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YIELD AND QUALITY OF AMARANTH AND WATER SPINACH AS AFFECTED BY ORGANIC FERTILIZERS AND LEGUME RESIDUES

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ABSTRACT

Amaranth (*Amaranthus paniculatus*) and water spinach (*Ipomoea reptans*) grown after legume residues with organic fertilizers are helpful to improve their yield and quality. Therefore, a study was carried out at the net house of the University of Malaya, Malaysia in pot assay from November 2014 to June 2015. Amaranth and water spinach were grown after yard long bean (YLB), bush bean (BB) and winged bean (WB) with VC+YLB, COM+YLB and FP+YLB; VC+BB, COM+BB and FP+BB; VC+WB, COM+WB and FP+WB treatments whereas legume was grown with VC, COM and FP treatments in complete randomized design. The highest biomass yield (889.81 g/m^2) and leaf number (15.67) of amaranth was observed in VC+YLB treatment. Maximum protein content (2.16 g/100g) was observed when amaranth was grown with VC+BB. Fe, Ca and Mg content of amaranth was also higher in VC+YLB treatment. Amaranth after YLB grown with VC showed superior performance among the treatments. For water spinach, the highest biomass yield (674.69g/m^2) and maximum leaf number (34.67) was observed in VC+WB treatment. Protein content of water spinach was highest (1.92 g/100g) in VC+WB treatment. Fe, Ca and Mg content in water spinach was also higher in VC+WB treatment for water spinach grown after winged bean. The biomass of bean showed a positive linear relationship with the growth and yield of amaranth and water spinach in all the treatments and rotations. The study has shown that the use of vermincompost with legume crop rotations has the potential to significantly increase yield in amaranth and water spinach.

Key words: Amaranth, water spinach, organic fertilizers, crop rotation and legume.

INTRODUCTION

In modern vegetable production the application of chemical fertilizers, herbicides and pesticides are a necessity. However, these agro-chemicals increase the productivity of crops, frequent use of these agro-chemicals destroys bio-diversity and affects human health (Magkos *et al.,* 2003). The flip side to overcome of these problems is to focus on alternative crop production systems. Organic fertilizers are safe for the environment and do not pose a threat to human health (Khan *et al*., 2007). As a result, organic vegetable production has gained importance all over the world due to their long-term effect on environment and soil parameters. Furthermore, to maintain organic soil management, organic fertilizers and crop residues are used to increase soil organic carbon and this will counteract the negative impact of inorganic vegetable production (Bajgai *et al*., 2013).

Different management practices change the properties of soil and the main focal point for crop production has to be soil quality and its modification occurs through diverse management systems (Islam and Weil 2000). Soil quality is the capacity to function within managed ecosystem to sustain productivity by improving or preserving the physical, chemical and biological properties of soil, by using natural resources and crop rotation as the component of sustainable agricultural management practices (Islam *et al*., 2011). The most effective way to retain organic carbon in the soil is to use organic fertilizer during crop production. Organic fertilizers have been shown to help preserve natural resources and reduce degradation of the ecosystem. As a result, organic agriculture has become an alternative technology which encourages the use of natural organic compounds, such as plant residues, manure, mulch and compost (Francis and Daniel, 2004).

Amaranth and water spinach are the most important leafy vegetables in the tropics due to their popularity, quick growth and nutritional value (Palada and Chang, 2003). These are used as human food and animal feed and contain significant amount of nutrients. This is because consumption of these leafy vegetables is increasing and also taking part in balance diet (Sajal Roy *et al*., 2014). Mono crop rotations has generally been economically successful, but it has negative biological and environmental consequences, such as-loss of soil organic matter and the degradation of soil physical characteristics (Sulc and Tracy, 2007). Nevertheless, crop rotation is an essential tool to overcome the aforementioned problems. Leafy vegetables grown after a legume crop rotation is helpful for leafy vegetable production because legume vegetables synthesize mineral N in the soil and for the production of leafy vegetables the N requirement is higher than for other nutrients (Khairuddin, 2002). However very little information is available on the growth of leafy vegetable after legume in organic fertilizer with legume residues. This study investigates the impact of organic fertilizers and legume residues on the yield and quality of amaranth and water spinach.

MATERIALS AND METHODS

Experimental site, soil management: Experiment was carried out at the net house of the Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur (3°7'25" N, 101°39'11" E) Malaysia. Soil was collected from a nearby nursery and homogenized to a fine texture, removing inert matter before being used for growing the legume and leafy vegetables. Amaranth after yard long bean (YLB), winged bean (WB) and bush bean (BB) were grown in plastic pots (pot area was 0.29 m^2). Similarly, water spinach after YLB, WB and BB were grown in same size plastic pots, the basic soil quality was clay loam. Average relative humidity (%) and temperature (^{0}C) in net house during study period is has been shown in Table 1.

Experimental design and set-up: Rotations of legume (YLB, BB and WB) in first season and leafy vegetables (amaranth and water spinach) in second season were grown with two organic fertilizers and one chemical fertilizer. Experiment started in November 2014 and ended June 2015, completing two cropping seasons. Complete randomized design (CRD) was adopted at each site and each treatment had three replications. The legumes (YLB, BB and WB) were planted on November 10, 2014 under three different treatments, namely, vermicompost, compost and farmer's practice (62.5-62.5-125 kg ha^{-1} of N, P_2O_5, K_2O respectively according to Ebert *et al*., 2011). Yard long bean and bush bean were harvested in February 10, 2015 whilst winged bean was harvested in March 10, 2015. After harvesting of the legume pods, all residues were thoroughly mixed with pot soil and the mixture was kept for 15-20 days to decompose. After decomposition, amaranth and water spinach seeds were sown in the pots (April 1, 2015) and harvested in May 10, 2015. Once harvested, amaranth and water spinach roots were washed properly and the plants were kept on a clean surface for air drying. On the following day the samples were wrapped in brown paper and oven dried.

Treatments and Seed germination: For the VC (vermicompost) treatment, 8kg of soil was thoroughly mixed with 2kg of VC whilst for the COM (compost) treatment 8kg of soil was carefully mixed with 2kg of COM. Ten kilogram of soil with N:P:K fertilizer at the rate of 1.81:1.81:3.62 g per pot (N: P: K: is 10:10:20 respectively) was considered as FP (farmer's practice) treatment. Four seeds of each legume (YLB, BB and WB) were sown in each pot. Two hearty seedlings were selected for growth in each pot after the germination of legume seeds. Watering was done every evening until completion of the experiment. After growing legume all plant residues were properly mixed with pots soil. Once mixing yard long bean (YLB), winged bean (WB) and bush bean (BB) residual with pot soil, VC treatment improved to VC + YLB, VC + WB and VC + BB treatments; COM treatment improved to COM+YLB, COM+ WB and COM+BB treatments and FP treatment improved to FP+ YLB, FP +WB and FP+BB treatments. Amaranth and water spinach were grown in those treatments.

As the seed coat of winged bean is very hard, the seeds were soaked in water for 48 hours prior to planting in the pots, under one inch of soil. As yard long bean and bush bean are direct seeded plants, the seeds were planted in the pots under the same depth of soil. Germination occurred in about 5-7 days, in soil temperatures ranging from 75-78^0 F. Soil temperature measured daily using a Fieldscout Spectrum Soil Stik. Water spinach and amaranth seeds were sown in the pots thinly covered with soil. Germination of water spinach and amaranth seeds occurred after about 8 to10 days, in soil temperatures ranging from75-78^0 F.

Data collection: Biomass, dry biomass, Plant height and nodule number were recorded properly for all the treatments and replications. Fresh biomass was determined using a weight scale, while plant height (root and shoot) was recorded by using a measuring tape. After harvesting the legume plants, the number of active nodules in each plant was recorded. Plant parts were oven dried at 158°F for 48 hours for dry weight determination. Dried samples were ground in a grinder prior to chemical analysis. Dry biomass determination was done by using the following formula-

$$\text{Dry biomass } (g/0.29m^2) = \frac{\text{total fresh weight X oven dried weight}}{\text{given fresh weight for oven drying}}$$

Nutrient analysis: Ground samples were analyzed for Calcium (Ca), Magnesium (Mg) and Iron (Fe) using the wet oxidation method (AOAC, 2005).

Calculation:
Calcium, Magnesium and Ferrous (mg/100g) calculation:

$$\text{Ca or Mg or Fe } (\%) = \frac{\frac{Volume}{Weight} X\ 100\%}{10^6} \text{X Amount of Ca/Mg/Fe from auto analyzer } \left(\frac{mg}{L}\right)$$

$$\text{Or, Ca/Mg/Fe } (\%) = \frac{\frac{100\ ml}{0.25\ g} X\ 100\%}{10^6} \text{X Amount of Ca/Mg/Fe from auto analyzer } \left(\frac{mg}{L}\right)$$

$$\text{Or, Ca/Mg/Fe } (\%) = 0.04\% \text{X Amount of Ca/Mg/Fe from auto analyzer } \left(\frac{mg}{L}\right)$$

$$\text{Therefore, Ca/Mg/Fe}\left(\frac{mg}{100g}\right) = \frac{Ca/Mg/Fe\ (\%)X1000}{100}$$

Protein Determination: Adjacent composition of dry matter (method 934.01) and crude protein (method 968.06), analysis were performed according to the AOAC official method of analysis (AOAC, 2005).

Statistical analysis: All the experiments were performed in triplicate. For plant height, nodule number, plant biomass, and nutrient content data were expressed as the means for each group. The normality and homogeneity of variance were determined by using the Shapiro-Wilk test and Bartlett's test, respectively. To compare the means, one-way analysis of variance (ANOVA) was performed using the statistical package tool STAR (Version 1.1 2013, Biometrics and Breeding Informatics, PBGB Division, International Rice Research Institute, Los Baños, Laguna). A post-hoc LSD test ($P<0.05$) was used to determine significant differences between the means. Pearson correlation regression were performed using Microsoft excel version 2010.

RESULTS

Plant dry biomass, plant height and nodule number were significantly affected by the treatment variables. Winged bean grown with VC produced the maximum total dry biomass and plant height (Table 2). A higher dry biomass and plant height was also observed for both bush bean and yard long bean when grown with VC treatment (Table 2). Bush bean grown in VC treatment produced the maximum number (27.33) of nodules, whilst the lowest number (21.00) of nodules was observed in FP treatment. A similar trend was also recorded for both winged bean and yard long bean when grown with VC (Table 2).

With regard to crop rotation, amaranth planted after yard long bean, produced the maximum yield (889.81 g/m^2) of amaranth, when grown in VC+YLB rotation treatment and the lowest yield (222.18 g/m^2) was observed in FP+YLB treatment. In amaranth after bush bean and amaranth after winged bean rotation, the maximum yield of amaranth was observed in VC+BB and VC+WB treatment. In all the above treatments, the yield of amaranth grown in VC+YLB treatment showed the best performance (Table 3).

Leaf number for amaranth also showed a significant difference between the treatments with amaranth after yard long bean, recorded the maximum leaf number (15.67) in VC+YLB treatment, while the lowest leaf number (10.33) was observed in FP+YLB treatment. Similarly, in amaranth after bush bean and amaranth after winged bean, the highest leaf number observed in VC+BB and VC+WB treatment. Overall the maximum leaf number was seen in VC+YLB treatment (Table 3).

With regard to protein content, crop rotation of amaranth after yard long bean and amaranth after winged bean, showed significantly higher amounts of protein compared to control but there was no significant difference when compared with the crop rotation of amaranth after bush bean. The maximum (1.67 g/100g) and minimum (1.42 g/100g) protein content was observed in amaranth after yard long bean and FP+YLB treatment, respectively. For amaranth after winged bean, the maximum protein content was observed in COM+WB (1.98 g/100g) and VC+WB (1.88 g/100g) treatments while low protein content (1.62 g/100g) was observed in FP+WB treatment. The maximum amount of amaranth leaf protein was observed in COM+BB treatment (Table 3).

With regard to mineral content in amaranth leaves, Fe and Ca showed a significant difference, whilst no significant difference was observed in the case of Mg (Table 4). In amaranth after yard long bean, the maximum amaranth leaf Fe and Ca content (2.52 mg/100g and 497.33 mg/100g respectively) was observed in VC+YLB treatment and the lowest Fe and Ca content (1.84 mg/100g and 362.67 mg/100g respectively) in FP+YLB treatment. In amaranth after bush bean, the maximum Fe and Ca content were 1.94 mg/100g and 494.67 mg/100g respectively in the VC+BB treatment and the lowest in FP+BB treatment. In amaranth after winged bean, the maximum Fe and Ca content were 1.68 mg/100g and Ca 509.07 mg/100g respectively in VC+WB treatment and similarly lowest in FP+WB treatment (Table 4).

In amaranth after bush bean, a positive linear relationship (R^2= 0.7835) was observed between total bush bean biomass and yield of amaranth. Plant height of amaranth had also showed a positive linier relationship (R^2= 0.7972) with total biomass of bush bean. In amaranth after winged bean a positive linear relationship (R^2= 0.8183) was found between total biomass of winged bean and yield of amaranth. Plant height of amaranth also exhibited a positive linier relationship (R^2= 0.9986) with total biomass of winged bean. In amaranth after yard long bean, a positive linear relationship (R^2= 0.9671) was observed between total biomass of yard long bean and yield of amaranth. Plant height of amaranth also presented a positive (R^2= 0.8274) linear relationship with total biomass of yard long bean (Figs.1a-c).

In the crop rotation of water spinach after yard long bean, bush bean and winged bean, the maximum water spinach yield (477.05g/m^2, 526.54 g/m^2 and 674.71 g/m^2 respectively) was observed in VC+YLB, VC+BB and VC+WB treatments while the lowest yield was observed in FP+YLB, FP+BB and FP+WB treatments (Table 5). A similar trend was also recorded for leaf number of water spinach. For water spinach after yard long bean, bush bean and winged bean rotation the maximum leaf number (34.67, 31.67 and 31.67

respectively) was observed in VC+YLB, VC+B Band VC+WB treatments. Overall, the yield and leaf number of water spinach was maximum when grown in VC+WB treatment (Table 5). Protein content in water spinach, crop rotation of water spinach after yard long bean water spinach after bush bean and water spinach after winged bean, the maximum protein content (1.85 g/100g, 1.76 g/100g and 1.92 g/100g) in the VC+YLB, VC+BB and VC+WB treatments and the lowest protein content observed in FP+YLB, FP+BB and FP+WB treatments. The maximum amount of water spinach protein was observed in VC+WB treatment (Table 5).

The amount of Fe, Ca and Mg content of water spinach showed a significant difference under the different treatments. In water spinach after yard long bean, the maximum Fe, Mg and Ca content (2.01 mg/100g, 35.26 mg/100g and 76.81 mg/100g respectively) were observed in VC+YLB treatment and the lowest Fe, Ca and Mg content was observed in FP+YLB treatment. In water spinach after bush bean and winged bean, the maximum Fe (1.87 mg/100g and 2.18 mg/100g), Ca (64.96 mg/100g and 72.89 mg/100g) and Mg (34.12 mg/100g and 35.26 mg/100g) content was observed in VC+BB and VC+WB treatments while the lowest Fe, Ca and Mg content was observed in FP+BB and FP+WB treatments (Table 6).

In water spinach after bush bean, a positive linear relationship (R^2 = 0.9835) was observed between total bush bean biomass and yield of water spinach. Plant height of water spinach had also showed a positive linier relationship (R^2= 0.8747) with total biomass of bush bean. In water spinach after winged bean, a positive linear relationship (R^2= 0.9972) was seen between total biomass of winged bean and yield of water spinach. Plant height of water spinach also exhibited a positive linier relationship (R^2= 0.9421) with total biomass of winged bean. In water spinach after yard long bean, the total biomass for yard long bean and yield of water spinach had displayed a positive linear relationship (R^2 = 0.9999). Plant height of water spinach also presented a positive (R^2= 0.9857) linear relationship with total biomass of yard long bean (Figs.2a-c).

Table 1. Average relative humidity (RH) and temperature (^{0}C) in net house during study period

Months	Average RH (%)	Average temperature	
		Minimum (^{0}C)	Maximum (^{0}C)
November, 2014	83.76	24.46	31.42
December, 2014	84.21	24.75	30.46
January, 2015	79.45	24.80	32.45
February, 2015	74.75	23.45	33.65
March, 2015	78.56	25.00	34.45
April, 2015	79.25	24.95	33.55
May, 2015	80.62	25.05	33.82
June, 2015	78.20	25.63	33.43

Table 2. Total dry biomass accumulation, plant height and nodule number of Bush bean, Winged bean and Yard long bean.

Treatment	Crop	Total dry Biomass (g m^{-2})	Plant height (cm)	Nodule (number/plant)
VC	Bush Bean	60.76 a	309.73 a	27.33 a
COM		25.93 b	269.50 b	24.67 ab
FP		14.23 c	171.13 c	21.00 b
VC	Winged Bean	175.71 a	249.93 a	12.66 a
COM		126.12 b	226.47 b	9.33 ab
FP		48..78 c	171.70 c	5.33 b
VC	Yard Long Bean	49.72 a	73.63 a	33.00 a
COM		34.19 b	61.26 a	20.00 b
FP		15.31 c	47.79 b	19.00 b

Means followed by the same letters are not significantly different for each treatment means at the 0.05 by LSD,

Table 3. Yield, Leaf number and protein content of amaranth grown after legume.

Treatment	Crop	Yield (g/m^2)	Leaf (no.)	Protein (g/100g)
COM+YLB	Amaranth after Yard Long Bean	651.70 b	12.67 b	1.67 a
VC+YLB		889.81 a	15.67 a	1.45 b
FP+YLB		222.18 c	10.33 c	1.42 b
COM+BB	Amaranth after Bush Bean	676.86 a	13.00 a	2.10 a
VC+BB		838.86 a	15.67 a	2.16 a
FP+BB		328.73 b	11.00 a	2.01 a
COM+WB	Amaranth after Winged Bean	344.78 b	11.33 b	1.98 a
VC+WB		815.51 a	13.67 a	1.88 a
FP+WB		281.35 b	9.67 c	1.62 b

Means followed by the same letters are not significantly different for each treatment means at the 0.05 by LSD,

Table 4. Fe, Ca and Mg of Amaranth grown after legume

Treatment	Crop	Fe (mg/100g)	Ca (mg/100g)	Mg (mg/100g)
COM+YLB	Amaranth after Yard Long Bean	2.04 b	394.12 b	33.17 a
VC+YLB		2.52 a	497.33 a	34.82 a
FP+YLB		1.84 b	362.67 c	32.56 a
COM+BB	Amaranth after Bush Bean	1.62 b	464.93 b	32.82 a
VC+BB		1.94 a	494.67 a	34.29 a
FP+BB		1.47 b	342.93 c	32.46 a
COM+WB	Amaranth after Winged Bean	2.04 b	483.33 b	32.60 a
VC+WB		2.48 a	509.07 a	34.26 a
FP+WB		1.68 c	408.93 c	31.61 a

Means followed by the same letters are not significantly different for each treatment means at the 0.05 by LSD,

Table 5. Yield, No. of Leaf, Protein of Water spinach grown after legume.

Treatment	Crop	Yield (g/m^2)	Leaf (no.)	Protein (g/100g)
COM+YLB	Water spinach after Yard Long Bean	342.14 b	28.33 b	1.76 ab
VC+YLB		477.05 a	34.67 a	1.85 a
FP+YLB		211.07 c	24.00 c	1.56 b
COM+BB	Water spinach after Bush Bean	219.97 b	25.33 a	1.69 a
VC+BB		526.54 a	31.67 a	1.76 a
FP+BB		171.70 b	22.00 a	1.22 b
COM+WB	Water spinach after Winged Bean	467.52 b	26.00 b	1.89 a
VC+WB		674.71 a	34.67 a	1.92 a
FP+WB		194.54 c	20.67 c	1.61 b

Means followed by the same letters are not significantly different for each treatment means at the 0.05 by LSD,

Table 6. Fe, Ca and Mg of Water spinach grown after legume.

Treatment	Crop	Fe (mg/100g)	Ca (mg/100g)	Mg (mg/100g)
COM+YLB	Water spinach after Yard Long Bean	1.73 b	76.38 a	31.12 b
VC+YLB		2.01 a	76.81 a	35.27 a
FP+YLB		1.51 c	43.29 b	29.65 c
COM+BB	Water spinach after Bush Bean	1.61 b	55.70 b	31.61 b
VC+BB		1.87 a	64.96 a	34.12 a
FP+BB		1.24 c	50.04 c	28.68 c
COM+WB	Water spinach after Winged Bean	1.75 b	59.03 b	29.93 b
VC+WB		2.18 a	72.89 a	35.26 a
FP+WB		1.32 c	49.14 c	25.86 c

Means followed by the same letters are not significantly different for each treatment means at the 0.05 by LSD,

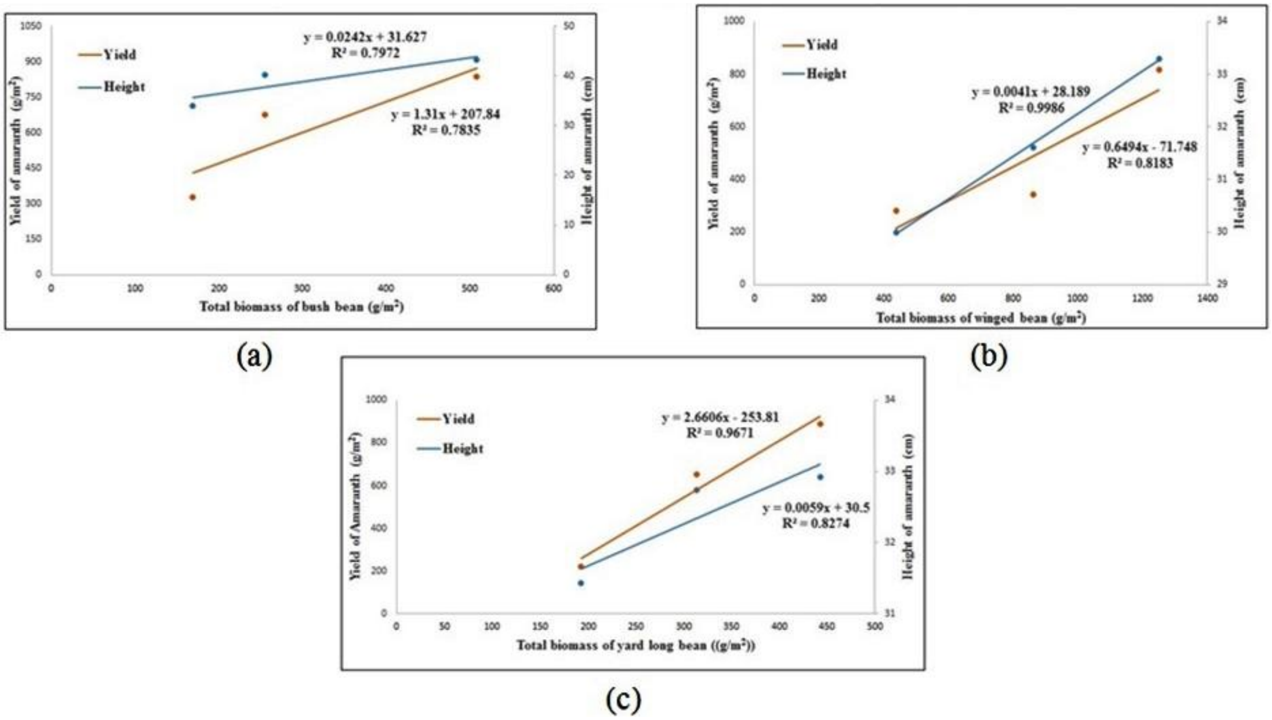

Fig. 1. Relation of (a) yield and height of amaranth with total biomass of bush bean (b) yield and height of amaranth with total biomass of winged bean and (c) yield and height of amaranth with total biomass of yard long bean

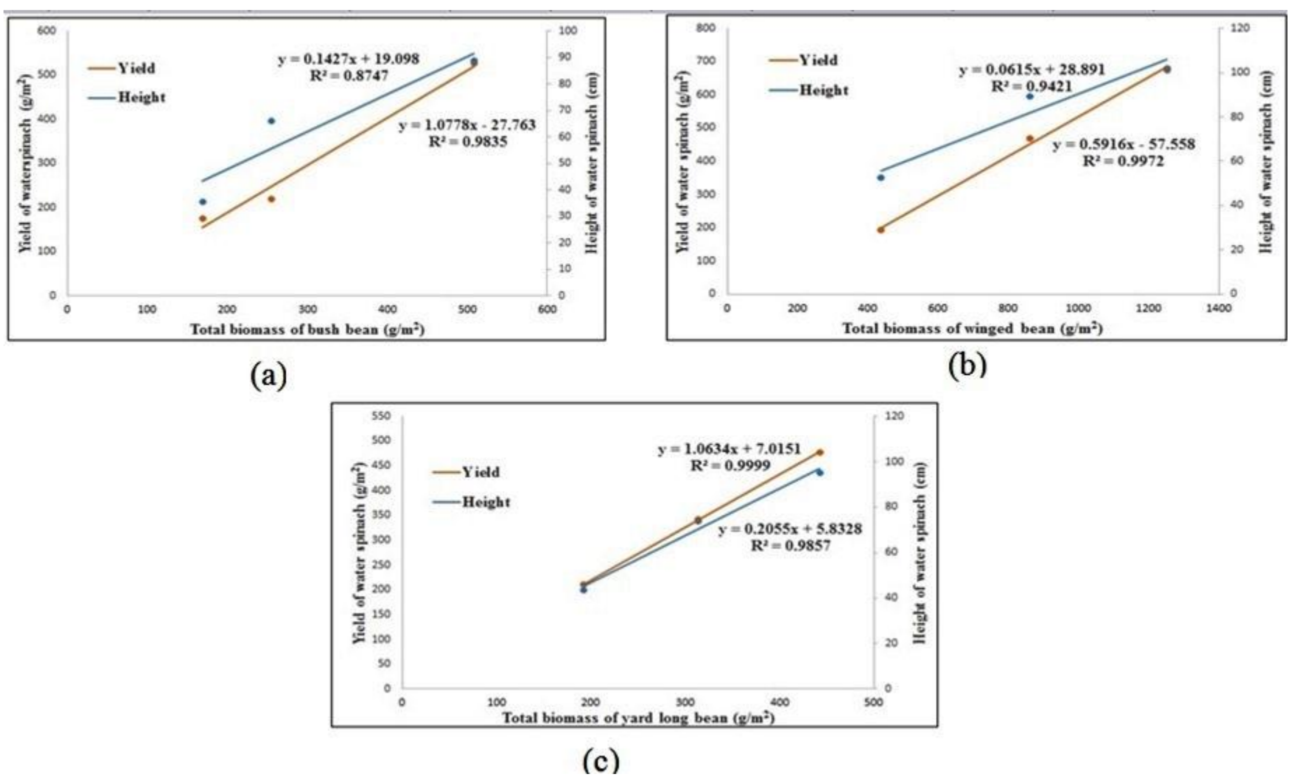

Fig. 2. Relation of (a) yield and height of water spinach with total biomass of bush bean (b) yield and height of water spinach with total biomass of winged bean and (c) yield and height of water spinach with total biomass of yard long bean

DISCUSSION

The application of organic fertilizers influences the growth parameters of amaranth and water spinach (Islam *et al*.,2011; Khan *et al*.,2007). In this study, the growth parameters of amaranth and water spinach were significantly influenced by organic fertilizers (Khan *et al*., 2007). Yildirim *et al*., (2006), observed that addition of bio-fertilizer significantly increased yield compared of leafy vegetables which has been support the present study. Yield and leaf number for amaranth was observed to be significantly better in vermicompost treatment in all the crop rotation cycles investigated. The increase in yield and leaf number with the addition of an organic fertilizer is consistent with reports from several other studies (Mahdy, 2011). For the crop rotations, amaranth after yard long bean rotation and VC+YLB treatment gave better yield and leaf number (Table 3). It is well documented that legumes can accumulate nitrogen in the soil to enhance its fertility (Luqueño *et al*., 2010). In this study legume residues mixed with vermicompst and soil enhanced the production of amaranth and water spinach. Similarly, leaf number and yield of water spinach was observed significantly higher in vermicompost treatment and for the crop rotations, water spinach after winged bean rotation and VC+WB treatment gives the better result (Table 5). It has been shown that organic fertilizers and legume residues can provide the essential plant nutrients required for water spinach production (Luqueño *et al*., 2010).

Vegetable quality is dependent on its nutrient and protein content (Sajal Roy *et al*., 2014). In the present study protein content in amaranth grown after bush bean, was higher in VC treatment (Table 3). Similar results were observed by Ebert *et al*., (2011). With regard to protein content, water spinach after winged bean crop rotation in VC+WB treatment showed higher values (Table 5). Chat (2005) also observed the highest protein in water spinach which was grown in organic fertilizer. In the present study iron (Fe), magnesium (Mg) and calcium (Ca) contents in amaranth were higher in vermicompost treatment in all the crop rotations. In each crop rotation VC+YLB, VC+BB and VC+WB treatments showed higher mineral content. However, the highest Fe and Mg content was observed in VC+YLB treatment and for Ca content the VC+WB showed the highest value (Table 4). This can be accredited to the balanced amount of nutrients in the vermicompost (VC) and legume residues. Magkos *et al.,* (2003) observed that higher contents of minerals such as Fe, Ca, P, Mg, Zn, Cu, and K have been reported in organic vegetables. This study has shown that after yard long bean crop rotation and vermicompost can improve that Fe and Ca content in amaranth. In the case of water spinach after yard long bean, bush bean and winged bean, in vermicompost treatment, significantly higher amounts of Fe, Ca and Mg were recorded. In the present study, both the VC+WB and VC+YLB treatments yielded higher mineral content in water spinach, in all the crop rotations (Table 6). Chat *et al.,* (2005) reported that a significant increase in mineral content in water spinach was observed, as a result of organic matter application. Mahmoodabadi *et al*., (2010) also reported that application of organic manure significantly increased N, Fe, Cu, Zn and Mn concentrations in soybean.

Legumes synthesize nitrogen in the soil with the help of the nitrogen fixing bacteria which can be fully utilized by plants (Luqueño *et al*., 2010). It has been shown that when legume residues are mixed with soil, it improves the soil quality and can increase crop yield (Bajgai *et al*., 2013). The height of amaranth and water spinach can be directly correlated with yield, as taller plants produce more leaves and more leaves can indicate higher yield (Xu *et al*., 2003). In the present study there was a positive linear relationship observed between height and yield of amaranth and water spinach and the total biomass of the legumes (Fig. 1a-c and Fig. 2a-c). Yield and height of amaranth and water spinach has positively correlated with biomass of legumes. Uddin *et al*., (2012) similarly reported that the yield and height of leafy vegetables was greater in organic fertilizer than inorganic fertilizer treatments. The present study has to support both observations that are bean residues with vermicompost i.e. VC enhance the growth of the leafy vegetables. Use of vermicompost and legume crop rotation increase production and improve the quality of amaranth and water spinach.

Conclusions: Amaranth after yard long bean rotation in vermicompost exhibited better performance with regard to yield and leaf number. Notably protein, Fe, Ca and Mg content was higher in VC+YLB treatment in amaranth. In water spinach, grown in vermicompost after winged bean, an improvement in yield, and leaf number was recorded. Protein, Fe, Ca and Mg content in water spinach also recorded higher values when grown in vermicompost after winged bean rotation. The biomass of the beans enhanced and showed a positive linear relationship with the growth and yield of amaranth and water spinach.

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