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Influence of different organic media on growth and flowering quality of cockscomb (*celosia sp.*) Cultivars

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ABSTRACT

Cockscomb (*Celosia cristata* L.) is an exotic, herbal and highly valuable seasonal flower. Susceptibility of cockscomb to insects and diseases is a considerable problem which lowers the quality of flower production. Due to adverse effects of inorganic fertilizers on environment, organic manures are preferred to study the growth and quality of cockscomb production. A research work “Response of cockscomb cultivars to different organic amendments” was undertaken at Ornamental Horticulture Nursery, the University of Agriculture Peshawar during the year 2018. The experiment was

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performed in Randomized Complete Design (RCBD) having two factors such as four different organic amendments (Control, spent mushroom compost, leaf mold and farmyard manure) and three cockscomb cultivars (Magenta, Lemon Lime and Giant Red) the experiment replicated three times and comprised of 12 treatments. Findings of the current experiment revealed that the maximum number of leaves (69.69) plant-1, leaf length (16.30 cm), leaf fresh weight (44.67 g), flower diameter (27.30 cm) flower fresh weight (49.56 g), flower dry weight (26.22 g), root length (18.26 cm), root fresh weight (8.11 g), root dry weight (5.78g) and plant height (42.62 cm) were recorded for plants planted on spent mushroom compost, whereas the minimum number of leaves (41.74) plant-1, leaf length (14.05 cm), leaf fresh weight (39.00 g), flower diameter (21.40 cm), flower fresh weight (40.44 g), flower dry weight (22.00 g), root length (14.52 cm), root fresh weight (6.56 g), root dry weight (3.5g) and plant height (32.68 cm) were observed in control media (silt +soil). Similarly, the results also revealed that the highest number of leaves (49.58) plant-1, leaf length (17.05 cm), leaf fresh weight (44.33 g), flower diameter (26.60 cm), flower fresh weight (48.08 g), flower dry weight (25.75 g), root length (17.63 cm) and root fresh weight (7.92 g), root dry weight (5.33 g) and plant height (40.56 cm) were noted in Magenta cultivar. The lowest number of leaves (41.44) plant-1, leaf length (12.37 cm), leaf fresh weight (38.25 g), flower diameter (22.78cm), flower dry weight (19.33 g), root length (14.44 cm), root fresh weight (6.25 g), root dry weight (4.25g) and plant height (34.01 cm) was recorded in Giant Red cultivars, while the minimum flower fresh weight (43.42 g) was noted in Lemon Lime cultivar while their interaction was found non-significant.

Key words: Cockscomb, Growth, Organic Media, Quality, Flowering

INTRODUCTION

Floriculture plants value and growth are greatly affected by the media in which they are grown (Vendrameet al., 2005) and the rate of germination is also significantly affected and many vegetative and reproductive attributes including number of flowers, leaves per plant as well as production and yield parameters good nutrition to the plants is provided by applying organic media such as farm yard manure, compost, leaf manure etc separately or in combine form (Khobragadeet al., 1997). Quality production of flowers and foliage appropriate organic media play a key role because it increase the root system of the plant (Awanget al., 2009). Organic media provide essential nutrients to the plant, increase water absorption of plant, and aerated the soil for good gases exchange (Abad et al., 2002).

Cockscomb (*Celosia cristata*) is an annual dicotyledon (Khoshoo and pal, 2008). It belongs to the family Amaranthaceae. It is commonly known as Celosia, quail grass, Lagos spinach, silver cock's comb and plumed cockscomb. Growth habit is erect annual and branching type stem from 15 to 90 cm height and wide upto 15 to 30 cm. leaves are arranged alternatively around the stem, oval shaped, and light green color upto 5 to 12 cm long. Appearance of fan-shaped, broad heads showed the inflorescence is terminal (Foster and Chongxi1992). The inflorescences are exist in different colors such as violet, white, yellow, orange and pink. The time from summer-mid to fall-mid is a blooming time for *Celosia cristata*. *Celosia* species range from *Celosia argentia*,

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Celosia cristata, Celosia leptostachya, Celosia nitida, Celosia nitida, Celosia odorata, Celosia palmeri, to *Celosia spicate*. There are as many as 60 species of annual or perennial *Celosia*. Cockscomb flowers are found in vibrant yellows, pink, red and gold colors and has got no fragrance (Alan and Nottingham, 2009). It is originated somewhere between Senegal and Cameron in West Africa (Badra, 1991). Some literatures suggest an Asiatic origin too (Martin et al., 1998). It can be grown in both tropical and temperate regions. It is cultivated and grows in different regions as a leafy vegetable such as across the West Indies, SouthAmerica, tropical Asia and tropical Africa. In Nigeria, it is famous with the name of 'sokoyokoto' where it is considered as the main leafy vegetable. In Western and Central Africa it is grown traditionally. Depending on type of soil and its variety, it grows rapidly from seed (Sakata, 2005).

Cockscomb flower is generally subject to few diseases, although fungal and bacterial leaf spots, Rhizoctonia root, Botrytis blight, and stem rot, root-knot, and damping-off. Nematode may occur in the area where humidity is high or where good growing practices, sanitation and other cultural disease management practices that decrease inoculum and spread of propagules are not followed (Afanide et al., 1976).

During mineralization processes the organic manure provides all required macro as well as micronutrients, hence organic manure plays a significant role in plant growth. It also better the soil physical and chemical properties (Fawzy,2012). The utilization of preparing media is basic part for pruned plants which are set up by a mix of different unrefined materials. These rough materials go about as a medium for sustenance and support of the in danger which can be used for enhance age and quality plants (Riazet al., 2008). For developing plants development media is an essential factor. Inorganic manures are utilized to achieve most extreme development and yield however may make issues human wellbeing and condition (Arisha and Bardisi, 1999). The utilization of developing media is picking up significance as it enhances the dirt condition yet in addition gives fundamental supplements to the plant. Treated the soil materials has been given an incentive in business; preparing substrates since they are wealthy in humus and these materials give required supplements, create capable water holding condition and also help cation trade capacities. This is set up by controlled natural debasement of natural materials. Manure invigorates the supplements up take and absorption, in some (Bachmain and Metzgier, 2007). When mushrooms are harvested it is used to prepare mushroom compost. Growth media is obtained from the remaining of horse manure, shells of cocoa, cotton remaining, and husk of maize. Presence of phosphorous 0.3%, potassium 0.3%, nitrogen 0.7% gives alkaline nature to the growing media. water holding capacity of soil, soil fertility and availability of essential nutrients are also increased by providing good organic media (Jonathan et al. 2002) .

Keeping in view the importance of organic media in enhancing quality and yield of cockscomb flower, the current experiment is designed to study the response of cockscomb cultivars to different organic media with the following objectives.

To evaluate the best organic media for better flower production cockscomb flower.

To determine the best cultivar grown under the agro-climatic conditions of Peshawar.

To study the interaction of organic media and cultivars for quality production of cockscomb flower.

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MATERIALS AND METHODS

Experimental Site

An experiment entitled "Response of cockscomb cultivars to different organic amendments" was carried out in the ornamental nursery, Department of Horticulture, The University of Agriculture Peshawar during 2018. Peshawar (subtropical) in the north (1600 km) of the Indian Ocean (Alam et al. 2020) is at 350 m elevation above sea level (latitude=34.01 ºN and longitude=71.35 ºE) (Ahmad et al. 2019). With the division of certain little water bodies, the Indus River also arrives from the Northwest side into the valley (Basit et al. 2022). Normally, the soil of Peshawar is a mixture of clays and silts (boulders, gravels, and pebbles) (Basit et al. 2022). Being a subtropical zone (extended summer=45 °C and severe winter=5 ºC), the hottest month is June (rainfall=7 mm) while March is considered the wettest (rainfall=78 mm) (Sajid et al. 2020; Gilani et al. 2021).

Experimental Design

Randomized Complete Block Design (RCBD) with two factorial arrangements i.e. Factor.A and B. Factor.A with four levels of organic amendments and Factor.B with three levels of cockscomb cultivars were used. Treatments were replicated three times, and total No. of treatments were 36. Both factors along with their levels are as follow.

Factor A (Organic amendments)

M_0 = Control (Silt + Garden Soil) (1:1)
M_1 = Spent mushroom compost + Silt + Garden soil (1:1:1)
M_2 = Leaf mold + Silt + Garden soil (1:1:1)
M_3 = Farm Yard Manure + Silt + Garden soil (1:1:1)

Factor B (C. Cristata Cultivars)

C_1 = Lemon Lime
C_2 = Magenta
C_3 = Giant Red

PREPARATION OF PLASTIC BAGS

Equal size of plastic bags (10 x 7") were collected from local market. The bags were punched with the help of punching machine in order to improve drainage. Six punches were made in each bag.

SOIL PREPARATION

Different types of soil amendments including silt, soil, FYM, mushroom compost and leaf mold were used in plastic bags. These organic amendments were mixed in different ratios i.e. (silt + Garden Soil) (1:1), Mushroom compost + silt (1:1:1), Leaf mold + Silt + Garden soil (1:1:1), Farm Yard Manure + Silt + Garden soil (1:1:1) of different organic amendments.

SOIL ANALYSIS

Soil analysis was carried out prior to the plantation of seedlings. Soil samples were collected from each treatment and analyzed in soil science laboratory, Department of Soil and Environmental Sciences, The University of Agriculture Peshawar. Each sample along with their analysis results are shown as below.

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Media	Organic Matter (%)	pH	N (%)	P (%)	K (%)
Control	0.28	7.4	0.14	0.0004	0.0082
Spent Mushroom	4.9	7.7	0.72	0.009	0.008
Leaf Mold	3.9	7.6	0.61	0.007	0.006
Farm Yard Manure	2.9	7.5	0.53	0.01	0.009

Transplanting seedlings to plastic bags

Twenty days old seedlings were purchased from Floral Nursery located at Hayatabad, Peshawar and were transplanted to plastic bags, one plant bag^{-1}. Bags were kept in shade for three days to prevent exposure to direct sunlight. Irrigation was done regularly throughout the experiment, depending upon the soil moisture contents and climatic conditions. All cultural practices were carried out in the same manner throughout the experiment as per requirement.

Parameters studied

Data was recorded from three randomly selected plants in each treatment. The flowing attributes were studied during the current study.

Number of leaves plant^{-1}

Leaves plant^{-1} were counted for all treatments in all replications. Mean value of the transplant data was calculated.

Leaf length (cm)

Leaf length was measured for all the treatments in all replication by using measuring tape for each treatment and replication and their means were recorded.

Leaf fresh weight (g)

Fresh weight of leaf was measured by weighing five plant fresh leaves from each treatment and each replication using electronic balance and their average was calculated.

Flower fresh weight (g)

Using electrical balance, the flower fresh weight of each treatment in all replication was weighed and average value was determined.

Flower dry weight (g)

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Flowers were dried in oven at 65°C for 24 hours and then were weighed again on electric balance. Average of the recorded weights was computed.

Diameter of flower (cm)

The width of flower for all the treatments in all replication was measured by using measuring tape and their average mean was calculated.

Root length (cm)

The length of root was measured by measuring tape in all the treatments of all replication was used and roots of randomly selected plants for each treatment and replication was taken and then averaged.

Root fresh weight (g)

Root fresh weight was obtained by taking five randomly selected plants from each treatment and replication to measure their root weight on average basis.

Root dry weight (g)

Root dry weight was obtained by taking five randomly selected plants from each treatment and replication to measure their root weight on average basis.

Plant height (cm)

The whole plant from base to tip of flower was measured for all the treatments in all replication with the help of measuring tape and then their mean value was calculated for each treatment.

Statistical Analysis

For the determination of treatments difference as well as their interactions, the collected data was analyzed using the analysis of variance. The statistical package MSTAT-C was used to analyze data and statistical significance was assessed by LSD test at 5 % significance level (Bricker, 1991).

RESULTS AND DISCUSSION

Number of leaves plant^{-1}

Data regarding the number of leaves plant^{-1} is given in Figure-1. Significant difference was recorded among the different organic amendments and cultivars, while the interaction between the treatments and cultivars was recorded as non-significant.

By using different organic amendments, the number of leaves plant^{-1} have been altered (Figure 1). Maximum number leaves (69.69) plant^{-1} were found in Spent Mushroom followed by Leaf Mold (55.79) and minimum number of leaves (41.74) plant^{-1} were found in Control treatment. Likewise, cultivars also affected the number of leaves plant^{-1}. Maximum number of leaves (56.49) plant^{-1} were observed in Magenta followed by (51.35) in Lemon Lime, while minimum number of leaves (50.74) plant^{-1} were observed in Giant Red.

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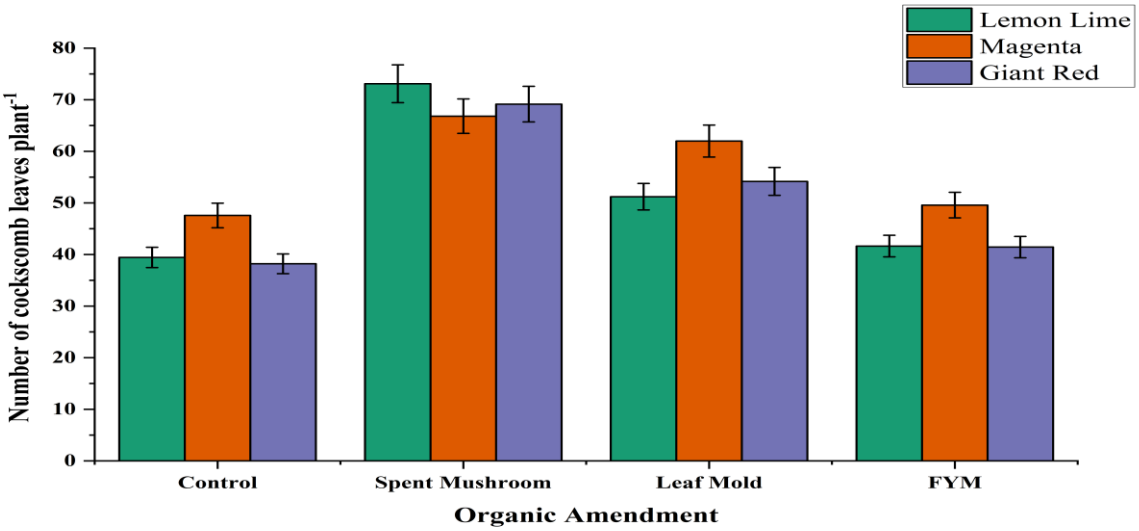


Figure 1: Number of leaves plant^{-1} as effected by different organic amendments

Number of leaves are much important in all plants, as they are the main site of photosynthesis, where food is being prepared. Jonathan et al. (2011) Maximum number of leaves were observed in spent mushroom compost in Capsicum annum and Abelmoscus esculentus. Spent mushroom compost excelled in the performance regarding number of leaves plant-^{1} due to presence of excess nutrients such as phosphorus, nitrogen and potassium. The pH of mushroom compost was high due to presence of chalk ($CaCO_3$). Electric conductivity (EC) values of spent mushroom compost were high which facilitates availability of nutrients to the plant (Medina et al., 2009). Similarly, Steffan et al. (1994) stated that soil structure was improved when mixed with mushroom compost as a result it increases organic matter with controlled weeds growth. As, the structure of spent mushroom is porous in nature so it reduces the accumulation of CO_2 and helped the microorganism in increase of their respiration which resultantly increased the number of leaves plant^{-1} (Abdulrahman and Sadeeq, 2014). More number of leaves could not be considered as factor contributing toward leaf area but it is mainly due to adequate supply of nutrients. Therefore, the nutrient rich substrate can be used to achieve significant results as maximum increase in size of leaves shows adaptability of plants to soil or growth media (Riaz et al., 2014; Cardens et al., 2006).

Leaves are important for plants as they are the major site of photosynthesis of green plants where glucose and proteins are manufactured and transpiration occurs. In plants number of leaf and leaf size are the major yield determinants. Spent mushroom compost influenced both number of leaf and leaf size in plants till harvest, this might be due to the fact that spent mushroom compost contains the essential plant nutrients that plants need to produce and retain leaves (Sendi, 2013). Though, number of leaves is influenced mainly by environmental conditions, nutrients present in growth media are also one of the factors which have prime importance in this regard. More number of leaves in plants reflect good vigor and their suitability to environment and growth media. Since nitrogen in growing media significantly affects the plant growth, increase in number of leaves

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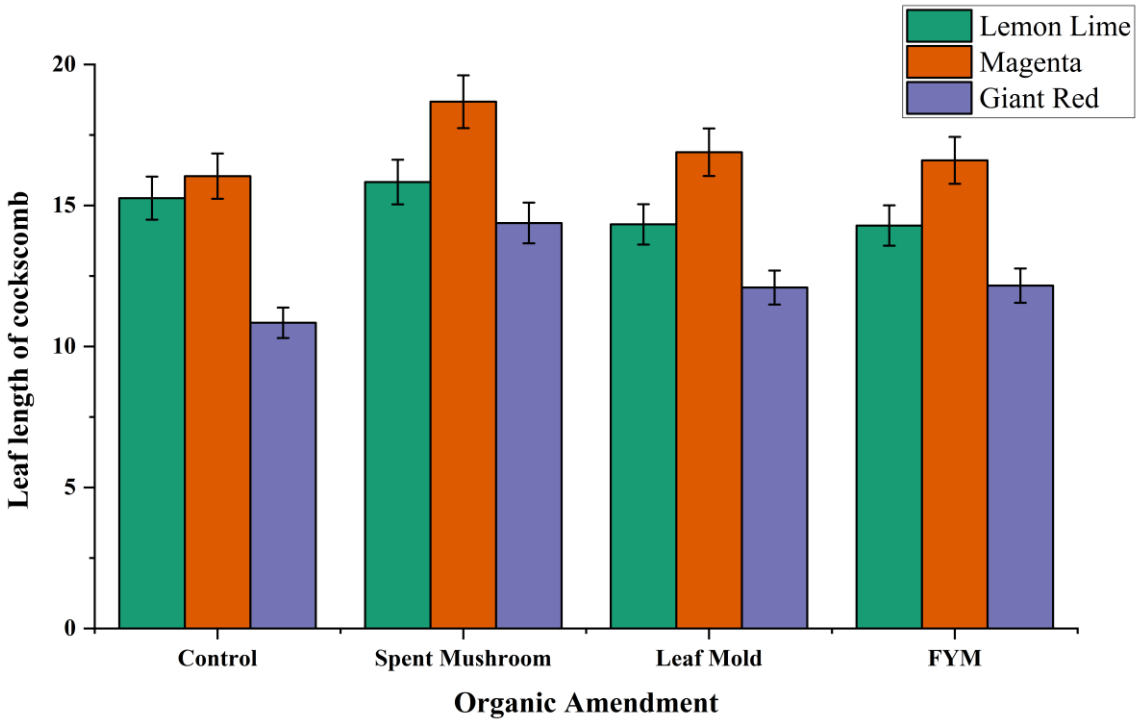
of plants can also be due to adequate availability of nitrogen content in growing substrate (Riaz et al., 2008; Khayyat et al., 2007; Benito et al., 2005). A good amount of leaves coupled with conducive root environment which would have led to proper nutrient uptake in the substrates may resulted in greater accumulation of food matter leading to increase number of leaves in rose.Same results were reported by Tahir et al. (2011) who studied freesia cultivar using different growing media. Maximum leaves in mushroom compost may be attributed to its water and nutrient holding capacity due to its high organic matter content. It also contains adequate concentration of NPK. The pH of this medium is also conducive for plant growth, which resulted in the preparation of more photosynthates and hence more leaves.

Leaf length (cm)

Mean values regarding the leaves length plant^{-1} is given in Figure-2. Significant difference was recorded between the different growing medias and cultivars, while the interaction among the treatments and cultivars was non-significant.

By using different growing media, leaves length was greatly affected (Figure 2). Maximum leaves length (16.30 cm) plant^{-1} was noticed in Spent Mushroom, followed by leaf mold (14.44 cm) and minimum leaves length (14.05cm) plant^{-1} were found in control treatment.

Similarly, cultivars also affected length of leaves plant^{-1}. Maximum length of leaves (17.05cm) plant^{-1} was observed in Magenta followed by Lemon Lime (14.93cm) while, minimum leaves length (12.37cm) plant^{-1} was measured in Giant Red.



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Figure 2: Leaf length (cm) as effected by different organic amendments

Spent mushroom compost is used as soil amendment, because it is made up of materials which are non-toxic to plants. It is also enriched in the nutrients which stimulates the development and growth of photosynthetic plants (Fasidi et al., 2008) and Maynard (1994). Spent mushroom compost has nourishing nature which trigger the production of chlorophyll which resulted larger leaves (El-Naggar and El-Nasharty 2009). Leaf length increased due to accumulation of more chlorophyll. Spent mushroom compost having high content of nitrogen and potassium might be the main drive behind the larger leaf length.

Additionally, spent mushroom compost is having high water and nutrient holding capacity which helps in growth of the plant that ultimately results in larger leaf length (Abdulrahman and Sadeeq 2014). Similarly, Khattak et al. (2011) reported that effects of mushroom compost for leaf length of Vinca rosea. While, Tahir et al. (2011) results for freesia cultivars are in align with current findings. The current findings are also corelated with Cardenas et al. (2006) who reported that the more number of leaves and length of leaf was observed in burnt composted rice husk complemented with coconut fiber in carnation flower.

Leaf fresh weight (g)

Data regarding leaf fresh weight (g) is given in Figure-3. Significant difference was observed among the different organic amendments and cultivars, while the interaction effect between the organic amendments and cockscomb cultivars was non-significant.

By using different organic amendments, the leaf fresh weight (g) have been significantly affected (Figure 3). Maximum leaf fresh weight (44.67 g) was found in spent mushroom compost, followed by leaf mold (40.78 g) and minimum leaf fresh weight (39.0 g) were observed in control treatment.

Likewise, cultivars also affected the leaf fresh weight (g). Maximum leaf fresh weight (44.33 g) was observed in cultivar Magenta followed by Lemon Lime (40.83 g) and minimum leaf fresh weight (38.25 g) were recorded in Giant Red.

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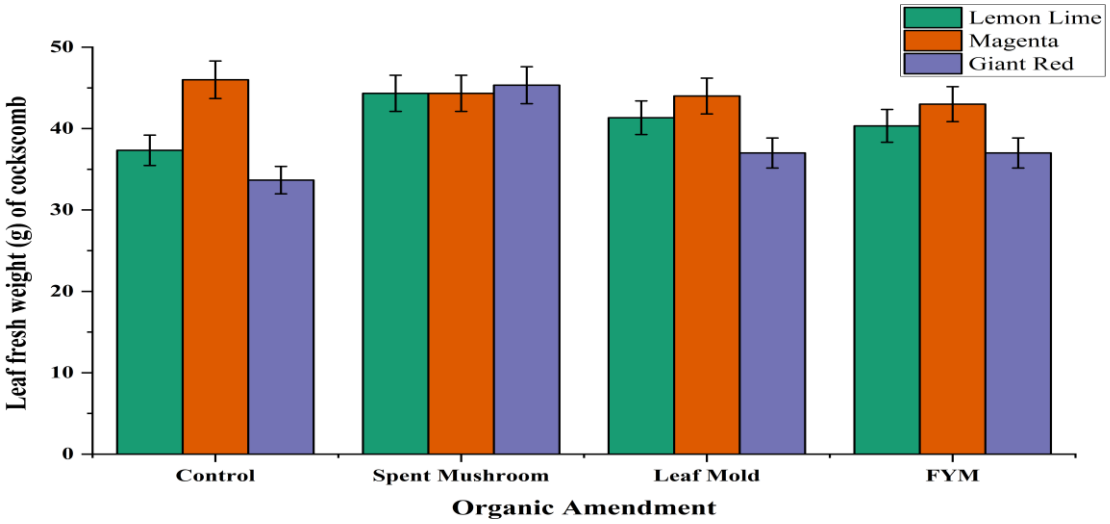


Figure 3: Leaf fresh weight (g) as effected by different organic amendments

Current results are in line with the findings of the results of Aghdak et al. (2016) who reported that spent mushroom compost gave the highest leaf fresh weight as compared to other organic amendments such as farmyard manure and leaf mold source. It leads to the fact that spent mushroom compost growing media provide enough nutrients and well balance minerals. It has also been reported that the spent mushroom compost media improved the vegetative growth parameters of the plants including plant height, leaf fresh weight and stem fresh and dry weight. Similarly, Samavatipour et al. (2015) reported that vermi compost significantly increased the leaf fresh weight of tomato and stem fresh and dry weight. The present findings corroborated with the findings of Ahlawat et al. (2009) who reported that Mixing of soil with SMC enhances the tomato quality with respect to superior fresh leaf weight. The present findings are in agreement to the findings of Jonathan et al. (2013) who also reported that SMC of Pleurotus ostreatus used as soil conditioner for the improvement of growth of Soyabean gave best result in respect of leaf fresh weight. Rhodas and Olson (1995) suggested that optimum SMC was for many crops and they postulated that increased leaf fresh weight and flower size was due to the nitrogen availability which was resulted with SMC treatments.

Flower diameter (cm)

Mean data pertaining the flower diameter (cm) is presented in Figure-4. Significance difference was noted in different organic amendments and cultivars, whereas interaction effect between the organic amendments and cultivars were non-significant. Mean value regarding using different organic amendments, flower diameter (cm) was greatly affected. Maximum flower diameter (27.30 cm) was found in spent mushroom compost followed by leaf mold (24.21 cm) and minimum flower diameter (21.40 cm) was observed in control treatment (Figure 4).

Similarly, cultivars also significantly affected the flower diameter (cm). Highest flower

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diameter (26.60 cm) was observed in cultivar Magenta followed by Lemon Lime (23.28 cm) and minimum flower diameter (22.78 cm) was noted in Giant Red.

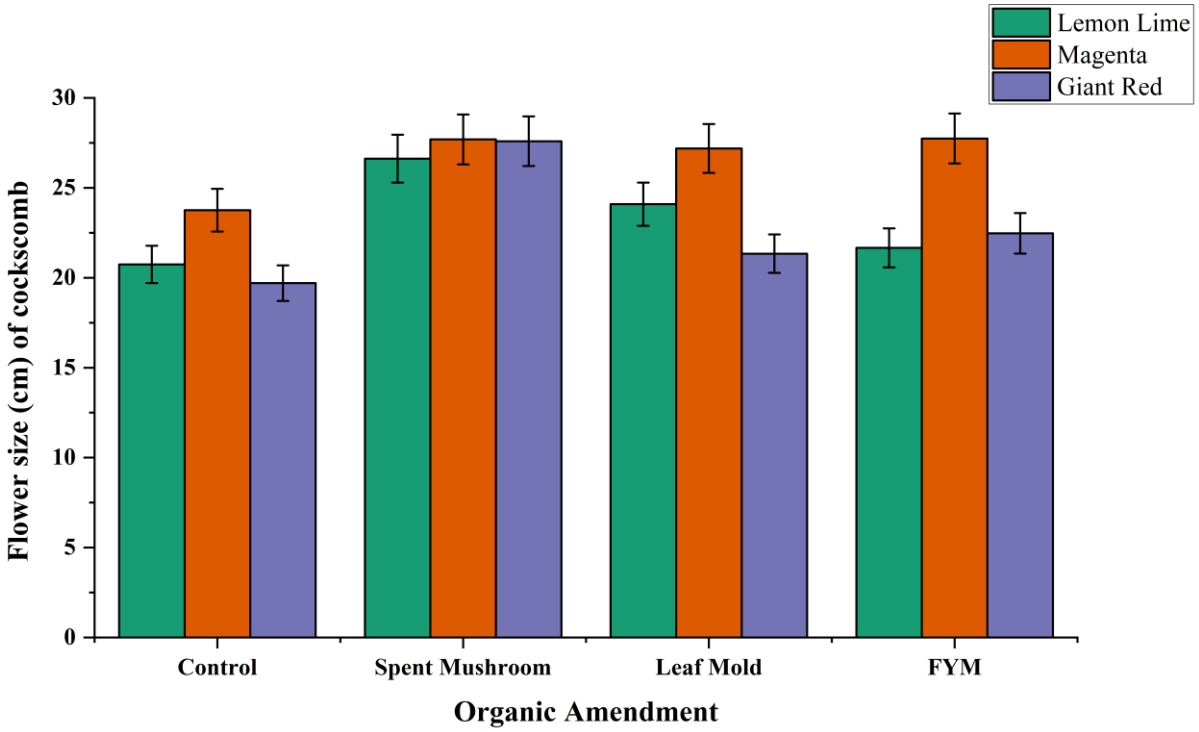


Figure 4: Flower diameter (cm) as effected by different organic amendments

The maximum flower diameter was due to presence of nutrients like nitrogen, potassium and organic matter content in spent mushroom compost. These findings are in accordance with the results of Riaz et al. (2008) who stated that the maximum flower diameter of zinnia in coconut compost which had medium range of nitrogen present in it. Phosphorus is vital nutrient of spent mushroom compost which play an important role for reproductive (flower) growth. Kiran et al. (2007) performed an experiment on dahlia and stated that maximum flower diameter was observed in media containing spent mushroom compost. Khattak et al. (2011) also stated maximum size of flower for Vinca rosea plants being cultivated in spent mushroom compost medium. The current results are also in accordance with the findings of Fakhri et al. (1995) who reported the maximum flower diameter of Fime cultivar of Gerbera grown in spent mushroom. Similarly, Ali et al. (2014) also reported that flower diameter of Zinnia elegans was greatly affected when it was grown on spent mushroom compost.

Flower fresh weight (g)

Mean values regarding the flower fresh weight (g) is given in Figure. Significant variation was recorded in the different organic amendments and cultivars, while interaction between the organic amendments and cultivars was non-significant.

Regarding using different organic amendments, flower fresh weight (g) was greatly affected (Figure 5). Maximum flower fresh weight (49.56 g) was found in mushroom

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compost followed by leaf mold (45.00 g) and minimum flower fresh weight (40.44 g) were found in control treatment.

Similarly, cultivars also affected the flower fresh weight (g). Highest flower fresh weight (48.08 g) was observed in Magenta followed by Giant Red (43.42 g) and lowest flower fresh weight (42.00 g) was noted in Lemon Lime.

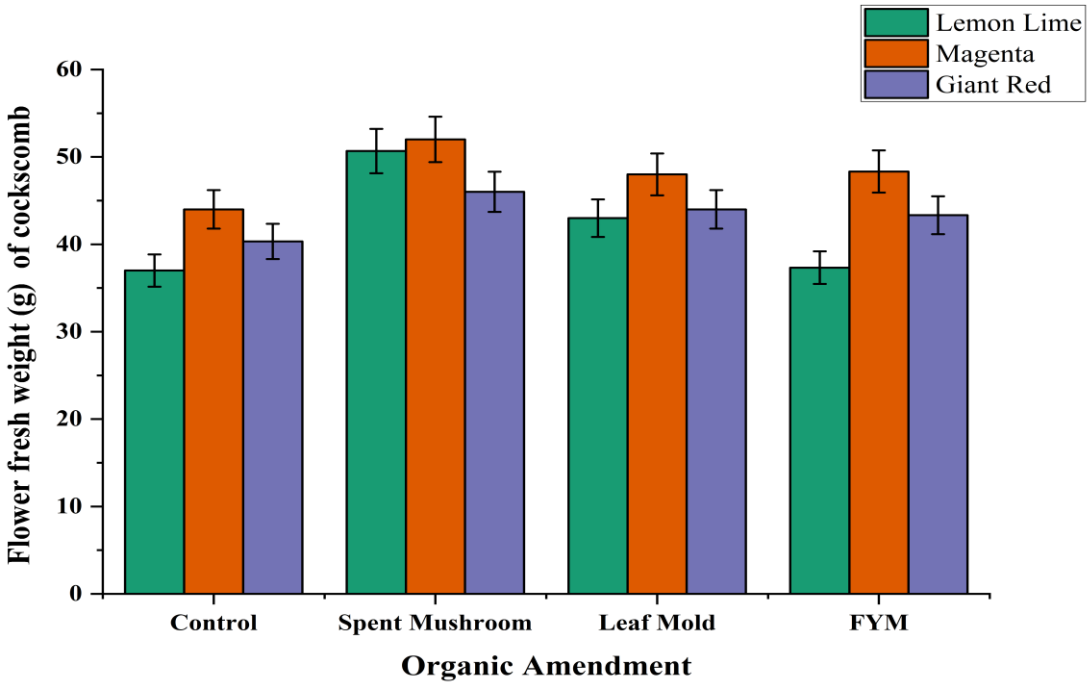


Figure 5: Flower fresh weight (g)) as effected by different organic amendments

The maximum flower fresh weight in spent mushroom compost and leaf mold might be due to maximum leaves in media that promote the process of photosynthesis and the high rate of photosynthesis increased the flower size, as in spent mushroom the plant produce maximum flower size so flower fresh weight may also increase (Zhang et al., 2004).

Present study results are being favored by Caballero et al. (2009) who also reported that organic amendments containing silt and spent mushroom compost promoted maximum flower fresh weight and its ratio contrast to conventional media which proved that this kind of media can be used for gerbera production effectively.

Current results are in consistent with the findings of Grassotti et al. (2003) who observed that organic amendments having combination of silt and mushroom compost can produce the maximum flower fresh and dry weights, of gladiolus and lily. Similarly, Younis et al. (2013) also concluded that the combination of leaf mold, spent mushroom compost, coconut coir, sand and peat produced the best quality of plants with considerable increase in flower fresh weight.

Flower dry weight (g)

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Mean values regarding the flower dry weight (g) is given in Figure-6. Significant difference was recorded in the different organic amendments and cultivars, while their interaction between the organic amendments and cultivars was non-significant.

Regarding using different organic amendments, flower dry weight (g) was greatly affected (figure 6). Highest flower dry weight (26.22 g) was found in spent mushroom compost followed by leaf mold (23.89 g) and minimum flower dry weight (22.00 g) were found in control treatment.

Similarly, cultivars also affected the flower fresh weight (g). Highest flower dry weight (25.75 g) was observed in cultivar Magenta followed by Lemon Lime (23.58 g) and lowest flower dry weight (22.50 g) was noted in Giant Red.

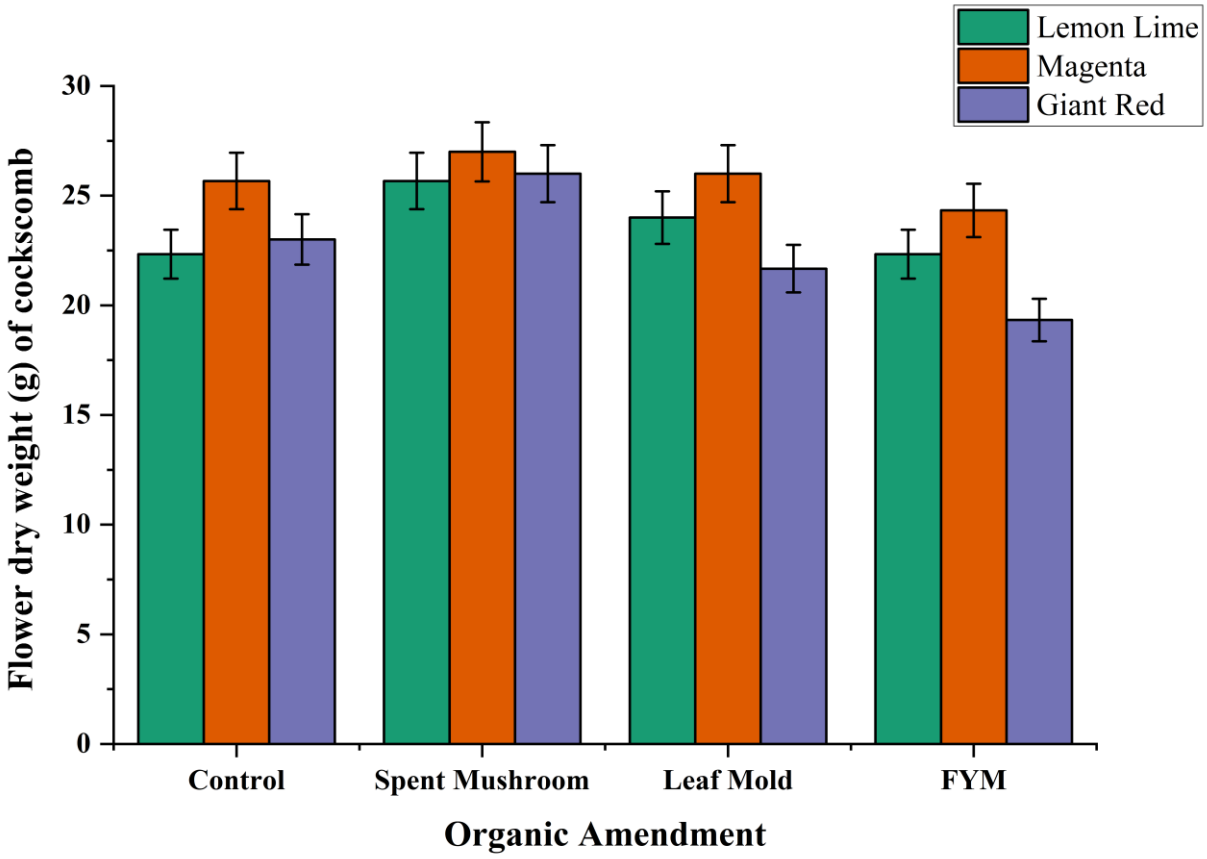


Figure 6: Flower Dry weight (g)) as effected by different organic amendments

The maximum flower dry weight in spent mushroom compost is due to the reason that spent mushroom compost is rich source of all macro and micro nutrients which help in increasing the growth of flower, size as well as dry weight. The more dry weight is due availability of high fresh weight as reported by Mousa et al. (2010). Moreover, Khalaj et al. (2011) also observed that maximum flower dry weight of Gerbera however, was due to use of perlite, mushroom and peat in recommended combination. Rich supply of nutrients like N, K, P and other nutrients in growing substrate is proved to be sufficient for production of good quality flowers. The adequate availability of essential nutrients

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increased flower fresh and dry weight.
Similarly, Nabi et al. (2002) also observed maximum flower dry weight in spent mushroom compost. Spent mushroom compost with excellent nutrient quality influences plant growth as availability of P and K contents in growth media has positive relationship with flowering indices Hence the results are in support of current findings.

Root length (cm)
Mean values pertaining to the root length (cm) is expressed in figure-7. Significance variation was noted among the different organic amendments and cultivars, whereas interaction effect between the organic amendments and cultivars was non-significant.
Mean value regarding using different organic amendments on root length (cm) was significantly affected. Maximum root length (18.26 cm) were noticed in spent mushroom compost followed by leaf mold (15.40 cm) and minimum root length (14.52 cm) were found in control treatment (Figure 7).
Similarly, cultivars also significantly affected the root length (cm). Maximum root length (17.63 cm) was observed in cultivar Magenta followed by Lemon Lime (15.14 cm) and the lowest root length (14.44 cm) was noted in Giant Red.

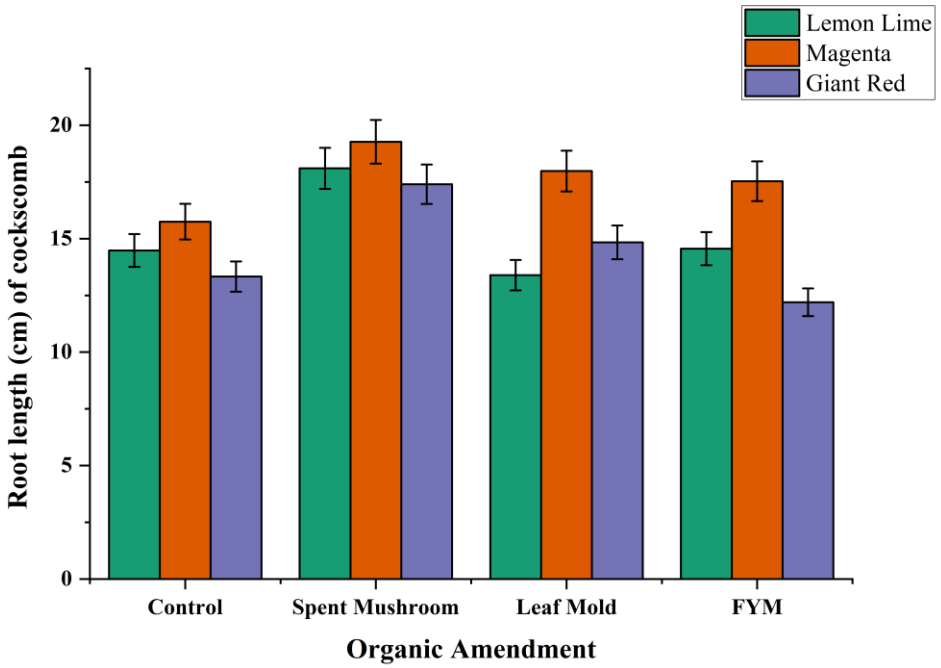


Figure 7: Root length (cm) as effected by different organic amendments

Mamba and Wahome (2010) obseved significant differences for root length growing in different media. They further unveiled that spent mushroom compost gave the maximum root length. In their findings, it was found that root length was twice in spent mushroom compost as compared to control. They also reported that long root length is due to high uptake of nutrients and water holding capacity, while the control media had

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not possess the ability of having high nutrients and water holding capacity. Hence, their findings are in support of current results of study. Moreover, Shah et al. (2006) stated that increased root length is due to presence of water and nutrients in root zone as spent mushroom compost has high water holding capacity and nutrients. Likewise, Marques et al. (2014) used 42–48% spent mushroom compost substrate for the cultivation of lettuce seedling (Latua satia L.) and showed that it provided the most adequate conditions for the growth and development of crisp head lettuce seedling roots. Similar results were reported by Farooq et al. (2014) that maximum root length was recorded in zinnia plants while grown on spent mushroom compost and concluded that spent mushroom compost improved the environment for plant root growth by decreasing soil bulk density so that root could grow and move easily.

Root fresh weight (g)

Mean values regarding the root fresh weight (g) is given in Figure 8. Significant variation was recorded in the different organic amendments and cultivars, while interaction effect between the organic amendments and cultivars was non-significant.

Regarding using different organic amendments, root fresh weight (g) was greatly affected. Maximum root weight (8.11 g) was found in spent mushroom compost followed by leaf mold (6.67 g) and minimum root fresh weight (6.56 g) were found in control treatment (Figure 8).

Similarly, cultivars also affected the root fresh weight (g). highest root weight (7.92 g) was observed in cultivar Magenta followed by Lemon Lime (6.75 g) and lowest root fresh weight (6.25 g) was recorded in Giant Red.

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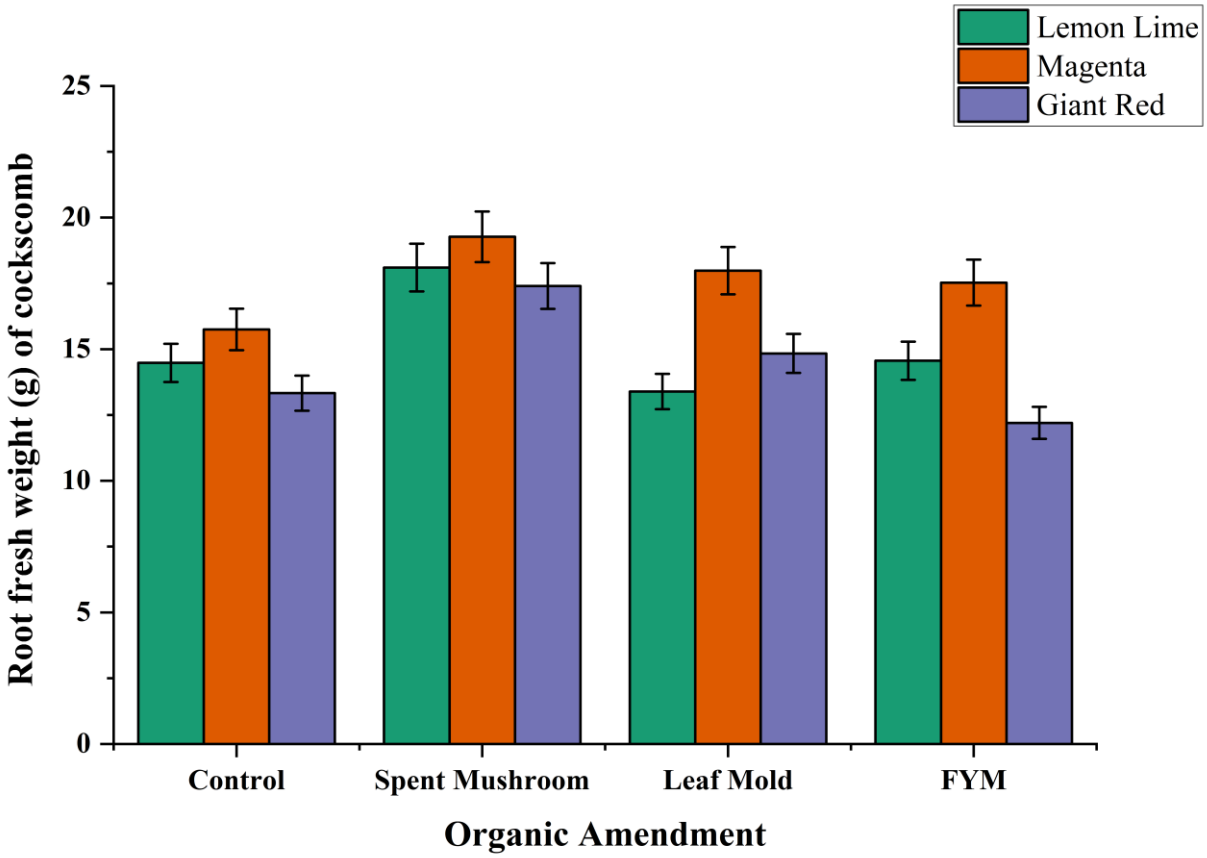


Figure 8: Root fresh weight (g)as effected by different organic amendments

Shah et al. (2006) investigated and observed that root weight of tomato expressed significant differences in tomato hybrids growing in spent mushroom compost. Adunga et al. (2015) stated that roots which are longer in length penetrate deep and have the capacity to absorb high amount of nutrients and water, result in increases the root fresh weight. It was also reported by him that proper aeration and drainage is obtained by mixing mushroom compost with silt which increase the porosity and good initiation of roots.

Odongo et al. (2008) also determined that growth and weight of root is highly affected by adding spent mushroom compost in soil. Similarly, Rao et al. (2005) also observed that growing media played important role initiating new roots formation and growth that results in increase in root weight. Hence, these above researchers findings are in close conformity with the current findings.

Root dry weight (g)

Mean values regarding the root dry weight is given in Figure 9. Significant variation was recorded in the different organic amendments and cultivars, while interaction effect between the organic amendments and cultivars was non-significant.

Regarding using different organic amendments, root dry weight was greatly affected.

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Maximum root dry weight (5.78 g) was found in spent mushroom compost followed by leaf mold (4.89 g) and minimum root dry weight (3.56 g) were found in control treatment (figure 9).
Similarly, cultivars also affected the root dry weight. Highest root dry weight (5.33 g) was observed in cultivar Magenta followed by Lemon Lime (4.58 g) and lowest root dry weight (4.25 g) was noted in Giant Red.

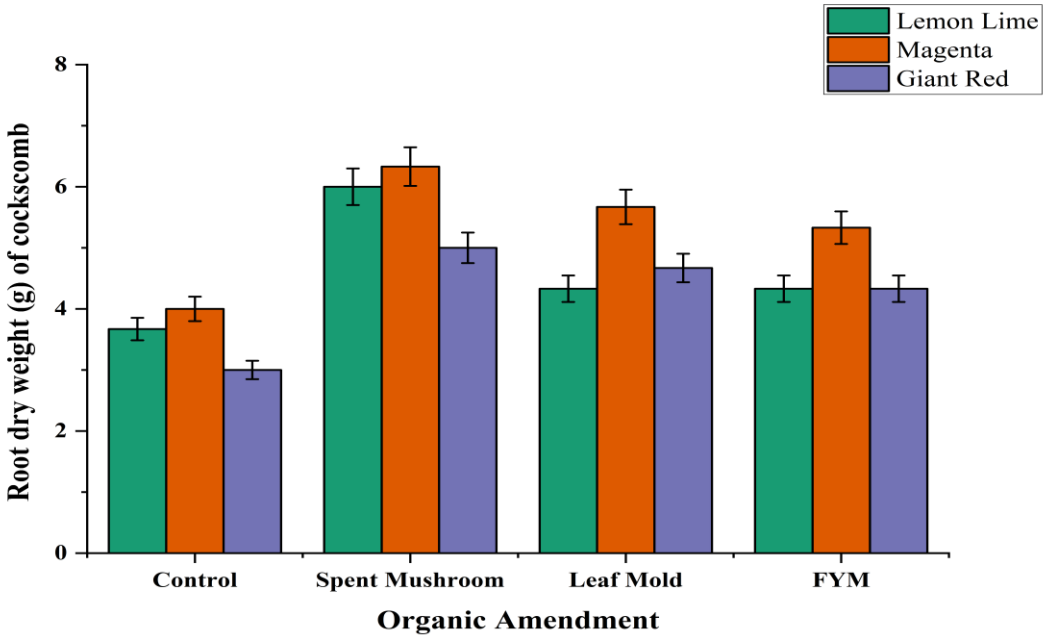


Figure 9: Root Dry weight (g) as effected by different organic amendments

Root dry weight of cockscomb cultivars is relying on vegetative growth. Except all organic amendments spent mushroom compost showed highest root dry weight. Rao et al. (2005) investigated variation in growing media, generate new roots and to promote root formation in tomato cloning via cutting, the thing which is most significant is to activate plant hormone. It plays important role in the making of adventitious roots in tomato cuttings. When organic medium was used as a potting medium in a result highest dry root weight was obtained with the combination of silt and topsoil (Khayyat, 2007). Moreover, current results are corelated with Chavez (2008) that also found significant increase in Petunia hybrida plant when grown in spent mushroom and river waste.
Idowu and Kadiri (2013) used the SMC of P. ostreatus to cultivate okra (Abelmoscus esculentus Moench) and found that the growth and yield of okra (fresh and dry weight of roots and number of okra roots) was significantly enhanced and these results are in agreement to the current findings. The present studies are in line with the findings of Irshad et al. (2014) who also observed significant differences among media. Among the tomato hybrid Sahil showed maximum response to produce maximum root dry weight as compared to other hybrids grown in spent mushroom compost.

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Plant height (cm)

Mean values regarding the plant height (cm) is given in Figure 10. Significant variation was recorded in different organic amendments and cockscomb cultivars, while their interaction between the organic amendments and cockscomb cultivars was non-significant.

While using different organic amendments, plant height was greatly affected (Figure 10). Maximum plant height (42.62 cm) was found in Spent Mushroom followed by Leaf Mold (36.03 cm) and minimum plant height (32.68 cm) was found in control treatment. Similarly, cultivar also affected the plant height. Highest plant height (40.56 cm) was observed in Magenta recorded by Lemon Lime (35.43 cm) and lowest plant height (34.01 cm) was noted in Giant Red.

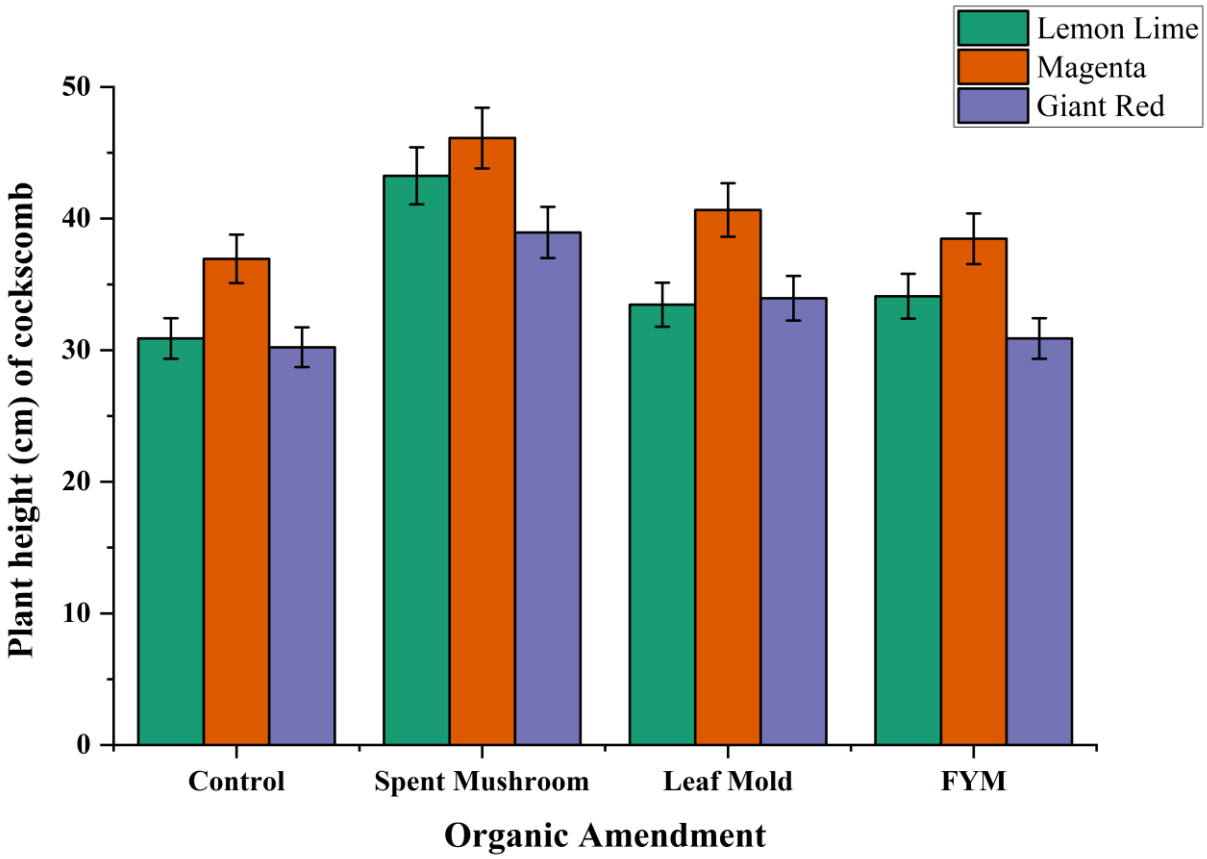


Figure 10: Plant height (cm) as effected by different organic amendments

In generally ideal potting mixture is the one that retains water and nutrient as well as develop soil structures. Among the treated media spent mushroom compost seems more efficient as it used as a growing media for bedding plants. As reported by (Tahir et al. 2011) who investigated freesia plants growing on different media and reported maximum plants height for the plants growing in spent mushroom compost.

Spent mushroom compost is enriched with nitrogen and a main component of amino acids. Presence of more nitrogen in spent mushroom compost results in more protein

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synthesis. The tall plants undergo through quick cell division and elongation can be the chief stimulus. Balanced rooting media using agricultural waste can greatly affect the plant height and are essential for attaining maximum height. These results are in accordance with Treder (2008) and Dubsky and Sramek (2008), who observed as excellent growth in plant height of perennials in spent mushroom and peat substrate with the addition of rock wool. Khattak et al. (2011) reported that taller plants are efficient when spent mushroom is used.

Same results were reported by Henny (1979) for peperomia as he found more plant height for the plants recorded in spent mushroom compost. Younis et al. (2008) recorded maximum plant height in Dahlia coccinia being grown in spent mushroom. Riaz et al. (2008), results for Zinnia elegans are in accordance with current findings.

Pearson correlation and PCA Analysis:

Pearson correlation was calculated among different growth, yield, and quality attributes of cockscomb. A significant correlation was recorded between some growth and quality attributes of cockscomb (Fig. 4). The positive correlation was recorded in flower diameter (FD) vs leaf length (LL) (0.74), FD vs root dry weight (RDW) (0.51), FD vs root length (RL) (0.59), fresh flower weight (FFW) vs leaf fresh weight (LFW) (0.55), FFW vs root fresh weight (RFW) (0.66), LFW vs RFW (0.69), LFW vs RL (0.54), LL vs RL (0.58), number of leaves per plant (NLP) vs plant height (PH) (0.38), NLP vs RDW (0.36), and PH vs RDW (0.20). In contrast, flower dry weight (FDW) and plant height (PH) had a negative correlation with fresh flower weight (FFW) and root fresh weight (RFW). Similarly, the correlation of FDW vs PH, LFW vs NLP, and PH vs FFW was found to be negative. NLP, PH, and RDW vs fresh weights and flower diameter were negatively correlated.

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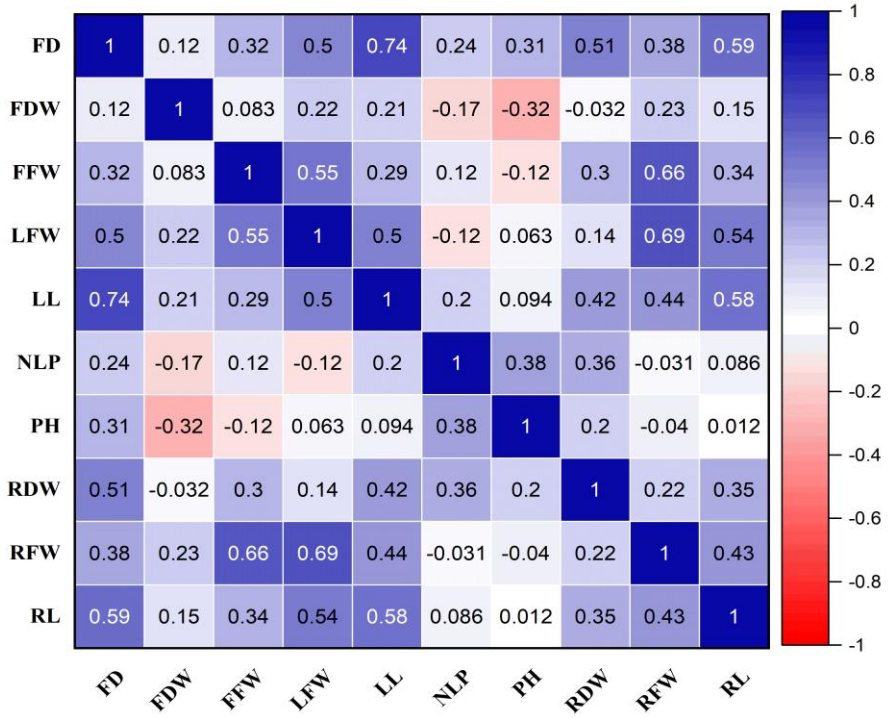
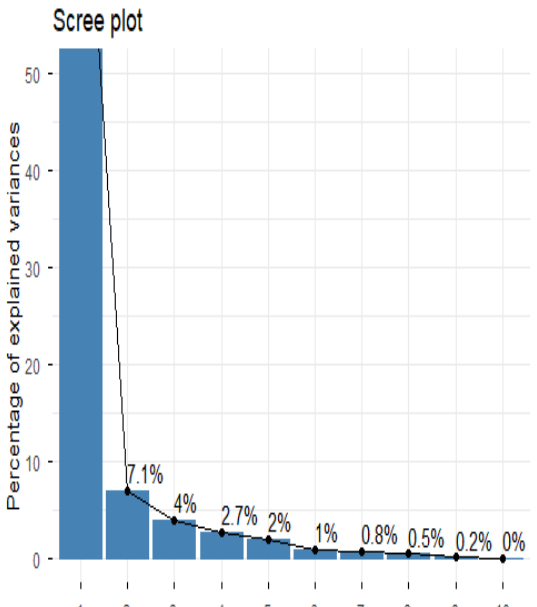
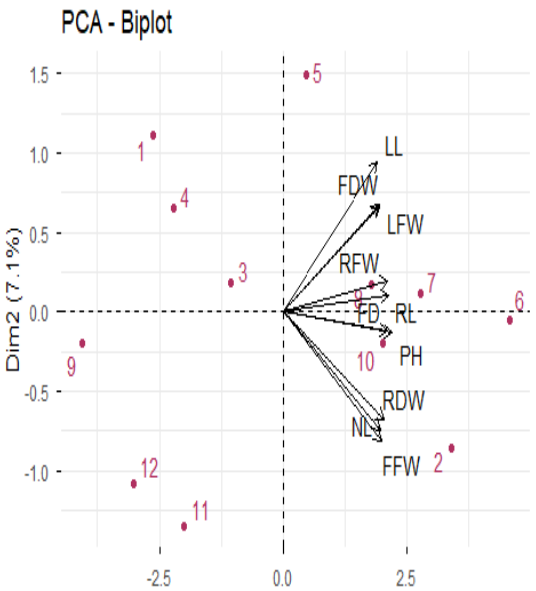


Figure 11: Pearson correlation of growth and yield attributes of cockscomb

Principal component analysis was calculated by using the mean value of growth and yield attributes of cockscomb (Fig. 11). According to the scree plot (Fig. 5), the highest contribution by variance was recorded in PC1 (81.6%), PC2 (7.1%), and PC3 (5.2%), which together covered about 93.9% of the total variance. Leaf length (LL), flower diameter (FD), and root length (RL) showed strong positive loading in the context of PC1. Leaf fresh weight (LFW), root fresh weight (RFW), and fresh flower weight (FFW) had positive loading in the context of PC2 (Fig. 6).





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Figure 12: Principal component analysis of growth and yield attributes of cockscomb

CONCLUSION AND RECOMMENDATIONS

Conclusions

Following conclusion are made from the present studies:

Among the different cockscomb cultivars Magenta showed the best performance for number of leaves plant^{-1}, leaf length, leaf fresh weight, flower diameter, flower fresh weight, flower dry weight, root length, root fresh weight, root dry weight and plant height.

Cockscomb cultivars grown in spent mushroom compost (SMC + silt + Garden soil) gave the best results in most of the plant growth parameters and flower production as compared to Control (Garden soil+silt), Leaf mold + Silt + Garden soil and Farm Yard Manure +Silt + Garden soil.

Recommendations

Based on the above conclusion the following recommendations are made,

Spent mushroom compost (SMC + Silt + Garden soil with 1:1:1) is recommended for cultivation of cockscomb cultivars under Peshawar condition.

Magenta cultivar performed better and hence recommended for Peshawar condition.

In order to standardize media and check the performance of other cultivars of cockscomb and growing media i.e Vermiculite, Perlite, and compost etc need to be tested under Peshawar condition.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

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Authors' Contributions

Muhammad Seemab Khan Abbasi and Syed Tanvir Shah designed the study. Muhammad Talha Awan, Zahid Ali, Abdullah, Midrarullah, and Zakir Khan conducted the experiments and collected the data. Muhammad Suleman Khan assisted with data analysis and interpretation. Muhammad Seemab Khan Abbasi and Muhammad Suleman Khan wrote the manuscript, with Muhammad Suleman Khan serving as the corresponding author.

All authors contributed to the study as per CRediT roles and approved the final

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Ethical Statement

This research did not involve human participants or animal subjects.

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