Ca, Mg and Na) increases as organic matters are applied to the soils; however aluminum content was suppressed by organic matters. This is in concordance with the findings of (Ayodele, 1984). The organic matter component of decomposed poultry manure led to the release of nutrients to the soil. Hence it was found that poultry manure increased soil N, P, K, Ca, and Mg significantly (Agbede et al., 2008). Cation exchange capacity (CEC) increases as organic matters are increased, this is probably due to its negative surface charges and its high specific surface area, the higher the CEC the higher the exchangeable bases, this is confirmed by Manya (2012). Available phosphorus is improved with the application of organic matter. Abbas, (2003) found that available phosphorus increases with increased in organic matter application.

Effects of Organic Matters on the Physiological Properties of Watermelon Grown on BRIS Soil

In this study, differences between treatments were observed starting from 10 DAT, this was because the plants had to establish a well-developed root system to tap nutrients and soil moisture, this argument is in concordance with the study of Ahmed et al. (2007). Vermicompost proved to be the best treatment in regards to length of vines of watermelon crop at succession of intervals, this observation is similar with the findings of Prabhu et al. (2006), whom reported that vermicompost improves the vine length of cucumber. Vermicompost has promising nutrients value than traditional organic manures. This is due to increased rate of mineralization and degree of humification by the action of biological agents. Vermicomposting has the properties to conserve moist in the soil and this in turn could help in improving vine lengths of watermelons. Increased length of vine induce other physiological parameters of watermelon, the number of leaves, leaf area, number of branches were also higher in fields treated with vermicompost, this was influenced as a result of vermicompost produces increased activity of microorganism which has a positive effect on plant growth and subsequently the enhanced plant height (Darzi et al., 2012). Application of poultry manure also improves the vine length of watermelon;

Table 2
Chemical properties of soil at harvest

Treatment	pH (w)	T-N	T-C	K	Av. P
		%		ppm	
Control	5.02	0.032	0.61	0.04	3.23
VC	6.78	0.139	1.34	0.75	76.54
PM	5.13	0.147	1.8	0.77	65.23
CD	5.75	0.059	1.07	0.43	25.87
GD	6.51	0.075	1.13	0.38	31.45
MLE	5.35	0.081	0.87	0.06	14.23

VC – Vermicompost, PM – Poultry manure, CD – Cowdung, GD- Goat dung, MLE – Moringa Leaf Extract, pH (w) – Soil pH in water, TN – Total Nitrogen, TC – Total Carbon, K – Potassium, Av. P – Available Phosphorus, ppm – parts per million

many investigators came to similar results. However, Agba and Enga (2005) reported that there was an increase in vine length and growth component of cucumber plants in respond to increase the level of poultry manure application.

Chlorophyll contents in the leaves of plants are related to the amount of nutrients absorbed by the plant from the soil, which translate to the physiological performance of the plant (Follet et al. 1981). Chlorophyll contents of watermelon crops were higher at 63 and 84DAT. Malgorzata et al. (2010) reported that chlorophyll content of vegetable crops increases at the peak growth stage. The opening and closure of stomata will affect photosynthetic CO_2 fixation in mesophyll tissues, this has also shown to be affected by organic matters in the soil. Results indicated that vermicompost improves the chlorophyll content in watermelon; Zhang et al. (2011) tested watermelon on vermicompost and reported that vermicompost could significantly increase the cholorophyll content. It has been reported that application of 1-Triacontanol increased the pigments content in the potted Bougainvillea plant (Khandaker et al., 2013). Poultry manure also shows a promising result, these results are consistent with those reported by Ondieki et al. (2011).The results are also in agreement with a research conducted by Sumeet et al. (2009), who reported that chlorophyll is strongly related to nitrogen concentration in the soil.

The chlorophyll fluorescence has become one of the most powerful and widely used techniques available to plant physiologist and it gives information about the state of photo system II (Adel. et al. 2011). Chlorophyll fluorescence was relatively lower in all the treated plants compared to the Control at all tested succession of days after transplant, this is because chlorophyll fluorescence ratio indicates the photochemical efficiency of crops, a higher decrease in this parameter occurs in plants grown in higher O_2 concentration when a higher N concentration was applied (Shangguan et al. 2000). The minimum level of fluorescence content adapted the state of leaves remained unchanged in all treatments, indicating that organic matters had effects on improving the chlorophyll fluoresce of watermelon.

Results indicated that number of fruits were higher in cowdung, this was because cowdung is rich in organic matter content which improves the soil physical properties which results in adequate moisture retention in the soil. This is confirmity with the studies of Giller (2002), who found out that cow dung increase organic matter content, water retension capacity and crop nutreints. It also improves the efficiency of mineral fertilizer by enhancing the physical properties of the soil. Soil amended with cowdung contains enough phosphorus and potasium and lime. (Deliparthy et al., 1994). The other organic matters also performed as expected, as compared with control. In many crops, fruit size is a genetic characteristic of the cultivars. Hence, Hence, fruit size is affected by the cultural practices including use of fertilizers and growth promoting substances (Moneruzzaman et al., 2012). Increased numbers of fruits per hectare with organic fertilzers is due to their effect on plant growth stimulation through increased cell division, as well as optimized uptake of nutrients and water (Abd-El- Kareem, 2007). Khandaker et al. (2013) reported that localized application of plant growth regulators increased the fruit size and yield of wax apple fruits. In another study, it has been reported that defoliation of excessive leaves and kinetin treatment increased the flower development (Moneruzzaman et al., 2010). Saifuddin et al. (2009) reported that application of plant growth regulators increased the flower bud opening and petal expansion.

Conclusion

Fom the above, our results demonstrated that vermicompost and poultry manure improves the chemical properties of BRIS soil and inturn improves the growth and physiological properties of watermelon grown on amended BRIS soil.

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