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EFFECT OF NIPPING ON GROWTH AND YIELD OF GREEN BELL PEPPER (*Capsicum annuum* L. *cv* GOLIATH) IN IWOLLO, SOUTH-EASTERN NIGERIA

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ABSTRACT
Field trial was conducted at the Research and Demonstration farm of the Department of Horticultural Technology, Enugu State Polytechnic, Iwollo to evaluate the effect of nipping on growth and yield of green bell pepper (*Capsicum annuum*). The experiment was laid out in randomized complete block design with three replications. Green bell pepper was raised in the nursery and transplanted at four weeks old. The treatments were nipping at 1 week after transplanting, nipping at 2 weeks after transplanting, and nipping at 3 weeks after transplanting. The control treatment was left non-nipped. Data were collected on growth and yield parameters. The data collected were analysed using analysis of variance (ANOVA) and the treatment means separated using least significant difference (LSD) at 5% probability level. The result showed that all the nipped green pepper plants performed better than the non-nipped plants (control).There was significant ($p<0.05$) difference among the treatments with respect to plant height, number of branches per plant, number of leaves per plant, number of fruits per plant, weight of single fresh fruit, weight of fresh fruit per plant and fresh fruit yield per hectare with nipping at 2 weeks after transplanting having superior values. It can be concluded that nipping has a positive effect on growth and yield of green bell pepper. Nipping at 2 weeks after transplanting could therefore be recommended for improved yield of green bell pepper (*Capsicum annuum).*

KEY WORDS: *Capsicum annuum*, Growth, Iwollo, Nipping, Yield.

INTRODUCTION

Vegetables constitute the major bulk of human diet. Owing to increase in human population, there is presently an urgent need for increased production of vegetables. Green bell pepper also known as sweet pepper is botanically fruits but are generally considered in culinary context to be vegetable (Garcia-closas *et al.*, 2004). It belongs to a cultivar group of the species "*Capsicum annuum*", the only cultivar group that lacks the burning sensation associated with other Capsicum cultivars when they come in contact with mucous membrane (Kumar *et al.*, 2011; Sweety, 2013; Uche *et al*, 2016). Green bell pepper is native to Mexico, Central America and Northern South America (Sweety, 2013). It grows well in warm soil, ideally 21 to 29^0C, that is kept moist but not water logged. It is sensitive to abundance of moisture and excessive temperature. Green bell pepper is a highly nutritious vegetable. It adds colour to dishes with tangy taste that enhances food flavour. It is a good source of vitamins, mineral and phytochemicals (Garcia-closas *et al.*, 2004; Fitday, 2016). Various vitamins and photochemicals found in green pepper have antioxidant properties. It contains vitamin A in the form of caroteniod as well as vitamins B6, B9 and C, all of which are powerful antioxidant. These vitamins play a vital role in neutralizing free radicals in the body which have the capacity to serious damage to cells during their roaming activities (Brucket and Rosebaum, 2011). Free radical also contribute to the building of cholesterol in blood vessel which increases the likelihood of stroke and heart disease (Brucket and Rosebaum, 2011). The phyto-nutrients in green pepper play anti-inflammatory role (Fitday, 2016). They make green pepper a useful dilatory item for people with rheumatoid arthritis or osteoarthritis. Phyto-nutrients also help to relax the airways and reduce wheezing in asthma cases (Fitday, 2016). According to USDA National Nutrition database (2011) green pepper contains 2 times more vitamins C than citrus fruits (Fitday, 2016). Vitamin B6 and B9 in green bell pepper reduce level of homocysteine, a toxic by-product of biochemical processes in the body. High level of homocysteine can damage blood vessels which increases the risk of stroke and heart attack (Fitday, 2016). Vitamin B6 and B9 convert homocysteine into beneficial molecules which provide more safety for blood vessels. High level of fibre in green pepper reduces degree of exposure of colon cells to bacteria and toxins. The fibre speeds up the transit time of matter through the gut (Fitday, 2016). This helps in reducing colon cancer.

Green pepper cultivation in commercial scale is not common in Africa. Grubben & El-Tahir (2004) reported that high disease infestation and pest attack make green pepper cultivation difficult in hot and humid tropical low land of Africa. Most western countries use Integrated Pest Management (IPM) technology, especially in green house to keep the crop healthy with a minimum application of

toxic chemical. Many kinds of biological products or natural enemies for the control of green pepper diseases and pests are available, but these are less appropriate for tropical African conditions (Grubben and El-Tahir, 2004). Because of the high cost, the majority of green bell pepper producers in Africa do not adopt chemical spraying. The high incidence of disease infestation and high pest attack have often discourage farmers from going into commercial green pepper production in South-eastern Nigeria characterized by high humid conditions which favours diseases. Most of the green bell peppers consumed in Nigeria are either produced in the northern part of the country where conditions are a bit favourable or imported. With the intensification of the cropping system, example high doses of fertilizer, the potential yield will rise considerably but so will the cost of production and the risk of high crop losses. To compensate for the high cost of production and crop losses there is need to research for other ways of increasing green bell pepper yield and maximizing profit other than breeding for high resistance varieties tolerable to hot and humid condition which may take time to develop and test.

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 (Khan *et al.*, 1993). Nipping is synonymous to topping, clipping and pinching. When plants are nipped, the apical buds which contain auxins (growth hormone) are removed. Some plants tend to branch out very little when they grow and growth in such plants, occur almost exclusively from apical meristem rather than axillary buds which do not develop as long as terminal bud is present. Such plants are said to exhibit apical dominance (Cline, 1994). In plant like green pepper with strong apical dominance, the auxin produced in the apical meristem inhibits the axillary bud from developing into actively growing shoots. Auxins from the shoot apex are believed to inhibit the growth of lateral buds through the method explained in direct inhibition hypothesis (Campbell *et al.*, 2008). When the apical meristem of a plant is intact, auxin from the apical bud will inhibit the growth of lateral buds. When the apical bud is removed, the cytokinins are able to promote the growth of lateral buds into branches (Campbell *et al.*, 2008). More branches will possibly initiate more flower buds and possibly more yield. Khan *et al.* (1993) 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. Singh and Diwakar (1995) revealed that foliage nipping at early stage of crop increased number of branches while restricting profuse vegetative growth thereby promoting crop yield. However, Aziz (2002) noted that nipping caused shock and delayed re-growth when done at the wrong stage of the plant's growth phase. There is uncertainty as to the appropriate time to nip for a particular crop to achieve optimum positive physiological processes. Chaube and Pundhir (2005) reported that chickpea nipping after 45 days of sowing increased yield as well as controlled disease severity. Several researchers have reported positive effect of nipping on crop production. The objective of this study was therefore to determine the effect of nipping on growth and yield of green bell pepper (*Capsicum annuum*) in Iwollo, south-eastern Nigeria.

MATERIALS AND METHODS

Description of the Study Area

The study was carried out in 2015 at the beginning of the second pattern of the bimodal rainfall pattern of the year at the Teaching and Research farm of the Department of Horticultural Technology, Enugu State Polytechnic, Iwollo (ESPOLY). The study area is located in the tropical rainforest of the southeast agro-ecological zone of Nigeria; geographical co-ordinate 6^{o} 27^{1} North 7^{o} 17^{1} East (Maplandia, 2015). The rainfall pattern is bimodal between April-July and September-November with short spell in August. The annual rainfall in the study year recorded with rain gauge at ESPOLY weather station was 2065.2mm.

Nursery Preparation

Farm soil was collected and mixed with a well cured poultry manure and sand in the ratio of 3:2:1 respectively. The soil mixture (nursery mixture) was watered for three days at the place of mixture before being transferred into the nursery box. Green bell pepper (*Capsicum annuum* cv. Goliath) seeds were sown in the box. The nursery was shaded to protect the seedlings from harsh weather condition. The nursery was watered as required. Seedling emergence was noticed 10 days after sowing and full emergence 4 days later. The nursery box was covered with mosquito net to control insect attack.

Field Preparation

The experimental field size of 11m by 5.5m (0.00605 ha) was marked out using measuring tape and marking peg. The field was ploughed and harrowed to fine tilt. Plant beds (plots) were prepared using hoe. A total of 12 plots of 2m x 1.5m ($3m^2$) each were made and demarcated into 3 blocks, each block having 4 plots. 50cm (0.5m) and 100cm (1m) alleys separated adjacent plots and blocks respectively. Poultry droppings at the rate of 15 tons/ ha was incorporated into the soil during field preparation.

Soil Sampling

Soil samples were randomly collected from the experimental field from a depth of 0-20cm and thoroughly mixed to make a composite soil sample before poultry droppings application. The composite soil sample was analysed as described by Okalebo *et al.* (2006) to determine pre-planting soil physical and chemical properties of the experimental area.

Experimental Design and Treatments

The experiment was laid out in randomized complete block design (RCBD) with three replications. The treatments were:

Nipping at 1 week after transplanting (N@1WAT).
Nipping at 2 weeks after transplanting (N@2WAT).
Nipping at 3 weeks after transplanting (N@3WAT)
No nipping (Control)

Horticultural Practices

Seedlings from the nursery box were transplanted to the prepared plant beds 4 weeks after sowing on 2^{nd} August 2015 with 50cm x 50cm spacing giving a total of 12 plants per $3m^2$ plots and plant population of 40,000 plants per hectare. Weeding was done manually every forth night. Pest was controlled using Knock-off insecticide. (Lambda cyhalothrin), while fungal diseases were controlled using

Camazeb fungicide (carbendazim + mancozeb). Nipping was done at the apical bud.

Data Collection

Data collection was from 6 tagged plants used as sample plants in each plot. Observation was taken on growth and yield parameters such as plant height, number of leaves per plant, number of branches per plant, days to 50% flowering, number of fruits per plant, weight of single fresh fruit, fresh fruit weight per plant and fresh fruit yield per hectare.

Plant height (cm)

Data on plant height was collected from six tagged sample plants at 60 days after planting. This was determined using a measuring tape to measure from the base of the plant to the top of the plant.

Number of leaves per plant

Data on number of leaves per plant was collected from six tagged sample plants at 60 days after planting. This was determined by direct counting of the leaves per plant.

Number of branches per plant

Data on number of branches per plant was collected from six tagged sample plants at 60 days after planting. This was determined by direct counting the branches per plant.

Days to 50% flowering

Days to 50% flowering was determined by counting the number of days it took half of the sample plants in each plot to flower.

Number of fruits per plant

Number of fruits per plant was counted from six sample plants at maturity.

Weight of single fresh fruit (g)

The weight of a single fresh fruit was determined on an electronic scale. Ten fruits from the sample plants were used to determine the weight of single fresh fruit. The average of the ten fruits was taken as the weight of single fresh fruit.

Fresh fruit weight per plant (kg)

Fresh fruit weight per plant was calculated using number of fruit per plant and weight of a single fresh fruit. Thus;

Fresh fruit weight per plant (kg) = Number of fruits per plant x weight of a single fresh fruit

Fresh fruit weight per hectare (tons)

Fresh fruit weight per hectare was calculated by multiplying fresh fruit weight per plant and potential number of plant per hectare. Thus;

Fresh fruit weight/hectare = fresh fruit weight per plant x potential plant density per hectare.

Statiscal Analysis

All the data obtained were subjected to analysis of variance (ANOVA) for randomized complete block design (RCBD) using Genstat Release 10.3DE software (GenStat, 2011). Separation of means for statistical significance was done using least significant difference at 5% probability level as outlined by Obi (2002).

RESULTS

Pre-planting Soil Properties of the Experimental Site

The result of pre-planting soil analysis as presented in Table 1 showed that the soil was sandy loam with organic matter and good moisture retaining properties. Most of its chemical nutrient elements were below the critical values (Adeoye and Agboola, 1985), which called for the application of soil amendment like poultry droppings. The pH of 5.80 of was within the range of pH considered suitable for vegetables (Tindal, 1983). The low fertility status of the soil was a true reflection of most soils of humid environment that are strongly affected by intense precipitation, erosion and leaching.

TABLE 1: Pre-planting soil physico-chemical properties of the experimental site

Soil Properties	Values
Physical Properties	
Sand (%)	70.70
Silt (%)	11.08
Clay (%)	17.23
Textural class	Sandy loam
Chemical Properties	
Nitrogen (g kg^{-1})	0.015
Organic carbon (g kg^{-1})	2.00
Organic matter (g kg^{-1})	3.45
Phosphorus (ppm)	20.56
Exchangeable cations (meq/100g soil)	
Potassium	0.36
Magnesium	2.62
Calcium	2.78
Sodium	2.84

Effect of Nipping on Growth of Green Bell Pepper (*Capsicum annuum*)

The results of the statistical analysis as presented in Table 2 showed that there was significant difference ($p<0.05$) among the treatments in plant height, number of branches per plant, and number of leaves per plant. The highest plant height (17.53 cm) was obtained in the un-nipped treatment (control), while the least (14.58 cm) was obtained in nipping@1WAT which was statistically at par with nipping@2WAT (15.34 cm). Consequently, nipping@2WAT had the highest number of branches per plant (10.50) which differed significantly with nipping@1WAT (9.5), nipping@3WAT (7.723) and with no nipping (control) treatment (6.442). The highest number of leaves per plant (54.61) was also obtained in nipping@2WAT. This was statistically at par with nipping@1WAT (52.72) but differed significantly with nipping@3WAT (45.51) and control (39.37). Control treatment recorded the least number of leaves. Nipping did not significantly ($p>0.05$) influence days to 50% flowering.

TABLE 2: Effect of nipping on growth parameters of Green bell pepper (*Capsicum annuum*)

Treatment	Plant Height (cm)	Number of Branches	Numbers of Leaves	Days to 50% flowering
Nipping@1WAT	14.58[c]	9.5[b]	52.72[a]	56.0
Nipping @ 2WAT	15.34 [bc]	10.5 [a]	54.61[a]	56.67
Nipping@3WAT	15.96 [b]	7.723[c]	45.51[b]	56.33
No nipping (Control)	17.53 [a]	6.447[d]	39.37[c]	56.33
LSD $_{0.05}$	0.887	0.5961	2.126	NS

WAT= Weeks After Transplanting. @ = At. NS= Non Significant. Mean value with the same letter are not significantly different (P>0.05).

Effect of Nipping on Yield of Green Bell Pepper (*Capsicum annuum*)

The results of the statistical analysis as presented in Table 3 showed that nipping significantly (P<0.05) influenced number of fruits per plant, weight of single fresh fruit, fresh fruit weight per plant and fresh fruit yield per hectare of green bell pepper. The highest number of fruits per plant (7.667) was observed in nipping@2WAT while the least (3.433) was obtained in the control treatment. The trend of number of fruits per plant as influenced by nipping was; nipping@2WAT > nipping@1WAT > nipping@3WAT > control. In addition, fruits harvested from control treatment recorded the highest weight of single fresh fruit (44.73 g) which differed significantly (P<0.05) with nipping@3WAT (39.17 g), nipping@1WAT (37.53 g) and nipping@2WAT (36.0 g). All the nipping treatments were statistically at par in respect to weight of single fresh fruit. In fresh fruit weight per plant, the highest value (0.2767 kg) was obtained in nipping@2WAT followed by nipping@1WAT (0.2216 kg) then, nipping@3WAT (0.1913 kg), while the least (0.1537 kg) was obtained in control treatment. Similar trend was observed in fresh fruit yield per hectare. The highest fresh fruit yield per hectare (11.07 tons) was obtained in nipping@2WAT while the least (6.15 tons) was in control. The trend was; nipping@2WAT> nipping@1WAT> nipping@3WAT>control.

TABLE 3: Effect of nipping on yield parameters of Green bell pepper (*Capsicum annuum*)

Treatments	Number of fruits/plant	Weight of single fresh fruit (g)	Fresh fruit weight/ plant (kg)	Fresh fruit yield/ hectare (tonne)
Nipping@1WAT	5.9[b]	37.53[b]	0.2216[b]	8.87[b]
Nipping@2WAT	7.667[a]	36.00[b]	0.2767[a]	11.07[a]
Nipping@3WAT	4.9[c]	39.17[b]	0.1913[c]	7.65[c]
No Nipping (control)	3.433[d]	44.73[a]	0.1537[d]	6.15[d]
LSD $_{0.05}$	0.4529	3.228	0.02501	1.00

WAT= Weeks After Transplanting. @ = At. Mean values with the same letter are not significantly different (P>0.05).

DISCUSSION

The results of the study showed that nipping significantly influenced growth and yield of green bell pepper (*Capsicum annuum*). Nipping significantly (p<0.05) decreased plant height of green bell pepper. The decrease in plant height observed in nipped plants as compared to non-nipped plants could be attributed to the removal of auxin (Indole Acetic Acid) at the apical bud which possibly reduced apical dominance of auxin. Similar result was obtained by Korla and Sani (2003) in Fenugreek. Consequently, there was significant effect of nipping on number of branches of green pepper as shown in Table 2. All the nipped plants recorded significant increase in number of branches per plant compared to control treatment (non-nipped plants) with nipping@2WAT recording the highest number. The significant increase in the number of branches per plant of nipped green bell pepper plants 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 (Khan *et al.*, 1993; Cline, 1994; Campbell *et al.*, 2008). In plants, the development of axillary buds is inhibited normally by Indole Acetic Acid (IAA) produced in the apical meristem (Campbell *et al.*, 2008). If the source of auxin is removed by excising the apical meristem, the lateral branching gets activated and accelerated. This result is in accordance with the findings of Imayararamban *et al.*, 2004; and Kokilavani *et al.*, 2007 on sesame. Similarly, nipping significantly increased the number of leaves per plant. The highest number of leaves was recorded on nipping@2WAT. This could possibly be due to induction of more number of lateral branches per plant as a result of nipping. The result of Kathiresan *et al.* (1997) on sesame provided support to this finding. There was non-significant difference among the treatments in days to 50% flowering. This was not in agreement with the findings of Aziz (2000) on chickpea and Kokilavani *et al.*, 2007 on sesame. Consequently, more number of fruits per plant was obtained in all the nipping treatments compared to no nipping treatment (control) with the highest number in nipping@2WAT as presented in Table 3. The significant increase in the number of fruits per plant as a result of nipping could be due to induction of more number of branches per plant which possibly initiated more flower buds that resulted to more fruits. The result was in accordance with the findings of Baloch and Zubir (2010). In addition, fruits harvested from control treatment recorded the highest weight of single fresh fruit (Table 3). The lesser value of single fresh fruit weight obtained in nipped green pepper was an indication of its smaller fruit size compared to bigger fruits obtained in control treatment. This could be attributed to compensation of fruit size for higher fruit number in nipped plants. It could

also be as a result of sink source relationship – more sink competing for limited photosynthate from the source thereby causing reduction in fruit weight. Fresh fruit yield per plant showed significant difference (P>0.05) among the treatments. It followed the same trend with number of fruits per plant indicating that number of fruits per plant had more influence on fresh fruit yield per plant. Higher single fruit weight obtained in control treatment as against the nipping treatments did not translate into higher fresh fruit weight per plant. All the nipped green pepper plants had significant higher yield per plant compared to non-nipped plants with nipping@2WAT having superior value. Consequently, nipping significantly increased fresh fruits yield per hectare with nipping@2WAT having superior value. The fresh fruit yield per hectare was an induction of fresh fruit yield per plant and both followed the same trend. Green bell pepper plants nipped at very early stage of 1WAT probably experienced severe shock as their roots were not yet fully established to the soil however, they were able to recover on time and put up vigorous vegetative growth before they entered reproductive phase. Plants nipped at 2 WAT appeared to have rooted effectively to the soil and were able to direct assimilates to the lateral buds thereby putting up optimum vegetative growths without interrupting floral bud initiation which could have resulted in their superiority over the other treatments in terms of overall performance. Plants nipped at 3 WAT had performance values slightly higher than non-nipped plants possibly due to short recovery time they experienced which made them unable to put up improved vegetative growths before they entered reproductive phase. The findings of the study were in agreement with the findings of Kathiresan *et al.* (1997), Romanathan and Chandrashekharan (1998), Imayararamban *et al.*, 2004 and Kokilarani *et al* (2007) on sesame; and with Baloch and Zubir (2010) on chickpea.

CONCLUSION AND RECOMMENDATION

The study revealed that manipulation through nipping positively influenced growth and yield of green bell pepper (*Capsicum annuum*). Nipping resulted in more number of branches per plant, more number of leaves per plant, and improved yield of green bell pepper (*Capsicum annuum*). The improved performance of nipped green bell pepper plants compared to non-nipped plants could be attributed to the removal of apical dominance of auxin through nipping. Among the different nipping periods evaluated, nipping at 2 weeks after transplanting had superior performance. It is therefore recommended for improved yield of green bell pepper in Iwollo, south-eastern Nigeria.

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