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EFFECT OF APICAL NIPPING ON GROWTH, YIELD AND YIELD CHARACTERS OF HOT PEPPER (*Capsicum frutescens* L.)

Olatunse, B. B., *Oyewusi, I. K., & Akeredolu, M. I.
Department of Agricultural Technology, Federal Polytechnic, Ado Ekiti, Ekiti State, Nigeria.
*Corresponding author email: kayoyewusi@gmail.com

ABSTRACT

Field trial was conducted to evaluate the effect of apical nipping on growth, yield and yield characters of hot pepper (Capsicum frutescens L.). The experiment was laid out in randomized complete block design (RCBD) with four treatments and three replications. Hot pepper was raised in the nursery and transplanted four weeks after planting. Nipping young pepper seedlings at the apical meristem was done three weeks after planting. The treatments consisted of nipping pepper seedlings at 1cm, 2cm, and 3cm, while the control treatment was left non-nipped. Data were collected on growth, yield and yield characters and these included plant height (cm), number of leaves, number of primary branches, shoot fresh weight (g), number of flowers per plant, number of fruits per plant, length of fruit per plant (cm), weight of fresh fruits per plant (g), and yield in tons per hectare. The data collected were analyzed using analysis of variance (ANOVA) and the treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability. Result showed that all the nipped hot pepper plants performed better than the (control). The superior performance observed in the nipped plant could be attributed to effective synthesis and translocation of photosynthates from source to sink which is evident with higher seed yield recorded at 2cm level (943.61 t/ha). The study revealed that manipulation through nipping positively influenced growth and yield of hot pepper. Nipping resulted in more number of branches per plant, more number of leaves per plant and improved yield and yield characters of hot pepper in the study area. The improved performance of nipped hot pepper plants compared to non-nipped plants is attributable to the removal of apical dominance of auxin through nipping. Among the different nipping rates evaluated, nipping at 2cm level had superior performance over other nipping levels.

KEYWORDS: Apical nipping; Growth analysis; Hot pepper; Yield characters; Yield

INTRODUCTION

Pepper *(Capsicum frutescens L.*), is a major constituent of human diet. Hot pepper, (Locally known as atawere in Yoruba (Nigeria) constitutes the major bulk of human diet. It is a highly nutritious vegetable that adds colour to dishes with tangy taste that enhances food flavor. It is also a good source of vitamin. Pepper powder provides trace amounts of anti-oxidants and other chemicals to aid digestive tissues, and also enhances the auto healing of upset stomach, reduce intestinal gas, cure diarrhea and act as a natural remedy for cramps (Fitday, 2016). It also aids the circulatory system and preventing heart disease by lowering blood serum cholesterol and reducing lipid deposits, thereby, reverses excessive blood clotting. It also dilates the blood vessels to aid blood flow, it improves metabolism which ultimately helps in weight loss (Brucket & Rosenbaum, 2011; FAO 2010).

Manipulation through nipping has been found to increase lateral branches of plants as a result of the removal of apical dominance of auxin (Cline, 1994). Nipping means the removal of top shoot

(apical meristem) of a plant to induce branching on the plant at the remaining nodes (Iyyannagouda, 2000; Khan et al., 2006). Nipping is synonymous to topping, clipping and pinching. When plants are nipped, the apical buds, which contain auxins, an important growth hormone are removed. Some plants tend to branch out very little when they grow and growth in such plant, occur almost exclusively from apical meristem rather than axillary buds which do not develop as long as the terminal buds are present. Such plants are said to exhibit apical dominance (Adinde et al., 2016). Time of nipping in short duration crops vary based on duration from 30 - 40 days after sowing and in cotton, 70 - 90 days of sowing. In field pea, nipping at 35 DAS of the crop could enhance the number of branches by confining profuse vegetative growth and thereby improving the crop yield (Dhital et al., 2017). There is need to explore the advantage of simple agro techniques like nipping, which suppresses the apical dominance and facilitates more lateral branches, ultimately resulting in more number of red fruit. This is partly because little research has been done and published on pinching of hot pepper. Consequently, there is need to investigate the effect of nipping in relation to the growth, yield and yield characters of hot pepper.

MATERIALS AND METHOD

Study site

The study was carried out at the Teaching and Research farm of the Department of Agricultural Technology, Federal Polytechnic, Ado-Ekiti between July and December, 2019 in the South western part of Nigeria with latitude (76^0N and $8^0$12N) and longitude ($5^0$4E and $4^0$15E). The surface soil at the site was sandy loam soil. The site which has been on fallow for a very long time with spear grass (*Imperata cylindrical* (L.), Siam weed (*Chromolaena odorata* (L) King and Robinson) and sunflower *(Halianthus annuus L.*). The rainfall pattern is bimodal between March-July and August-November with short spell in August.

Plant materials

The species of hot pepper (*Capsicum frutescens L.*) seed was obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo state, Nigeria. The pepper fruit used for this study is characterized by its unique aroma, hotness due to the capsaicin content, nutritional values, adaptability to the existing cropping systems and potentials for wealth creation. The distinctive aroma of hot pepper enhances its acceptability in the market and attracts higher price than other pepper types in the local and urban markets (Abu & Uguru, 2006; Asogwa, 2006). The pepper variety is not widely cultivated in most states in the country, this may be because of its tendency to lose its pungency, aroma and colouring in other areas (Uguru, 1999, 2000).

Land preparation and field layout

The land was prepared by slashing the bush manually with cutlass, packing was also done manually. A 10m by 7m plot of land was marked out into twelve plots of (2m by 2m) each with 0.5m (discard). One seedling of the hot pepper was planted in a hole at a spacing of (2m by 1m) thereby (having twelve stands per plot). The layout was marked using tape and pegs. The seedbed was prepared manually while the experiment was laid out in a Randomized Complete Block Design (RCBD), with four treatments and three replicates.

Nursery preparation

Nursery bed of 2m by 2m was prepared. The nursery was shaded to protect the seedlings from harsh weather condition and watered regularly.

Seedling emergence was noticed 8 days after sowing and full emergence 4 days later. The young growing plants were watered as required using watering can. Weeding was done manually by hand picking while pest was controlled using Cypermethrine insecticide and fungal disease was controlled with Redforce fungicide (Metalaxyl-M 6% + Copper (I) oxide 60% WP). Apical nipping was done on the plants by removing the apical bud of the plants at three weeks after emergence. Nipping young pepper seedlings at the apical meristem was done at three weeks after planting so that the inhibitory action of apical auxin could be limited thereby promoting the development of more auxillary buds into active growing shoot. The treatments consisted of nipping pepper seedlings at 1cm, 2cm, and 3cm, while the control treatment was left nipped at (0cm).

Plant height (cm)

Data on plant height was collected from three tagged sample plants at two weeks after treatment application. Plant height was measured from the contact point (crown) of the stem with soil to the apical point of the main shoot. This was to monitor the systematic process of growth and development of nipped tagged plants every seven days. (Mohammad-Amin, 2008).

Number of visible leaves

Data on number of leaves per plant was collected from three tagged sample plants at two weeks after treatment application**.** This was determined by direct counting of all the leaves on the sample plants per plot and dividing by number of the sampled plants. (Mohammad-Amin, 2008)

Leaf area (cm2)

Three leaves per replicate were collected and their area was measured by using digital leaf area meter and the average leaf area was calculated (Ghoreishi et al., 2012).

Stem diameter (mm)

Plant stem diameter was measured using Vernier calipers at the height of 5cm from the soil surface in millimeters (mm) (Sabli, 2012).

Number of primary branches

Number of sub branches was counted from the smaller main branches (Mohammad-Amin, 2008).

Shoot fresh weight per plant (g)

Fresh weight of shoot system was measured by sensitive balance immediately after harvest (Iannotti, 2009).

Shoot dry weight per plant (g)

Shoot system was oven-dried to constant weight at 70°C for 72hours and the weight was measured by sensitive balance (Iannotti, 2009).

Number of Flowers per plant

Number of flowers was identified, counted weekly when the first flower was observed from three selected plants in each plot (Mohammad-Amin, 2008).

Weight of fruit (g)

The weight of matured fruit was determined on an electronic scale. Fruits from the sample plants were used to determine the weight of nipped fresh fruit) (Beyer, 2012).

Number of fruits per plant

Number of fruits per plant was counted from three sample plants at maturity. This was done to determine the number of fruits harvested on each plot (Kabir, 2014).

Fruit yield per plot (kg)

This was measured from weighted marketable fruits during the period from first to final harvest for all plants in each experimental unit (Mitra, 2007).

Yield (t/ha)

The total fruits harvested were weighed using a weighing balance and the result was recorded (Aman & Rab, 2013).

Data collection and analysis

Data on growth characteristics and yield components were determined from three plants per treatment per plot. Fruit harvesting of hot pepper was carried out when the fruits were still green, but full-sized. The data collected on various parameters were subjected to the analysis of variance (ANOVA) and means were compared using Duncan Multiple Range Test (DMRT) at 5% level of probability. The statistical analysis system SAS was used for the analysis. Standard error and Standard deviation were also computed as a measure of the level of dispersion. Data were collected on growth, yield and yield characters including plant height (cm), stem diameter (cm), number of leaves, number of sub branches, leaf area (cm^3), shoot fresh weight (g), shoot dry weight (g) number of flowers per plant, number of fruit per plant, length of fruit per plant (cm), weight of fresh fruit per plant (g), and fruit yield in (t/ha).

RESULTS AND DISCUSSION

Initial soil fertility

Table 1 shows the initial fertility of soil used before the treatments were applied. Some chemical and physical properties of the soil were taken from different locations of the field at 0 - 30cm depth according to the method of soil analysis by (Estefan et al., 2013). The result of the analysis shows that the percentage of organic matter (1.34%) was below the 2% recommended value for crop production of Southwestern Nigeria (Gichuru etal., 2003). The Nitrogen (0.07%) was less than (0.15%) of the critical level for production of vegetables in Southwestern part of Nigeria (Osiname and Sobulo, 1987). The pH value (5.50) in 1:1 water suspension shows that the soil was slightly acidic. The available phosphorus was 4.00 Kg. The result shows that the soil was sandy loam in texture with high proportion of sand (82.3%). This implies that basic cations such as Ca, K, Na and Mg would be leached more easily as texture determines the degree of retention or ease of leaching of basic cations (Gichuru et al., 2003).

Effect of apical nipping on growth and development of hot pepper

Result showed that the control had taller plants when compared to other nipping treatment levels with the highest mean of (14.01). Table 2 while higher number of leaves and primary branches were obtained from (1cm) level of nipping with the mean value at (161.2) and (8.24) respectively, at 10 weeks after transplanting (WAT). Table 3 and 4. The result of apical nipping effect on stem girth in Table 5 shows that there was no significant effect on stem diameter; however, significant value was obtained for leaf area among the treatments, Table 6. Highest values were recorded for hot pepper plants nipped at 2cm level (27.07) and this was followed by the 3cm level. The lowest value was recorded for the control.

Effect of apical nipping on yield and yield characters of hot pepper

Highest number of flower/plant was obtained for nipped hot pepper plant at the 2cm level (38.15). Similarly, significant increase at 2cm level was recorded for shoot fresh weight (584.58g), number of fresh fruits (15.66), length of fresh fruits (56.90 mm), weight of individual fresh fruits (9.522g), and yield per plot, (43.6 t/ha). The lowest value on yield characters of hot pepper was recorded for the control for most of the measured parameters. There was no significant difference in the fresh fruit thickness for all the treatments evaluated. This result is further explained in Figure 3 where significantly higher values were recorded for shoot fresh weight, number of fruit per plant, fruit length,

fruit thickness, weight of individual fruit and fruit yield (t/ha). Table 7.

The decrease in plant height observed in nipped plants level at (2cm) compared to the control could be attributed to the removal of auxin at the apical bud which possibly reduced apical dominance of auxin. Similar result was obtained by Korla and Sani (2003). All the nipped plants recorded significant increase in number of primary and secondary branches but the most superior of all was apical nipping level at (2cm). This could be attributed to the vigorous vegetative growth of the lateral shoots as a result of the removal of the apical bud which reduced apical dominance of auxin and initiated lateral buds (Seo et al., 2006). The higher plant height noticed with the control was mainly due to the fact that plants grew to their original height without reduction while, number of branches per plant were more in case of nipped plants. This may be due to nipping effect of apical buds which resulted in production of more secondary branches and restriction to vertical growth on account of effective translocation of hormones, particularly auxins which are being diverted to the potential and tertiary shoot buds which in normal conditions remain dormant. Apical clipping has been reported to increase lateral branches and fruit yield (Adinde et al., 2016); and produce desirable fruit size (Khan et al., 2006). Adinde et al., (2016) and Lakshmi et al., (2015) in separate studies opined that nipping chicken pea and other vegetable crops after 45 days of sowing increased yield and reduced disease severity. They further stressed that nipping significantly improved growth and yield of green pepper with nipping at 2 weeks after transplanting producing superior performances. When the apical bud is removed, the cytokinins are able to promote the growth of lateral buds into branches. More branches will possibly initiate more flower buds and possibly more yield. Adinde et al., (2016) in his study on effect of nipping on seed yield and fodder production of rape-seed reported a delay in flowering and non-significant increase in yield. Lakshmi et al., (2015) revealed that foliage nipping at early stage of crop increased number of branches while restricting profuse vegetative growth thereby promoting crop yield. Although, Aziz (2002) noted that nipping caused shock and delayed re-growth when done at the wrong stage of the plant's growth phase. Several researchers have reported positive effect of nipping on crop production. More production techniques are required to improve pepper quality and yield. Chauhan et al., (2009) studied the effect of apical pinching on the seedlings growth of bell pepper, and found that it had significant effect on plant height, number of branches per plant, days to first picking of green fruits, days of harvest duration of green fruits, and green fruit per hectare. Pinching chili at early growth stages increased the marketable yield to total yield ratio, fruit number, and the production of physiologically ripe fruits (Buczkowska, 2001). According to Sharma et al., (2003), reasons for the above change were that the energy which was provisionally used by the plant was diverted towards branching. Similar reports were made by Shankargoud and Patil (1994) in sunflower, Sharma et al., (2003) in pigeon pea, Khan et al., (2006) in chickpea and Singh and Devi (2006) in pea. The reduction in plant height in nipped plants is mainly due to elimination of apical dominance and diversion of the plant metabolites from vertical growth to horizontal growth and recording more number of branches per plant. As the apical dominance is removed usually the plant itself adjusts to encourage the growth of

auxiliary buds which may be converted into branches. Similar results were obtained by Arjun Sharma et al., (2003). Apical bud nipping is known to alter the source-sink relationship by arresting the vegetative growth and hastening the reproductive phase. It also helps in production of more pods bearing branches thus, resulting in increased photosynthetic metabolic activity, accumulation of more photosynthates and metabolites, ultimately resulting in better seed quality with higher seed yield. Alsadon et al., (2013) found that pepper plants when pruned on one branch caused significant increase in early yield, fruit size and internal fruit quality however plants pruned to four branches produced the highest yield per hectare. Ahirwar and Hedau (2015) studied the effect of shoot pruning (zero, two, three and four branches) on yield and quality of *Capsicum annuum* L., the results showed that marketable yield increased linearly in plants with four branches treatment than in those with control, two and three branches. Beneficial effects noticed with nipping perhaps could be related to effective synthesis and translocation of photosynthates from source to sink which is evident with higher seed weight (Baloch & Zubair, 2010; Krishnaveni et al., 2014; Olfati & Malakouti, 2013). Apical bud nipping helps in production of side shoots or branches thus resulting in increased photosynthetic activity and accumulation of more photosynthates ultimately results in increased seed size and yield (Lakshmi et al., 2015). According to Dhital et al., (2017), time of nipping in short duration crops vary based on duration from 30 - 40 days after sowing and in cotton it will be around 70 - 90 days of sowing. In field pea, nipping at 35 DAS of the crop could enhance the number of branches by confining profuse vegetative growth and thereby improving the crop yield, he further stated that nipping is an important agronomic practice which arrests the apical growth and boosts the lateral branches that subsequently improves the number of pods. Hence nipping plays an important role for better maintenance of source and sink relationship and for ameliorating crop productivity.

CONCLUSIONS AND RECOMMENDATIONS

The study revealed that manipulation through nipping positively influenced growth and yield of hot pepper (*Capsicum frutescens L.*). Nipping resulted in higher number of branches per plant, more number of leaves per plant and improved yield and yield characters of hot pepper in the study area. Among the different nipping rates evaluated, nipping at 2cm level had superior performance over other nipping levels. Results from this study suggest that smallholder farmers can nip their plants at the 2cm level of growth to encourage growth and development and enhance crop yield.

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Table 1: Pre soil physical and chemical properties at experimental site

Chemical Properties	Values
pH	5.50
Nitrogen (g/kg)	0.07
Available Phosphorus (mg/kg)	4.00
Exchangeable Na (cmol/kg)	0.02
Exchangeable K (cmol/kg)	0.02
Exchangeable Ca (cmol/kg)	1.47
Exchangeable Mg (cmol/kg)	4.20
Soil Organic matter (%)	1.34
Particle size distribution	
Sand	62.8
Silt	12.0
Clay	25.2
Bulk density (g/cm^3)	1.32

Table 2: Effect of apical nipping on plant height of hot pepper during the 2018/19 rainy season

Treatments Nipping Levels	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	Mean
0	8.500^{a}	10.833^{a}	13.111^{a}	16.889^{a}	20.444^{a}	14.01
1	6.667^{b}	9.833^{ab}	11.556^{ab}	14.400^{ab}	17.389^{ab}	11.97
2	5.611^{b}	7.678^{b}	9.333^{b}	11.044^{b}	12.556^{b}	9.33
3	5.778^{b}	8.167^{ab}	10.556^{ab}	12.989^{ab}	16.056^{ab}	10.71
SE±	0.005	0.008	0.009	0.009	0.014	

Means sharing the same alphabet within the column are not significantly difference at 5% level of probability according to DMRT. WAT: Week After Transplanting, SE: Standard Error

Table 3: Effect of apical nipping on number of leaves of hot pepper during the 2018/19 rainy season

Treatments Nipping Levels	2 WAT Number	4 WAT Of	6 WAT leaves	8 WAT	10 WAT	Mean
0	26.780^{a}	56.110^{b}	93.110	145.220^{ab}	214.560^{ab}	107.1
1	68.890^{a}	118.000^{a}	147.110	203.560^{a}	268.330^{a}	161.2
2	45.330^{ab}	69.330^{b}	85.560	109.670^{b}	148.780^{b}	91.7
3	36.110^{b}	61.890^{b}	96.110	143.670^{ab}	218.670^{ab}	111.3
SE±	0.746	1.337	1.641	2.329	3.091	

Table 4: Effect of apical nipping on sub branches of hot pepper during 2018/19 rainy season

Treatments Nipping Levels	2 WAT Sub	4 WAT Branches	6 WAT	8 WAT	10 WAT	Mean
0	2.333[a]	4.000[b]	5.778[ab]	5.222[b]	5.667[b]	4.60
1	7.333[a]	7.778[a]	8.222[a]	8.889[a]	8.981[a]	8.24
2	4.444[b]	4.444[b]	4.444[b]	4.889[b]	4.889[b]	4.62
3	3.667[b]	4.222[b]	5.000[b]	4.556[b]	4.778[b]	4.44
SE±	0.067	0.077	0.074	0.079	0.077	

Means sharing the same alphabet within the column are not significantly difference at 5% level of probability according to DMRT. WAT: Week After Transplanting, SE: Standard Error.

Table 5: Effect of apical nipping on Stem diameter of Hot pepper during 2018/19 rainy season

Treatments Nipping Levels	2 WAT Stem	4 WAT Diameter	6 WAT (mm)	8 WAT	10 WAT	Mean
0	0.667 [ab]	0.967 [ab]	0.978[ab]	1.122[a]	1.722[a]	1.09
1	0.611 [ab]	0.822 [ab]	1.211[a]	1.144[a]	1.811[a]	1.12
2	0.533 [ab]	0.689 [ab]	0.778 [ab]	0.967 [ab]	1.256 [a]	0.84
3	0.500[ab]	0.744 [ab]	0.878[ab]	1.033 [a]	1.500[a]	0.93
SE±	0.005	0.008	0.009	0.009	0.014	

Table 6: Effect of apical nipping on Leaf area of Hot pepper during 2018/19 rainy season

Treatments Nipping Levels	2 WAT Leaf	4 WAT Area	6 WAT (cm^3)	8 WAT	10 WAT	Mean
0	19.05 [ab]	20.21[b]	22.19[c]	23.90 [ab]	20.23 [b]	21.11
1	21.64 [ab]	22.43[b]	24.69 [b]	24.81 [ab]	23.89 [a]	23.49
2	25.67 [a]	29.85 [a]	30.18[a]	26.98 [a]	22.69 [a]	27.07
3	24.90 [a]	26.71[ab]	28.36[ab]	25.42 [a]	22.91 [a]	25.66
SE±	1.529	2.156	1.797	0.648	0.762	

Means sharing the same alphabet within the column are not significantly difference at 5% level of probability according to DMRT. WAT: Week After Transplanting, SE: Standard Error.

Table 7: Effect of apical nipping on yield and yield characters of Hot pepper during 2018/19 rainy season

Treatments Nipping Levels	Number of flowers/plot	Shoot fresh weight (g)	Shoot dry weight (g)	Number of fruit/ plant	Length of fruit/plant (mm)	Fresh Fruit Thickness (mm)	Weight of individual fruit/plant (g)	Yield/plot (t/ha)
0	35.79^{c}	480.55^{b}	140.44^{b}	9.667^{c}	51.98^{b}	2.55^{a}	4.617^{d}	22.43^{c}
1	37.25^{b}	483.88^{b}	152.22^{a}	11.667^{b}	52.20^{b}	2.63^{a}	7.833^{c}	36.63^{b}
2	38.15^{a}	584.58^{a}	152.60^{a}	15.667^{a}	56.90^{a}	3.43^{a}	9.522^{a}	43.61^{a}
3	36.09^{d}	569.02^{a}	153.91^{a}	12.111^{b}	53.29^{b}	3.12^{a}	8.102^{b}	38.42^{b}
SD	1.284	54.99	8.17	2.49	2.28	0.42	2.07	9.04
SE±	0.642	27.49	4.08	1.25	1.14	0.21	1.03	4.52

Means sharing the same alphabet within the column are not significantly difference at 5% level of probability according to DMRT. WAT: Week After Transplanting, SE±

: Standard Error.

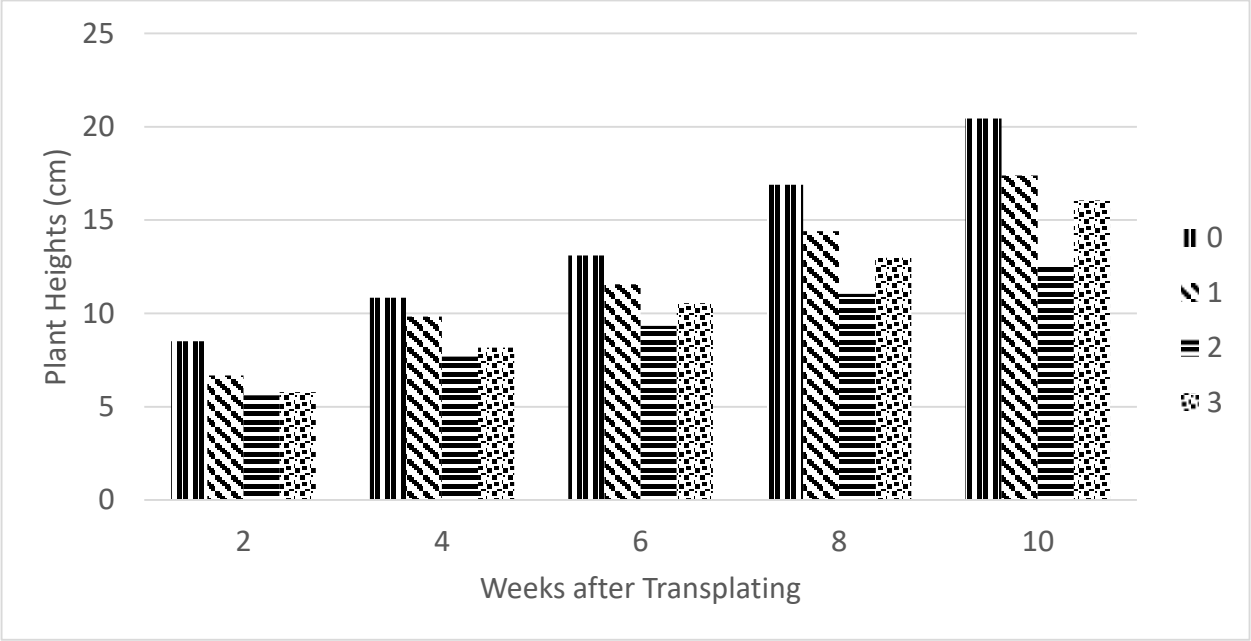

Figure 1. Effect of apical nipping on plant height of hot pepper

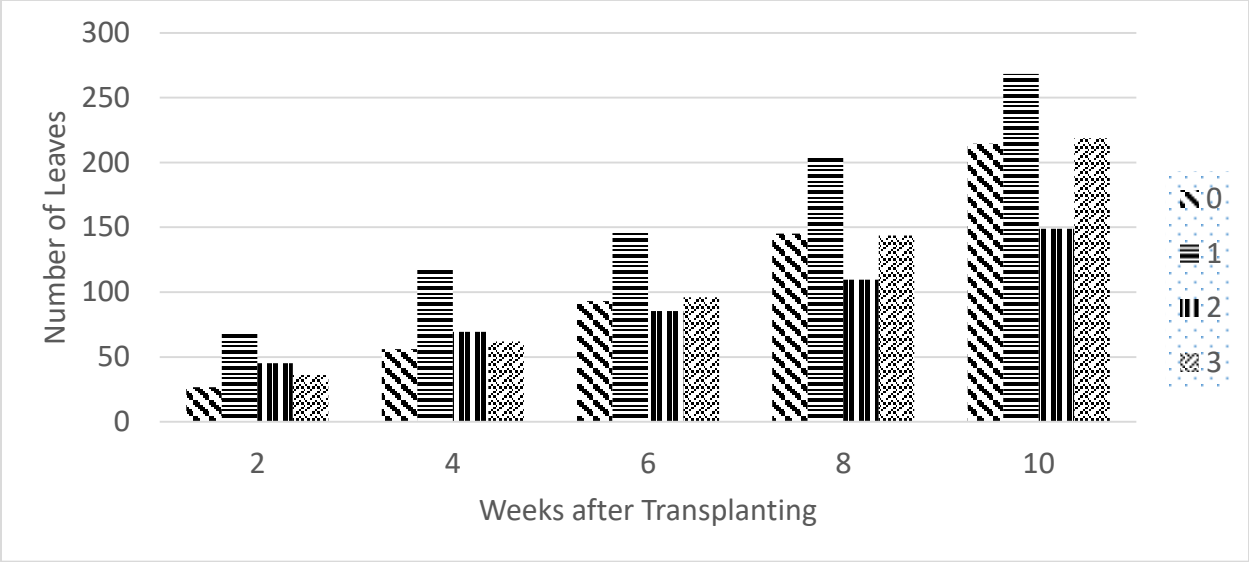

Figure 2. Effect of apical nipping on number of leaves of hot pepper

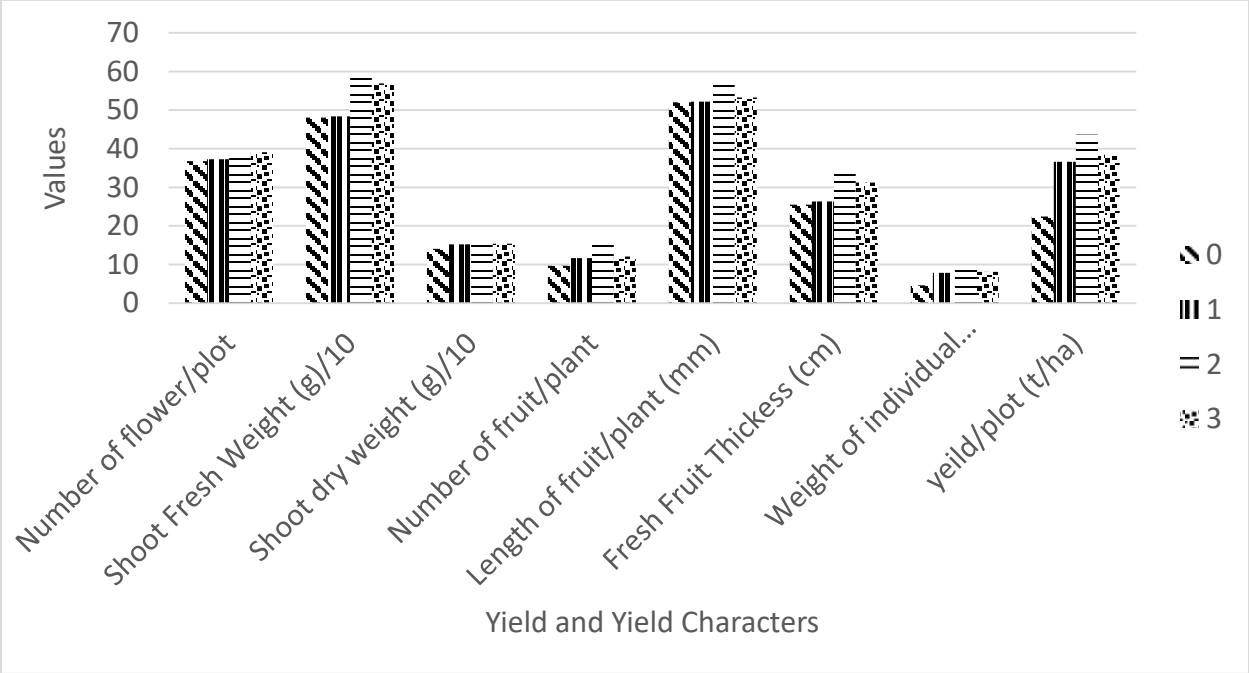

Figure 3. Effect of apical nipping on yield and yield characters of hot pepper