Changes of Morphological and Biochemical Properties in Organically Grown Zucchini Squash (Cucurbita pepo L.)

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Abstract. The present research was undertaken with the aim of justifying the effect of morphological, physiological, and nutritional properties in organically produced zucchini squash. The experiment consisted of two factors: three levels of pruning (P0 = no pruning, P1 = primary pruning at 20 days after transplanting (DAT), and P2 = secondary pruning at 30 DAT) and four levels of vermicompost application (V0 = control, V1 = 5 t/ha, V2 = 10 t/ha, and V3 = 15 t/ha). The results demonstrated that morphological parameters, reproductive components, and yield and proximate compositions were significant differences among the treatments. Increased male and female flower production were recorded from primary pruning with 10 t/ha vermicompost treatment plots compared with control treatments. Finally, increased fruit number, individual fruit weight, fruit length, fruit diameter, total yield, carbohydrate, protein, crude fat, fiber, and ash were reported from the same treatment combination (P1V2). Taken together, 10 t/ha vermicompost with primary pruning appear to provide maximum output in terms of yield and nutrient value compared with other treatments.

Materials and Methods

Experimental site. The research was conducted at the horticultural farm of Sher-e-Bangla Agricultural University, Dhaka-1207, for two seasons, from Nov. 2015 to Feb. 2016 and from Nov. 2016 to Feb. 2017. The experimental field was located at 90°22′E longitude and 23°41′N latitude at an altitude of 8.2 m above the sea level. It was in Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with deep red-brown terrace soil, which belongs to the Noddy cultivated series. The soil was sandy loam in texture with a particle density of 2.65 (g cc⁻¹) and bulk density of 1.52 (g cc⁻¹). The soil pH was 6.43; organic matter 0.84 (%); total N 0.46 (%); exchangeable K 0.41 (meq/100 g soil); available P 18.65, S 20.92, Fe 225, Zn 4.55, and Cu 0.84 (ppm).
Vermicomposting and pruning. Vermicompost was applied in each plot by making pit as a basal dose. Then expected doses of vermicompost were applied in each pit and covered with one layer of soil for 1 week for composting. Pruning was done according to their treatment. Primary pruning was done by removing the first branch at 20 d after transplanting, and secondary pruning was done by removing the second branch at 30 d after transplanting.

Data collection. Growth parameters such as stem diameter (cm), stem length (cm), number of male flowers, number of female flowers, individual fruit weight (g), total number of fruit, fruit length (cm), fruit diameter (cm), yield (t/ha), and proximate compositions were measured following the standard procedure.

Proximate analysis. AOAC (1990) standard methods were used to quantify nutrients for proximate analysis (% moisture, % proteins, % fat, % ash, and % carbohydrate) from fruit samples. Oven-drying (Gallenkamp, plus II ovens, Germany) was used to determine moisture content followed by Sadiq et al. (2013). The NCS elementary analyzer (Flash 2000 Organic Elemental Analyzer, Germany) was used to estimate crude proteins. Crude fat content was determined from fruit samples by using hexane as an organic solvent. Ash content was determined by using muffle furnace (Carbolite RHS 1600, Germany), and carbohydrate (%) was determined with the following formula (Kwiri et al., 2014):

\[
\% \text{CHO} = 100 - (\% \text{moisture} + \% \text{proteins} + \% \text{Fat} + \% \text{Ash})
\]

Statistical analysis. Data were recorded and processed over two growing seasons and analyzed using SPSS statistical software version 21.0. The mean for the treatments was calculated, and analysis of variance for each of the characters was performed by F test. Comparisons of the mean data and se were determined by DMRT (Duncan’s multiple range tests) at P ≤ 0.05 level of significance.

Results and Discussion

Effects of growth parameters by pruning and vermicomposting

Growth parameters were significantly influenced by pruning and vermicompost application. At 40 DAT and 55 DAT, a maximum stem length of 49.5 cm and 52.3 cm, respectively, was observed with P2 treatment; stem diameter of 1.5 cm and 2.2 cm, respectively, was recorded with P1 treatment. The shortest stem length with P1 treatment was 47.4 cm and 51.4 cm, respectively, and stem diameter of 1.4 cm and 1.9 cm in P0 (no pruning) treatment (Table 1). Similar results were found during harvest (Table 1).

### Table 1. Effect of pruning and vermicompost on growth parameters of zucchini squash.

| Treatments | 40 DAT | 55 DAT | Harvest | 40 DAT | 55 DAT | Harvest |
|------------|--------|--------|---------|--------|--------|---------|
| **P0**     | 48.6 ± 1.83 a | 51.5 ± 1.51 a | 55.1 ± 1.63 a | 1.2 ± 0.04 a | 1.4 ± 0.07 a | 1.9 ± 0.08 a |
| **P1**     | 47.4 ± 1.24 a | 51.4 ± 1.22 a | 55.0 ± 1.40 a | 1.3 ± 0.08 a | 1.5 ± 0.12 a | 2.2 ± 0.13 a |
| **P2**     | 49.5 ± 1.86 a | 52.3 ± 1.91 a | 55.4 ± 1.28 a | 1.2 ± 0.03 a | 1.5 ± 0.05 a | 2.0 ± 0.10 a |
| **Significance Level** | NS | NS | NS | NS | NS | NS |

**Effect of pruning**

**Effect of vermicomposting**

| V0  | 41.6 ± 0.65 c | 44.5 ± 1.11 c | 48.4 ± 1.62 b | 1.0 ± 0.01 b | 1.2 ± 0.03 b | 1.6 ± 0.04 c |
| V1  | 47.4 ± 0.71 b | 51.4 ± 0.72 b | 56.1 ± 1.01 a | 1.2 ± 0.02 b | 1.3 ± 0.04 b | 1.9 ± 0.07 b |
| V2  | 53.1 ± 1.03 a | 55.9 ± 1.09 a | 58.7 ± 1.32 a | 1.4 ± 0.07 a | 1.7 ± 0.10 a | 2.3 ± 0.10 a |
| V3  | 51.9 ± 0.85 a | 55.1 ± 0.74 a | 57.5 ± 1.03 a | 1.4 ± 0.05 a | 1.6 ± 0.07 a | 2.3 ± 0.06 a |
| **Significance Level** | *** | *** | *** | *** | *** | *** |

Data represent mean ± se. Different letters following values within the same column indicate significant effect of pruning and vermicompost at P ≤ 0.05 and nonsignificant (NS) by Duncan’s multiple range tests. DAT = days after transplanting; P0 = no pruning; P1 = primary stem pruning; P2 = secondary stem pruning; V0 = no compost; V1 = 5 t/ha; V2 = 10 t/ha; V3 = 15 t/ha.

### Table 2. Interaction effect of pruning and vermicompost on growth parameters of zucchini squash.

| Treatments | 40 DAT | 55 DAT | Harvest | 40 DAT | 55 DAT | Harvest |
|------------|--------|--------|---------|--------|--------|---------|
| **P0V0**   | 41.7 ± 0.44 g | 44.0 ± 1.44 e | 48.3 ± 3.33 b | 1.0 ± 0.01 e | 1.1 ± 0.01 f | 1.5 ± 0.04 f |
| **P0V1**   | 48.2 ± 1.74 def | 52.0 ± 2.02 bc | 57.4 ± 2.39 a | 1.1 ± 0.01 cde | 1.3 ± 0.03 def | 1.7 ± 0.06 def |
| **P0V2**   | 52.7 ± 0.17 abc | 54.3 ± 0.33 abc | 57.2 ± 1.09 a | 1.2 ± 0.03 bcde | 1.5 ± 0.06 cde | 2.0 ± 0.09 cde |
| **P0V3**   | 52.0 ± 0.50 abed | 55.5 ± 1.80 abc | 57.7 ± 3.03 a | 1.4 ± 0.12 bc | 1.6 ± 0.07 b | 2.2 ± 0.11 bc |
| **P1V0**   | 41.5 ± 1.26 g | 45.8 ± 2.74 de | 49.3 ± 4.06 b | 1.0 ± 0.01 e | 1.1 ± 0.03 cdef | 1.6 ± 0.12 ef |
| **P1V1**   | 47.8 ± 1.30 ef | 51.8 ± 0.93 bc | 56.8 ± 1.42 a | 1.1 ± 0.04 de | 1.3 ± 0.03 cdef | 2.0 ± 0.14 bc |
| **P1V2**   | 50.7 ± 1.74 bcd | 54.3 ± 1.45 abc | 57.0 ± 1.53 a | 1.6 ± 0.11 a | 2.0 ± 0.14 a | 2.7 ± 0.06 a |
| **P1V3**   | 49.7 ± 1.36 cdef | 53.5 ± 0.29 bc | 56.8 ± 1.01 a | 1.3 ± 0.13 ab | 1.6 ± 0.20 bc | 2.3 ± 0.16 b |
| **P2V0**   | 41.5 ± 1.80 g | 43.7 ± 1.92 e | 47.5 ± 1.80 b | 1.0 ± 0.07 e | 1.2 ± 0.09 ef | 1.5 ± 0.07 f |
| **P2V1**   | 46.5 ± 0.76 f | 50.3 ± 0.60 cd | 54.2 ± 1.17 ab | 1.2 ± 0.02 bcde | 1.5 ± 0.06 bcd | 1.9 ± 0.08 cde |
| **P2V2**   | 56.0 ± 1.53 a | 59.2 ± 2.05 a | 62.0 ± 3.06 a | 1.4 ± 0.05 bc | 1.6 ± 0.06 bcd | 2.2 ± 0.03 b |
| **P2V3**   | 54.2 ± 1.20 ab | 56.2 ± 1.17 ab | 58.0 ± 1.44 a | 1.3 ± 0.32 bcd | 1.6 ± 0.07 bc | 2.3 ± 0.06 b |
| **Significance Level** | *** | *** | *** | *** | *** | *** |

Different letters following mean ± se. values within the same column indicate significant differences between interaction effects between pruning and vermicompost at P ≤ 0.05 by Duncan’s multiple range tests. DAT = days after transplanting; P0 = no pruning; P1 = primary stem pruning; P2 = secondary stem pruning; V0 = no compost; V1 = 5 t/ha; V2 = 10 t/ha; V3 = 15 t/ha. ***Highly significant.
Furthermore, vermicomposting significantly influenced the stem length at various days after transplanting. Compared with the control treatment, the longest stem length (53.1 cm) and largest stem diameter (1.7 cm) at 40 DAT were recorded from V2 treatment (Table 1). At 55 DAT and at harvest time, we found similar results with the application of vermicompost (Table 1). The interaction effect of pruning and vermicompost showed statistically significant differences in stem length and diameter. The longest stem length (56.0 cm) and greatest stem diameter (1.6 cm) at 40 DAT was observed from the treatment combination P2V2 compared with other treatments. Similar results were also found at 55 DAT and harvest time (Table 2).

Pruning helps to generate a better plant condition; sunlight more easily reaches the whole plants, increasing interception of light for photosynthesis. We observed that the stem length and stem of squash were greatest with pruning practices at the early growth stage of 40 d after transplanting. A similar result was also reported by Syamsi et al. (2017), who noted that proper accumulation of light increases the availability of air circulation and CO2 in the stem and ultimately increases stem length and diameter. The availability of light and CO2 increases the photosynthesis rate in plants, and nonpruned plants display extreme vegetative growth, causing suboptimal use of photosynthesis and resulting in decreases of plant yield (Coggins and Lovatt, 2014). Stem pruning is expected to create optimal space for the vegetative growth, which helps promote photosynthesis, resulting in cell enlargement in fruit length and diameter (Pompelli et al., 2010). Pruning helps reduce unproductive plant parts, which allows the photosynthesis process to be more widely allocated, enhancing fruit weight and production (Yu et al., 2013). We also found that proper pruning significantly enhanced yield-contributing parameters. We observed increased flowering, fruit number per plant, fruit length and diameter, and ultimately increased yield compared with no pruning. Awalin et al. (2017) described a similar result with regard to fruit setting, fruits per plant, and ultimate yield with early-stage stem pruning in bell pepper.

Vermicomposting is an anaerobic and biotic method that promotes eco-friendly, humus-like organic substances (Chanda et al., 2011). Vermicompost is an important organic fertilizer containing high contents of humus, nitrogen (2% to 3%), phosphorous (1.50% to 2.25%), and potassium (1.80% to 2.25%) micro-nutrients, as well as beneficial soil microbes such as nitrogen-fixing bacteria and mycorrhiza fungi, which increase vegetative growth of squash (Guerrero 2010). In general, application of vermicompost increases seed germination, stem height, number of leaves, leaf area, leaf dry weight, root length, root number, total yield, number of fruits per plant, chlorophyll content, pH of juice, total soluble solids of juice, micro- and macronutrients, carbohydrate (%), and protein (%) content and improved the quality of the fruits and seeds (Joshi et al., 2014).

**Pruning and vermicompost application influenced yield attributes**

Pruning significantly influenced yield-contributing parameters in zucchini squash (Tables 3 and 4). The maximum number of female flowers (14.30), number of fruits per plant (12.3), individual fruit weight (377.0 g), fruit length (20.0 cm), fruit diameter (5.30 cm), and yield (476.7 t/ha) were recorded from P2 treatment. Only male flower (13.0) was recorded for V1 treatment, whereas the minimum number of female flowers (8.10), number of fruits per plant (5.40), individual fruit weight (198.60 g), fruit length (11.10 cm), and yield (107.7 t/ha) (Table 1A) were observed in P0 (control) treatment (Tables 3 and 4).

Vermicompost also significantly influenced yield-contributing attributes of zucchini squash (Tables 3 and 4). The maximum number of female flowers (13.60), number of fruits per plant (12.3), individual fruit weight (377.0 g), fruit length (20.0 cm), fruit diameter (5.30 cm), and yield (476.7 t/ha) were recorded from V2 treatment. Only male flower (13.0) was recorded for V3 treatment, whereas the minimum number of female flowers (8.10), number of fruits per plant (5.40), individual fruit weight (198.60 g), fruit length (11.10 cm), and yield (107.7 t/ha) (Table 1B) were observed in V0 (control) treatment (Tables 3 and 4).

The combined effect of pruning and vermicompost also influenced yield-contributing attributes of zucchini squash (Tables 5 and 6). The maximum number of female flowers (18.70), number of fruits per plant (13.70), individual fruit weight (433.30 g), fruit length (21.7 cm), fruit diameter (5.80 cm), and yield (592.7 t/ha) were recorded from P3V2 treatment. Only male flowers (14.30) were recorded for P2V3 treatment, whereas the minimum number of female flowers (6.3), number of fruits per plant (4.0), individual fruit weight (175.30 g), fruit length (10.30 cm), fruit diameter (4.10 cm), and yield (7.0 t/ha) were observed in P0V0 (control) treatment (Tables 5 and 6).

Vermicomposting is proven to enhance plant growth (Chauoi et al., 2003). We found that vermicomposting significantly influenced the yield and yield-contributing characteristics of zucchini squash. This might be because vermicompost contains a high amount of essential nutrients such as nitrogen, potassium, and micronutrients that enhance photosynthesis, cell division, and cell enlargement, ultimately improving the yield-contributing characteristics of zucchini squash. Joshi et al. (2015) also suggested that vermicompost is an ideal organic manure for better growth and yield of many plants. Jauksham et al. (2014) reported that vermicomposting improved the micronutrient levels in soil that are important.

**Table 3. Effect of pruning and vermicompost on yield parameters of zucchini squash.**

| Treatments | No. male flower | No. female flower | Total no. fruit/plant | Individual fruit wt (g) |
|------------|-----------------|-------------------|-----------------------|------------------------|
| P0         | 8.5 ± 0.69 b    | 9.4 ± 0.77 b      | 7.0 ± 0.72 b          | 253.3 ± 17.91 b        |
| P1         | 11.0 ± 0.04 ab  | 14.3 ± 1.16 a     | 10.8 ± 0.88 a         | 313.7 ± 30.46 a        |
| P2         | 11.5 ± 0.96 a   | 13.1 ± 0.97 a     | 9.8 ± 0.87 a          | 288.1 ± 24.52 a        |
| Level of significance | **             | **                | **                    | **                     |

**Effect of vermicomposting**

| V0         | 6.8 ± 0.40 c    | 8.1 ± 0.68 c      | 5.4 ± 0.50 c          | 198.6 ± 16.39 c        |
| V1         | 9.2 ± 0.72 b    | 11.3 ± 0.86 b     | 8.6 ± 0.76 b          | 244.1 ± 14.25 c        |
| V2         | 12.3 ± 0.94 a   | 15.8 ± 1.15 a     | 12.3 ± 0.72 a         | 377.0 ± 22.77 a        |
| V3         | 13.0 ± 0.83 a   | 13.9 ± 0.90 ab    | 10.6 ± 0.65 a         | 320.4 ± 18.68 b        |

**Level of significance**

Different letters following values within the same column indicate significant differences in pruning and vermicompost at P ≤ 0.05 by Duncan’s multiple range tests. P0 = no pruning; P1 = primary stem pruning; P2 = secondary stem pruning; V0 = no compost; V1 = 5 t/ha; V2 = 10 t/ha; V3 = 15 t/ha.

**Table 4. Effect of pruning and vermicompost on yield parameters of zucchini squash.**

| Treatments | Fruit length (cm) | Fruit diam (cm) |
|------------|------------------|----------------|
| P0         | 14.8 ± 1.02 a    | 4.5 ± 0.10 b   |
| P1         | 17.7 ± 1.22 a    | 5.1 ± 0.18 a   |
| P2         | 16.0 ± 1.08 a    | 4.8 ± 0.15 ab  |
| Level of significance | ***             | NS             |

**Effect of vermicomposting**

| V0         | 11.1 ± 0.40 c    | 4.2 ± 0.05 c   |
| V1         | 14.81 ± 0.57 b   | 4.6 ± 0.09 b   |
| V2         | 20.0 ± 0.67 a    | 5.3 ± 0.17 a   |
| V3         | 18.9 ± 0.65 a    | 5.0 ± 0.16 a   |

**Level of significance**

Different letters within the same column following mean ± SE values indicate significant differences of pruning and vermicompost at P ≤ 0.05 and nonsignificant (NS) by Duncan’s multiple range tests. P0 = no pruning; P1 = primary stem pruning; P2 = secondary stem pruning; V0 = no compost; V1 = 5 t/ha; V2 = 10 t/ha; V3 = 15 t/ha.

**P ≤ 0.01; ***highly significant; **nonsignificant.**
for plant growth and development. Vermicomposted soil also contains a high amount of carbon, which supports the slow release of essential nutrients into the soil and allows the plants to utilize available nutrients (Ansari and Sukhraj, 2010). In the present study, we evaluated the effects of vermicomposting on growth and yield of zucchini squash, and significant results were observed with the application of 10 t/ha vermicompost compared with control. The yield was also significantly higher in tomato plants treated with optimal concentrations of

Fig. 1. Effect of (A) pruning and (B) vermicompost on yield (t/ha) of zucchini squash.

Table 5. Combined effects of pruning and vermicompost on yield parameters of zucchini squash.

| Treatments | No. of male flower | No. of female flower | Total no. of fruit/plant | Individual fruit wt (g) |
|------------|--------------------|----------------------|--------------------------|--------------------------|
| P0V0       | 6.0 ± 1.00 d       | 6.3 ± 0.88 g         | 4.0 ± 0.57 f             | 175.3 ± 2.72 d           |
| P0V1       | 7.3 ± 1.53 bcd     | 8.3 ± 0.66 fg        | 6.0 ± 0.58 e             | 258.3 ± 0.05 cde         |
| P0V2       | 9.7 ± 2.08 bcd     | 11.7 ± 0.89 de       | 9.7 ± 0.88 cd            | 293.3 ± 3.33 bcd         |
| P0V3       | 11.0 ± 1.00 ab     | 11.3 ± 1.20 def      | 8.3 ± 0.88 d             | 286.3 ± 9.75 cd          |
| P1V0       | 7.0 ± 1.73 cd      | 9.0 ± 1.15 feg       | 6.3 ± 0.67 e             | 199.0 ± 4.09 d           |
| P1V1       | 9.7 ± 2.31 bcd     | 13.7 ± 0.88 cd       | 11.0 ± 0.59 bc           | 254.3 ± 9.19 cd          |
| P1V2       | 13.7 ± 2.52 a      | 18.7 ± 1.21 a        | 13.7 ± 0.33 a            | 433.3 ± 6.67 a           |
| P1V3       | 13.7 ± 2.89 a      | 16.0 ± 1.0 abc       | 12.3 ± 0.66 ab           | 368.0 ± 9.22 ab          |
| P2V0       | 7.3 ± 0.58 bcd     | 9.0 ± 1.00 efg       | 6.0 ± 0.58 e             | 221.3 ± 4.26 de          |
| P2V1       | 10.7 ± 1.53 abc    | 12.0 ± 0.58 de       | 8.7 ± 0.33 d             | 219.7 ± 5.19 de          |
| P2V2       | 13.7 ± 2.30 a      | 17.0 ± 0.57 abc      | 13.7 ± 0.33 a            | 404.3 ± 1.73 abc         |
| P2V3       | 14.3 ± 2.51 a      | 14.3 ± 1.33 bcd      | 11.0 ± 0.00 bc           | 307.0 ± 0.81 bc          |

Level of significance *** *** *** ***

The data represent mean ± SE. Different letters within the same column correspond to significant differences at P ≤ 0.05 by Duncan’s multiple range tests. P0 = no pruning; P1 = primary stem pruning; P3 = secondary stem pruning; V0 = no compost; V1 = 5 t/ha; V2 = 10 t/ha; V3 = 15 t/ha.

***Highly significant.

Table 6. Interaction effect of pruning and vermicomposting on yield parameters of Zucchini squash.

| Treatments | Fruit length (cm) | Fruit diam (cm) | Yield (t/ha) |
|------------|------------------|----------------|-------------|
| P0V0       | 10.3 ± 0.85 g    | 4.1 ± 0.07 g   | 7.0 ± 1.24 g |
| P0V1       | 13.2 ± 0.64 ef   | 4.3 ± 0.13 efg | 15.8 ± 3.09 f |
| P0V2       | 18.4 ± 0.58 bc   | 4.8 ± 0.09 cd  | 28.4 ± 2.64 cd |
| P0V3       | 17.4 ± 0.51 c    | 4.6 ± 0.19 def | 24.4 ± 0.94 de |
| P1V0       | 11.8 ± 0.80 fg   | 4.3 ± 0.03 efg | 12.0 ± 1.59 fg |
| P1V1       | 16.6 ± 0.23 cd   | 4.8 ± 0.03 cd  | 28.2 ± 4.11 cd |
| P1V2       | 21.7 ± 0.82 a    | 5.8 ± 0.16 a   | 59.2 ± 2.05 a  |
| P1V3       | 20.8 ± 0.73 a    | 5.5 ± 0.21 a   | 45.1 ± 0.44 b  |
| P2V0       | 11.2 ± 0.09 fg   | 4.2 ± 0.05 fg  | 13.0 ± 0.20 fg  |
| P2V1       | 14.7 ± 0.68 de   | 4.7 ± 0.14 cd  | 19.1 ± 1.78 ef  |
| P2V2       | 19.9 ± 1.26 ab   | 5.4 ± 0.24 ab  | 55.1 ± 2.02 a  |
| P2V3       | 18.3 ± 1.04 bc   | 5.1 ± 0.14 bc  | 33.8 ± 2.29 c  |

Level of significance *** *** *** ***

Data represent mean ± SE. Different letters following values within the same column indicate significant differences between pruning and vermicompost at P ≤ 0.05 by Duncan’s multiple range tests. P0 = no pruning; P1 = primary stem pruning; P3 = secondary stem pruning; V0 = no compost; V1 = 5 t/ha; V2 = 10 t/ha; V3 = 15 t/ha.

***Highly significant.
vermicompost, as suggested by Vaidyanathan and Vijayalakshmi (2017). Azarmi et al. (2008) reported similar results, noting that the addition of optimal quantities of vermicompost significantly increased growth and yield compared with control in tomato plants.

Relation of Different Morphological Characters of Zucchini Squash with Yield. The yield of zucchini squash was positively correlated (Figs. 2–15) with fruit length ($R^2 = 0.8645$), fruit diameter ($R^2 = 0.9448$), number of male flowers ($R^2 = 0.776$), number of female flowers ($R^2 = 0.9314$), total number of fruits per plant ($R^2 = 0.9134$), individual

Fig. 2. Relationship between fruit length and yield of zucchini squash.

Fig. 3. Relationship between fruit diameter and yield of zucchini squash.

Fig. 4. Relationship between the number of male flower and yield of zucchini squash.

Fig. 5. Relationship between the number of female flower and yield of zucchini squash.

Fig. 6. Relationship between the total number of fruit per plant and yield of zucchini squash.

Fig. 7. Relationship between individual fruit weight and yield of zucchini squash.

Fig. 8. Relationship between stem length and yield of zucchini squash.

Fig. 9. Relationship between stem diameter at base root and yield of zucchini squash.

Fig. 10. Relationship between moisture (%) and yield of zucchini squash.

Fig. 11. Relationship between fat (%) and yield of zucchini squash.

Fig. 12. Relationship between protein (%) and yield of zucchini squash.

Fig. 13. Relationship between ash (%) and yield of zucchini squash.

Fig. 14. Relationship between crude fiber (%) and yield of zucchini squash.

Fig. 15. Relationship between carbohydrate (%) and yield of zucchini squash.
fruit weight ($R^2 = 0.9562$), stem length ($R^2 = 0.534$), stem diameter ($R^2 = 0.8066$), moisture ($R^2 = 0.8181$), fat ($R^2 = 0.8084$), protein ($R^2 = 0.6613$), ash ($R^2 = 0.9155$), crude fiber ($R^2 = 0.8918$), and carbohydrate ($R^2 = 0.6554$). These results indicate that with the increase in these characteristics, yield increased as well. Individual fruit weight ($R^2 = 0.9562$) had the most intimate relationship with yield, suggesting that squash plant producing higher fruit diameter, number of the female flowers, the total number of fruit, fruit length, stem diameter, and stem length will produce high economic yield and vice versa.

**Pruning and vermicompost improved the proximate analysis.** Proximate compounds such as carbohydrates (%), protein (%), moisture (%), crude fibers (%), ash (%), and fat (%) were determined from fruit samples in this experiment. Proximate compounds showed significant differences due to pruning and vermicomposting except fat (%)(Table 7). High content of carbohydrate (25.82%), fiber (3.26%), ash (5.72%), protein (4.25%), and fat (1.27%) were recorded from the P1V2 treatment (primary pruning at 20 DAT with 10 t/ha vermicompost). Squash is a good energy source because of its high carbohydrate content (25.82%). Squash has a low content of crude fat, cholesterol and anticonstipation. Fiber also helps maintain healthy blood sugar levels and provides energy throughout the day. The presence of high ash content indicates that squash has greater mineral content element, which improves the metabolic process and growth (Elinge et al., 2012). Fedchenkova et al., 2015; Nwofia et al., 2012). We observed similar qualitative properties due to pruning and vermicompost application. We found higher content of carbohydrate, fiber, ash, and protein from P1V2 (primary pruning at 20 DAT with 10 t/ha vermicompost), whereas the lower contents were recorded from P0V0 combination (Table 7). The maximum moisture content was determined from P1V3 and the minimum level of moisture was counted from P2V2 treatment combination. Excess moisture spoilage the fruit rapidly that’s why squash fruit need to store at cool conditions (Aruah et al., 2012; Ghani et al., 2013). Ansari and Ismail (2012) reported that vermicomposting facilitates microbial population of N2-fixing bacteria and actinomycetes activities, which are responsible for healthy soil and also help improve quality squash production. The results of our experiment exhibited positive effects not only on growth and yield, but also on some of the elemental content of zucchini squash with the addition of vermicompost compared with untreated control plots. Vermicompost at the optimal concentration increased EC of fruit juice and percentage of fruit dry matter up to 30% and 24%, respectively, in tomato compared with control in plants (Azarmi et al., 2015).

**Conclusion**

In conclusion, the maximum stem length, stem diameter, and flowering and highest fruit number, length and diameter, yield, and proximate properties were observed from the treatment combination of P1V2 (primary pruning with 10 t/ha vermicompost). Therefore, primary pruning with 10 t/ha vermicompost is a suitable cultural practice for better morphological and biochemical properties of zucchini squash (Cucurbita pepo L.).

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**Table 7. Effect of pruning and vermicomposting on proximate compositions of zucchini squash.**

| Treatments | Moisture (%) | Fat (%) | Protein (%) | Ash (%) | Crude fiber (%) | CHO (%) |
|------------|--------------|---------|-------------|---------|----------------|--------|
| P0V0       | 70.43 ± 0.64 a | 1.27 ± 0.06 c | 3.27 ± 0.08 c | 3.81 ± 0.23 c | 2.13 ± 0.05 c | 19.07 ± 0.16 f |
| P1V1       | 68.70 ± 0.23 ab | 1.37 ± 0.08 abc | 3.85 ± 0.14 b | 4.10 ± 0.24b | 2.48 ± 0.08 d | 19.50 ± 0.27 ef |
| P1V2       | 66.27 ± 0.61 bcd | 1.46 ± 0.10 ab | 3.93 ± 0.11 b | 4.64 ± 0.26 b | 2.76 ± 0.10 bc | 20.94 ± 0.89 def |
| P1V3       | 65.17 ± 1.21 cde | 1.52 ± 0.08 abc | 3.86 ± 0.10 b | 4.51 ± 0.22 b | 2.68 ± 0.09 e | 22.26 ± 0.82 bcd |
| P2V0       | 68.18 ± 0.58 ab | 1.31 ± 0.07 bc | 3.53 ± 0.11 c | 3.92 ± 0.22 c | 2.24 ± 0.04 cd | 20.82 ± 0.45 def |
| P2V1       | 64.35 ± 2.02 d | 1.47 ± 0.07 ab | 4.13 ± 0.12 ab | 4.32 ± 0.23 bc | 2.83 ± 0.05 bc | 22.90 ± 2.21 bcd |
| P2V2       | 59.30 ± 0.49 g | 1.65 ± 0.09 a | 4.25 ± 0.09a | 5.72 ± 0.23 a | 3.26 ± 0.06 a | 25.82 ± 0.49 a |
| P2V3       | 60.73 ± 0.86 fg | 1.50 ± 0.06 ab | 4.13 ± 0.11 ab | 5.67 ± 0.26 a | 3.20 ± 0.07 a | 24.69 ± 0.67 ab |
| P3V0       | 67.57 ± 0.36 bc | 1.28 ± 0.09 c | 3.44 ± 0.10 c | 3.85 ± 0.22 c | 2.97 ± 0.07 ab | 24.65 ± 0.75 abc |
| P3V1       | 63.40 ± 0.61 ef | 1.45 ± 0.11 abc | 3.93 ± 0.12 b | 4.20 ± 0.24 bc | 2.68 ± 0.08 cd | 24.34 ± 0.54 abc |
| P3V2       | 61.22 ± 0.20 fg | 1.53 ± 0.08 abc | 4.03 ± 0.09 ab | 5.66 ± 0.27 a | 3.13 ± 0.06 a | 24.43 ± 0.70 abc |
| P3V3       | 61.51 ± 0.38 ab | 1.49 ± 0.08 abc | 3.94 ± 0.07 ab | 5.35 ± 0.21 a | 2.97 ± 0.07 ab | 24.65 ± 0.75 abc |

Significance level

**** Highly significant; ***nonsignificant.

Data represent mean ± se. Different letters following values within the same column indicate significant differences between pruning and vermicompost at P ≤ 0.05 by Duncan’s multiple range tests. CHO = carbohydrate; NS = nonsignificant; P0 = no pruning; P1 = primary stem pruning; P2 = secondary stem pruning; P3 = no compost; V0 = 5 t/ha; V1 = 10 t/ha; V2 = 15 t/ha.
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