Manipulation of chili plant architecture to enhance productivity and pests control

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Abstract. Pruning of chili pepper caused changes in the plant architecture affecting the management practices, both resulted in greater fruit production and controlled pest population. The present study was aimed to evaluate the effects of different pruning systems on yield and pests abundance in chili pepper (cv. Mega Top F1). The experiment was conducted in a farmer’s field at Banyuresmi District, Garut, West Java (850 m asl) from June, 2018 to January, 2019. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The treatments consists of five pruning treatments including a control where no plants were pruned. The results showed that different type of pruning affected growth, yield and pests abundance on chili. Treatments with two branches remaining and shoot pruning/pinching in the nursery significantly affected the plant growth with maximum yield (16.47 tonha⁻¹). Pruning significantly affected fruit yield from 19.87 - 30.92% and reduced the population of several pests, such as T. parvispinus, B. tabaci and S. litura up to 13.33 – 88.01%. Pruning induced the plants to have wider architecture and this could be practiced to increase the quality yield of chili pepper.

Keywords: Chili pepper (Capsicum annuum L.), pruning, plant architecture, yield, pests

1. Introduction

Chili pepper (Capsicum annuum L.) (Solanaceae) is an economically important vegetables in most of tropical and sub-tropical countries and is grown by farmers all over the world. Indonesia is currently ranked fourth in chili production after China, Mexico and Turkey and, accounts for about 5 percent of global annual chili production [1]. In Indonesia, this crop is grown on 142.547 hectares with an annual production of about 1.21 million tonnes [2]. More than 85 percent of the total national chili production occurs on Java and Sumatra, the two largest islands in the archipelago. Chili ranked as the first horticultural crop produced, surpassing cabbage, shallot, potato, and tomato production. An average production, however, is low (8.46 tonsha⁻¹) compared to potential yields of 12 to 20 tonsha⁻¹. Chili pepper demand tends to be stable, but demand can drastically increase especially before and during religious holidays [3].

Several factors might be associated with low yields, including climatic change, lack of good cultivation practices, high production costs (seed, fertilizers, and pesticides), as well as pests [4-6]. Thrips, mites, white fly, fruit borers, cut worms, and fruit fly are pests on chili pepper where as antrachnose and several virus caused by Geminivirus are important diseases during the growing season [7]. Therefore better production techniques are needed to improve chili quality and yield.
Chili pepper plants have a dichotomous branching habit, therefore, changes in plant architecture (such as pruning) is a management practices to obtain not only greater fruit production, but also to reduce populations of pest and diseases [8]. Plant architecture can affect arthropod pests by modifying: (a) the attractiveness of the host-plant; (b) the within-plant life conditions including microclimate, availability and accessibility of resources and reproduction sites, and enemy-free spaces; (c) the efficacy of chemical or alternative pest control methods (including the use of pheromones also may be affected). Manipulation of plant architecture may also affect the light distribution in the canopy and photosynthesis. Pruning is the judicious removal of plant parts viz., shoot, root, leaves, flowers, panicles or fruits. It may improve the growth performance and control the growth pattern of the plant. The benefits of chili pepper pruning as followed: (a) developing a stronger framework of branches; (b) exposing canopy area for tapping maximum solar energy; (c) distributing the fruiting branches throughout the canopy and securing the balance in canopy; (d) accommodating the higher number of plants per unit area to increase yields and (e) help to overcome pest and disease problems.

Several studies had reported an increase in fruit yield due to proper pruning practices. Examples include brinjal [9-11] and tomato [12]. In tomato pruning reduced production costs, increase yields and improve the quality of fruits due to better light penetration inside the plant canopy. Disease pressure also was reduced [13]. The two stem pruning method gave the highest marketable yield compared to single stem and non-pruned plants of indeterminate tomato cultivars [14]. Apical pinching on the seedlings had significant effect on plant height and number of branches [15]. Higher marketable yields were realized from sweet pepper pruned to four stems, compared to those pruned to two or one stem [16]. Pruned cucumber had higher weight of fruits than the unpruned ones. The removal of the lateral shoots had a positive effect on the total yield of bitter gourd [17]. This present study was to evaluate the effect of different pruning method on yield and pest abundance in chili pepper cv. Mega Top F1.

2. Material and Methods
The experiment was carried out between June 2018 – January 2019 on a farmer’s field in Banyuresmi District, Garut, West Java (70 45’S, 10807 30’E) with an elevation of 850 meters. The soil at the experimental site was alluvial (pH 7.8) and the mean temperature ranged between 19.9 - 24.43°C and relative humidity ranged between 52.0-72.0%. Six treatments were arranged in a Randomized Complete Block Design (RCBD) replicated four times. The treatments were (A) shoot pruning or pinching of plant in the nursery stage, (B) two branches remaining; (C) three branches remaining; (D) four branches remaining; (E) removal off shoot sides and (F) control (unpruned plant). The chili pepper variety “Mega Top F1” was used in the experiment. Seedlings of the variety were raised in nursery stumps and covered with silvery plastic mulch.

An area of 2000 m² was divided into 4 equal blocks. There were 24 plots altogether in the experiment. The size of each plot was 13 m x 14 m and the plots had a 50 cm x 70 cm (200 plants/plot) spacing between plots. The distance within blocks and plots were 1 m and 0.5 m respectively. Organic materials consisting of mature compost were applied as basal fertilizer along with NPK composite fertilizers. The dose of organic materials and NPK was 30 t ha⁻¹ and 1 t ha⁻¹ respectively. The beds were covered with silvery plastic mulch.

Data were collected from ten plants which were randomly selected from each plot (U Shape) for data collection on growth and yield characteristics during the growth of plants and at harvest. Data were collected on the following: height and canopy width (cm), fruit length (cm), fruit diameter (cm), individual fruit weight (g), incidence of pest and diseases, and yield per hectare was calculated. The yield increase was calculated using the following formula:

\[
\text{Yield increase (\%) = } \frac{\text{Yield in treatment} – \text{Yield in control}}{\text{Yield in control}} \times 100 \%
\]
Data for different characters were statistically analyzed, the mean values were evaluated and analysis of variance was performed by the "F" test. Significance differences among the treatment was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability.

3. Results and Discussion

3.1. Plant Growth Parameters

Pruning resulted in significant differences in all vegetative growth attributes like plant height and canopy width. Data on plant height are shown in Table 1 was significantly affected by different pruning treatment at 30, 58, 79, 86 and 93 DAP. Amongst the pruned plots at 93 DAP, treatments with shoot pruning/ pinching in nursery (69.85 cm) was significantly (p < 0.05) shorter than the other three treatments. Two branches remaining (77.82 cm) was significantly taller compared to the three branches remaining (77.55 cm) followed by four branches (77.55 cm) pruned treatments. Varying response of plant height to pruning was probably due to competition between plants for available water, nutrients and light is less in less branch system than in much branches system [18]. The removal of some branches leads to increased supply of nutrients in the remaining branches [19]. Pruning limits vegetative growth and allows more light penetration which and resulted in higher amount of photosynthates and nutrients that enhances cell division and formation of more tissues resulting into more vegetative growth [20]. Pinching treatments produced smaller stem lengths as compared to the non-pinched treatments. Pinching of ‘Sun Bright’ after three weeks of planting produced a crop with uniform stems about 91 cm long, whereas the non-pinched stems grew up to a length of 152 cm [21]. Pinching on the seedling stage of ornamental sunflowers increased vegetative growth. The process induced the lower branches production and the number of stems per plant [22].

Table 1. Effect of various pruning methods on plant height in chili.

| Treatments                        | Plant Height (cm) at ............................................(DAP) |
|-----------------------------------|---------------------------------------------------------------|
|                                   | 30    | 37    | 44    | 51    | 58    | 65    | 72    | 79    | 86    | 93    |
| Shoot pruning/ pinching in nursery| 14.85 | 18.43 | 19.30 | 36.60 | 46.33 | 58.18 | 63.15 | 65.60 | 69.72 | 69.85 |
| Two branches remaining            | 15.68 | 19.52 | 22.43 | 39.95 | 50.60 | 60.80 | 68.80 | 73.10 | 76.75 | 77.82 |
| Three branches remaining          | 16.05 | 20.20 | 21.70 | 39.58 | 47.05 | 59.65 | 67.08 | 72.88 | 76.22 | 77.55 |
| Four branches remaining           | 15.20 | 19.25 | 21.63 | 38.15 | 49.97 | 63.13 | 68.50 | 73.80 | 76.28 | 76.58 |
| Removal side shoot                | 17.18 | 21.30 | 21.40 | 41.28 | 52.68 | 60.58 | 69.38 | 71.45 | 75.85 | 76.15 |
| Control (no pruning system)       | 16.93 | 20.80 | 20.63 | 40.23 | 48.50 | 58.95 | 63.13 | 68.15 | 69.22 | 71.38 |

Means followed by the same letter in the column are not significantly different according to Duncan’s Multiple Range Test at α = 0.05

Results for canopy width are presented in Table 2. The statistical analysis of variance showed significant difference in canopy width among pruning methods and control at 58, 79, 86 and 93 DAP. Shoot pruning/ pinching in nursery at 93 DAP showed a maximum value (76.06 cm) followed by removal side shoot (65.87 cm) and control (no pruning system). The minimum value of canopy width (62.22 cm) was found in two branches remaining. These results were in line with several studies stating that the removal of some branches would lead to a better nutrient supply in the remaining branches and stimulated the development of more branches [19, 23-24]. Furthermore, pruning could improve the translocation of crop hormonal and nutritional which stimulated the development of the vascular system and triggered nutrient transport [25].
Table 2. Effect of various pruning methods on canopy width in chili.

| Treatments                        | Canopy width at.................DAP |
|-----------------------------------|-----------------------------------|
|                                   | 30  | 37  | 44  | 51  | 58  | 65  | 72  | 79  | 86  | 93  |
| Shoot pruning/ pinching in nursery| 10.51a | 14.24a | 15.41a | 29.13a | 34.95b | 48.25a | 53.90a | 62.96ab | 66.81a | 76.06a |
| Two branches remaining            | 10.61a | 14.08a | 15.59a | 28.53a | 36.17ab | 48.04a | 54.89a | 65.40a | 63.88ab | 62.22b |
| Three branches remaining          | 11.13a | 14.01a | 14.58a | 27.16a | 39.14ab | 49.35a | 52.14a | 65.40a | 63.88ab | 62.22b |
| Four branches remaining           | 10.20a | 13.73a | 13.83a | 23.45a | 34.03b | 45.03a | 50.49a | 57.49c | 65.24b |
| Removal side shoot                | 11.26a | 13.95a | 14.20a | 31.65a | 41.54ab | 48.23a | 52.26a | 60.54b | 65.87b |
| Control (no pruning system)       | 11.30a | 15.60a | 15.50a | 27.81a | 41.54ab | 47.91a | 55.40a | 62.91ab | 64.36ab | 65.83b |

Means followed by the same letter in the column are not significantly different according to Duncan’s Multiple Range Test at α = 0.05

3.2. Pests on chili pepper
Chili plants have been infesting by numerous insect pests that attack at their various growth stages. Usually, it has infested by a group of sucking or borer pests. Severe damage normally occurs when a large number of pests feed on the plants. The major pests of chili during the growing season were the sap-sucking insects which include the thrips and whiteflies and the borer insects such as fruit borers (Table 3, 4 and Fig. 1).

Table 3. Effect of various pruning methods on population of T. parvispinus in chili.

| Treatments                        | Population of thrip at..............DAP | Total |
|-----------------------------------|----------------------------------------|-------|
|                                   | 30  | 37  | 44  | 51  | 58  | 65  | 72  | 79  | 86  | 93  |     |
| Shoot pruning/ pinching in nursery| 0.65a | 1.20a | 0.48a | 1.28a | 0.33b | 2.40a | 3.25a | 5.93a | 6.15a | 7.35a | 29.02 |
| Two branches remaining            | 0.98a | 0.80a | 0.68a | 1.78a | 0.78b | 1.73a | 2.83a | 6.00a | 6.25a | 7.48a | 29.31 |
| Three branches remaining          | 0.80a | 1.17a | 0.55a | 1.68a | 0.70b | 2.23a | 2.68a | 6.58a | 6.63a | 8.15a | 31.17 |
| Four branches remaining           | 0.80a | 1.73a | 0.40a | 1.48a | 0.98b | 2.65a | 2.97a | 5.85a | 6.93a | 8.15a | 31.94 |
| Removal side shoot                | 1.20a | 1.33a | 0.48a | 1.05a | 1.55a | 2.38a | 3.10a | 6.20a | 6.05a | 8.65a | 31.99 |
| Control (no pruning system)       | 1.48a | 1.27a | 0.45a | 2.05a | 1.05b | 1.93a | 3.12a | 6.87a | 6.35a | 9.40a | 33.97 |

Means followed by the same letter in the column are not significantly different according to Duncan’s Multiple Range Test at α = 0.05
During the growing season, the number of thrips was lower in the pruned plot than control plot (no pruning) (Table 3). In the pruning treatment, the lowest population occurred in shoot pruning, followed by two and three branches remaining and the highest was presented in check (no pruning system). Pruning made canopy was more open and improved pest control due to increased air movement throughout the canopy, improved drying conditions, improved spray coverage, and reduced severity of many diseases.

Observation results on the percentage of plant damage caused by thrips infestation was presented in Table 4. There were significant differences in plant damage at each sampling date. Plant damage remained low throughout the season. However, plant damage was lowest in shoot pruning plot and reduced maximum plant damage (88.01%) followed by two and three branches remaining (76.23%), four branches remaining (64.45%) and removal sides shoots (33.40%). Other studies suggested that there might be an inverse relationship between the attack rates and the number of branches. Shivute [26] reported that pruned tomatoes were less prone to pest attack than those, which were not pruned.

| Treatments                                         | Plant damage (%) at....... DAP | Reduction of plant damage (%) |
|----------------------------------------------------|-------------------------------|-------------------------------|
|                                                    | 30   | 37   | 44   | 51   | 58   | 65   | 72   | 79   | 86   | 93   |          |
| Shoot pruning/pinching in nursery                  | 8.06 | 14.45| 11.67| 13.61| 11.95| 9.72 | 5.83 | 5.56 | 3.06 | 0.56 | 88.01    |
| Two branches remaining                             | 7.22 | 12.50| 10.84| 10.83| 10.56| 6.95 | 8.89 | 3.33 | 1.95 | 1.11 | 76.23    |
| Three branches remaining                           | 7.50 | 10.69| 11.67| 13.33| 15.00| 9.73 | 5.84 | 5.84 | 3.33 | 1.11 | 76.23    |
| Four branches remaining                            | 8.34 | 15.48| 14.17| 13.89| 14.72| 7.22 | 8.33 | 5.28 | 1.11 | 1.66 | 64.45    |
| Removal side shoot                                 | 14.72| 14.72| 14.17| 12.22| 15.28| 15.00| 7.22 | 4.72 | 4.94 | 3.11 | 33.40    |
| Control (no pruning system)                        | 8.89 | 14.44| 12.83| 13.33| 10.28| 8.06 | 4.72 | 4.17 | 3.33 | 4.67 |          |

Means followed by the same letter in the column are not significantly different according to Duncan’s Multiple Range Test at α = 0.05.

Numbers of *B. tabaci* and *S. litura* are presented in Figure 1. The lowest population occurred in shoot pruning/pinching in nursery, followed by two branches remaining, removal side shoots and highest was presented in control. Saunyawa & Knapp [27] stated that pruning could reduce mite populations. Pruning made the sunlight freely illuminates the parts of plants and the leaves more productive in carbohydrates production, this situation provides benefits to the plant because it could reduce the infestation level of pests and diseases. Costes et al. [28] reported that plant architectural traits impacted the pest and disease through various modifications of life conditions and influenced the ability of natural enemies to control the pest [29] but it also depends on the pruning type. Plants with more branches provided more refuges to the prey and more obstacles to the predator, leading to decreasing attack rates [30]. *Coccinella septempunctata* killed significantly more prey over 24 hours on plants with increasing morphological complexity (smaller leaves and more branches) [31]. Predator mite *Phytoseiulus persimilis* searched for prey sooner on the smaller leaves of plants with 6 leaves than on the larger leaves of plants with 2 leaves [32]. Population of aphids (*Dysaphis plantaginea*) was reduced with branching/pruning in apple trees.
[33], egg densities of the pest mites *Panonychus ulmi* and *Aculus schlechtendali* was reduced 50% compared to no pruning [28]. Manipulation of plant architecture can affect arthropod pests by modifying: (a) the attractiveness of the host-plant; (b) the within-plant life conditions including microclimate, availability and accessibility of resources and reproduction sites, and enemy-free spaces; (c) the efficiency of chemical or alternative pest control methods (including the use of pheromones).

![Figure 1. The effect of pruning system on *B. tabaci* and *S. litura* populations in chili](image)

**Figure 1.** The effect of pruning system on *B. tabaci* and *S. litura* populations in chili

### 3.3. Physical fruit characteristics

The results about the effect of pruning treatments on physical fruit characteristics expressed by average of individual fruit, length of fruit and diameter of fruit are shown in Figure 2. The results indicated that the pruning treatments had a positive effect in average fruit weight, length and diameter. Weight of individual fruit showed significant differences due to pruning. The maximum (18.13 g) weight of individual fruit was recorded from two branches remaining, while the plants grown without pruning (control) gave the lowest results (14.20 g).

Significant differences were recorded on length of fruit due to pruning in chili pepper. The maximum (14.86 cm) length of fruit was recorded from two branches remaining, which was followed by shoot pruning/pinching in nursery (14.075 cm), while the minimum (13.72 cm) length of fruit was obtained from control. Hernandez and Sanches [34] found that fruit length and total number of fruit on tomato was greatest in plants for pruning one stem, Thakur *et al.* [12] stated that fruit size can be improved by removing the axillary shoots. Different levels of pruning showed significant variation on diameter of fruit. The maximum (1.89 cm) diameter of fruit was recorded from two branches remaining, while the minimum (1.58 cm) diameter of fruit was found from control. The increment of average fruit weight, length, and diameter according to pruning treatments than the control may be due to that the control treatment produced a much higher number of shoots as it utilizes nutrients absorption from the plants, and slow down nutrient uptake by shoot growth causing less in fruit weight, diameter and length. On the other hand, because vegetative growth, as a powerful sink, consumes assimilates, limitation of vegetative growth enhances assimilate transport to roots or fruits. Thus, proper balance between vegetative and reproductive growth could improve fruit quantity and quality [35]. Our results are in agreement with those of obtained by Ekwu *et al.* [36] on cucumber and Maboko *et al.* [37] on tomato. Muhammad and Singh [38] reported that the mean diameter of fruit was significantly higher in two stem and three stem pruned plants than unpruned plants.
Note: A. shoot pruning or pinching of plant in nursery stage; B. two branches remaining; C. three branches remaining; D. four branches remaining; E. Removal side shoots and F. control (unpruned plants)

Figure 2. The effect of pruning system on physical fruit characteristics in chili [A. Weight of individual fruit; B. Diameter of fruit; C. Length of fruit.]

3.4. Yield characteristics.
The yield per hectare differed significantly across pruning treatments (Fig. 3 & 4). The highest (16.47 tonsha⁻¹) yield was recorded from shoot pruning/pinching in nursery followed by two branches remaining (15.84 tonsha⁻¹), three branches remaining (15.44 tonsha⁻¹), four branches remaining (15.41 tonsha⁻¹) and removal side shoots (15.08 tonsha⁻¹), while the lowest (12.58 tonsha⁻¹) yield was recorded from control/no pruning. It is obvious that, different results were detected among pruning treatments and increased yield per hectare up to 19.87% - 30.92%. The total yield enhancement per hectare due to shoot pruning/pinching in the nursery compare with the other pruning or control treatment might be attributed to increased more branches and it provided a parallel effect on flowers and fruit production.
than the other pruning treatments. Pruning caused net photosynthetic rate and transpiration rate to increased. In addition pruning improve crop biomass and production and changed the microclimate under canopy (such as increased, air temperature, soil water content and decreased the relative humidity). Several studies reported that tomato yield was increased with an increase in branch number [39-40]. Seifi et al. [41] investigated the effects of shoot pruning (without pruning and with three main branches) on yield characteristics and growth of sweet pepper. Shoot pruning had significant effects on yield per plant, yield, fruit weight, number of fruits per plant and plant weight. These results concluded that the effect of pruning on chili pepper showed a direct relation with leaf area, dry matter, and stem diameter; in others word, pruning allowed more light penetration, increases photosynthesis efficiency, and finally improve vegetative growth of plants efficiency to provide fruit weight average increased [20].

These results concluded that shoot pruning/pinching in nursery application should be implemented for higher yield in chili pepper. This might be happening due to better vegetative growth and more fruits per plant caused the increase of the total yield, another reason of maximum yield enhancement possibly made by balanced nutrients supply and sufficient space for vegetative growth, which ensured healthy plants [15]. Resh [42] reported that the reduced number of branches by the pruning process during peppers cultivated in a greenhouse could improved light interception, fruit set, and fruit quality. Thus, pruning was considered as powerful method to boost higher production and quality. Therefore, chili farmers should adopt this pruning practice to obtain higher marketable yield.

Figure 3. The effect of pruning system on yield in chili

Note: A. shoot pruning or pinching of plant in nursery stage; B. two branches remaining; C. three branches remaining; D. four branches remaining; E. Removal side shoots and F. control (unpruned plants)
Note: A. shoot pruning or pinching of plant in nursery stage; B. two branches remaining; C. three branches remaining; D. four branches remaining; E. Removal side shoots and F. control (unpruned plants)

Fig. 4. The percent increase in yield over control in various treatments in chili

4. Conclusions
Different type of pruning affected growth, yield and pests abundance on chili. Two branches remaining and shoot pruning/pinching in nursery significantly affected the plant growth with maximum yield (16.47 ton ha⁻¹). Pruning significantly affected fruit yield from 19.87 - 30.92% and reduced the population of several pests, such as *T. parvispinus*, *B. tabaci* and *S. litura* up to 13.33 – 88.01% compared to other pruning system. Pruning induced the plants to have wider architecture and could be practiced to increase the quality yield of chili pepper.

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References
[1] FAOSTAT. 2019. FAOSTAT online. Rome: United Nations Food and Agriculture Organization.
[2] BPS.1998. Statistes Indonesia.
[3] Anwarudin, M.J., Sayeki, A.L., Marendra A., Hilman, Y. 2015. Innovation Development of Agriculture. 8(1): 33–42.
[4] Vos, J. G. M. 1994. Integrated Crop Management of Hot Pepper (*Capsicum* spp) in Tropical Lowlands. Wageningen Agricultural University.
[5] Darmawan, D., and Pasandaran, E. 2000. AVRDC publication no. 00-498.
[6] Basuki, R.S., Adiyoga, W., and Gunadi, N. 2009. In International Symposium on the Socio Economic Impact of Modern Vegetable Product ion Technology in Tropical Asia (pp. 101–112).
[7] Setiawati, W., Hasyim, A. and Hudayya. A. 2013. Survey on pests and diseases and its natural enemies of chili pepper (*Capsicum frutescens* L). Indonesian Vegetables Research Institute, Lembang, West Java. 9 pp.
[8] Dasgan, H.Y and Abak, K. 2003. J. Agric. For., vol. 27, pp. 29-35.
[9] Ambroszcyk, A.M., Cebula S., Sekara, A., 2008. *Folia Horticulturae* Ann., 20 (2): 3-15
[10] Tinni, T.B.R., Ali, M.A., Mehraj, H., Mutahera, S. and Jamal-Uddin, A.F.M. 2014. J. Expt. Bio sci. 5(1):55-60.
[11] Zrar, D.B. and Kanimarani, S.M.S.A. 2019. Journal of University of Duhok., Vol. 22, No.1 (Agri. and Vet. Sciences), Pp 166-183.
[12] Thakur, O., Kumar, V. and Singh, J. 2018. J. Curr. Microbiol. App. Sci. 7(2): 3556-3565.
[13] Heuvelink, E., Bakker, M.J., Elings, A., Kaarsemaker, R. and Marcelis, L.F.M. 2005 Acta Hort. 691, 43–50.
[14] Myint, A. 1999. Effect of pruning and spacing on performance of fresh market tomato. AVRDC report. Kasestart University, Thailand.
[15] Chauhan, M.R., Sharma, S.K., Shukla, Y.R. and Kansa, S. 2009. Haryana Journal of Horticulture Science, 38 (3 and 4), p. 310-315.
[16] Jovicich, E., Cantliffe, D.J and Hochumth, G.J. 1999. National Agricultural Congress. p: 184-190.
[17] Palada, M.C. and Chang, L.C. 2003. AVRDC. No. 3 pp. 547.
[18] Alasadon, A., Wahb-Allah, M., Abdel-Razzak, H., and Ibrahim, A. 2013.. Australian J. Crop Science 7(9):1309-1316.
[19] Alam, M.S., Islam, N., Ahmad, S., Hossen, M.I. and Islam, M.R. 2016. Journal of Agricultural Research, 41(3):419-432.
[20] Preece J.E. and Read, P.E. 2005. United States, 528 p.
[21] Emino, E. R. and Hamilton, B. 2004. The cut flower quarterly 16 (4): 12-13.
[22] Wien, H.C. 2014. Hort Technology 20: 575 - 579
[23] Abdulla, A.A. 2012. Journal of Agricultural Sciences, 4(2): 337-345.
[24] Toit, E.S.D., Sithole, J., Vorster.J. 2020. Journal of Botany. Vol.12, pp.44 - 456
[25] Hussain, S., Dar, K.R., Kumar, A., Maqbool, S., Mehdi, Z., and Dar, M.A. 2019. J. Curr. App. Sci. 8(05): 639-643.
[26] Shivute, B.K.L. 2005. Agricultura Tropica Et Subtropica, 38 (2): 79 – 81.
[27] Saunyawa, I.G.M. and Knapp, M. 2003. Crop Science Journal, 11 (4) : 269 – 277.
[28] Costes, E., Lauri, P.E., Simon, S., and Andrieu, B. 2013. J Plant Pathol. 135:455–470
[29] Simon, S., Sauphanor, B., and Lauri, P. É. 2007. Pest Technology, 1, 33 – 37.
[30] Hauzy, C., Tully, Spataro, T., Paul, G., and Arditi. R. 2010. Oecologia, 163(3): 625-636.
[31] Legrand, A. and Barbosa, P. 2003. Environmental Entomology, 32(5): 1219-1226.
[32] Gontijo, L.M., Nechols, J.R., Margolies, D.C. and Cloyd. R. A. 2012. Experimental and Applied Acarology, 56 (1): 23-32.
[33] Simon, S., Morel, K., Durand, E., Brevalle, G., Girard, T., & Lauri, P. É. 2012. Structure and Functions, Vol. 26, pp. 273–282.
[34] Hernandez, C.V.M. and Sanches, F.C.D. 1992.. Deptt. of de Fisitencia, Unverdad Aufonoma Chapingo. 15 (73-74):23-25.
[35] Arzani K. Bahadori, F and Piri, S. 2009. Environ Biotechnol 50(2):84-93.
[36] Ekwu, L.G., Nwokwu, G. N. and Utobo, E.B. 2017. The Nigerian Agricultural Journal. 48 (2) : 51 – 59.
[37] Maboko M. M. Du Plooy, C.P and Chiloane, S. 2011. African Journal of Agricultural Research Vol. 7(11), pp. 1742-1748.
[38] Muhammad, A. and Singh, A. 2007. J. Plant Sci., 2(3): 310-317.
[39] Ara, N., Bashar, M.K., Begum S. and Kakon, S.S. 2007. J. Sustain. Crop Prod. 2(3):35-39.
[40] Maboko M. M. and Du Plooy, C.P. 2009. African Crop Science Conference Proceedings, Vol. 9. pp. 27 – 29.
[41] Seifi, S., Nemati, S.H., Shoor, M. and Abedi, B. 2012. Journal Science and Technology of Greenhouse Culture, 3(11). (Abstract).
[42] Resh, H.M.1996. Woodridge Press Publ. Co., Santa Barbara, California.