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Effect of Growth Retardant Chemicals (Cycocel and Alar) on Poinsettia (*Euphorbia pulcherrima*) Growth and Cutting Quality

Alemayehu Negash[1], **Diriba-Shiferaw G**[2]✉

[1]Red Fox Ethiopia, Koka kebele, Lume wereda, Oromia Regional State, P.O.Box 1501, Ethiopia
[2]Department of Horticulture and Plant Science, College of Agriculture and Environmental Science, Arsi University, P.O. Box 193 Asella, Ethiopia

✉**Corresponding Author:**
Diriba-Shiferaw G., Email: dsphd2010@gmail.com or senadiriba2012@yahoo.com

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ABSTRACT

From the many cultivated bedding and potted floriculture, poinsettia (Euphorbia pulcherrima) is one of the commercially important plant species which revealed undesirable stretch growth habits. To keep them shorter, compact and more branched growth regulation is an important by using growth retardant chemicals; but misapplications are leading to catastrophic results, toxicity, delayed flowering, ruined growth habit, and stunted growth, which in turn lower plant quality and yield. Thus, the study was conducted to evaluate the effect of growth regulatory chemicals on growth and cuttings quality of poinsettia at Red Fox Ethiopia P.L.C. from May to December 2018 under greenhouse condition. The two growth retardants used for the study were Alar (daminozide) at concentrations of 0g/L, 1g/L, 2g/L, and 3g/L and Cycocel (chlormequat chloride) at concentrations of 0ml/L, 0.5ml/L,

1ml/L, and 1.5ml/L using completely randomized design in three replications. Rooted cuttings of poinsettia were used for the study to develop into stock plant. The results of the investigation which consisted of two types of growth retardants (Alar and Cycocel) at four concentrations each had apparent effect on the stock plant growth of Poinsettia. A highly significant ($P<0.01$) differences were observed among the different concentrations of Alar and Cycocel treatments in relation to average leaf area, internodes length, main stem length and canopy diameter. In contrast, the interaction effect between Alar and Cycocel failed to have significant($P<0.05$) effects on internodes length, main stem length, stem diameter, branch number, average leaf area, canopy diameter and number of cuttings. Cognizant with the findings of this study, Alar and Cycocel influenced the growth of poinsettia (Euphorbia pulcherrima) stock plants and cutting yield without causing a significant reduction on subsequent rooting performance of cuttings. Application of the two chemicals at different rates significantly improved the growth and cuttings quality of poinsettia in relation to commercial acceptances as compared to the control. Based on this aspect application of 3 g-1L Alar and 1.5 ml 1L Cycocel, which demonstrated positive influence on growth and cutting production can be utilized for improving the productivity of poinsettia for use by commercial growers. However, it needs further study using various growth regulatory chemicals at different levels by replicating time of cultivations.

Keywords: Alar and Cycocel, Cuttings quality, Growth retardants, Poinsettia

1. INTRODUCTION

In Ethiopia, floriculture is becoming very promising business opportunity and growing very fast. Currently there are more than 250 projects of floriculture industry in Ethiopia. The total flower production has shown increment and the number of exporters had increased from just five in 2002 to more than 120 in 2017. During the same period, foreign exchange earnings abruptly increased from US $1.5 million to in excess of US $225 million and it is expected to go up to 270 million US $ in 2017. This sub-sector has also played an important role in generating employment by creating job opportunities for more than 120,000 peoples out of which 85% are women (EHPEA, 2017).

Cut flower production is the major component of floriculture industry in Ethiopia, which covers an estimated 85% of the production area (EHPEA, 2017). Another category of the industry comprises propagators, who are mainly subsidiaries of European breeding companies. Until 2004, Ethiopian exports of unrooted and rooted cuttings were negligible. From 2005 onwards, however, some breeding companies have set up propagation facilities in Ethiopia for production of planting material (Joosten, 2007). At the moment, there are eight cutting propagating farms in Ethiopia producing pot plant and bedding plant cuttings, which covers about 15% of the production area of the floriculture industry (EHPEA, 2017).

Many of the cultivated bedding and potted plants reveal undesirable stretch growth habits. To keep them shorter, compact and more branched growth regulation is important (Kessler, 1998). One way of controlling excessive plant growth is treating plants with chemical growth retardants. Chemical growth retardants are very useful tools for controlling the height of bedding plants and also to create more branched stock plants for maximizing cutting yield (Cox, 2007). For many species and cultivars of bedding plants the treatment with such chemicals is an obligatory commercial procedure (Anita *et al*., 2003). Chemicals, including Bonzi®, Sumagic®, Alar®, Cycocel®, Alar®/Cycocel® mixed use, and Ethephon®, are most commonly used and effective in controlling growth of numerous horticultural crops, including many herbaceous perennials (Burnett *et al*., 2000, Erwin and Warner, 2003; Latimer, 2009,). Generally, all the growth retardants can delay cell division and elongation in shoot tissue and ultimately affect the quality and manipulating shape, size and form of pot plants (Renu *et al*., 2013).

Poinsettia, *Euphorbia pulcherrima*, had a good market potential as potted flowering plants and belongs to the family Euphorbiaceae. There is a constant demand for diversity in flowering pot plants. This demand can be met through the use of growth retardants. A good example is poinsettia, in which there is no genetic dwarf plant. The application of growth retardants has produced mini poinsettia cuttings (Murti and Upreti, 1995, Renu *et al*., 2013). Plant growth retardants are commonly applied in order to produce high quality, compact plants. Among various plant growth retardants, cycocel and alar are well known for production of quality plants (Renu and Ranjan, 2013).

Cycocel is widely used to control stem elongation of geraniums, hibiscus, poinsettias and begonias (Erwin, 2003). Cycocel (2-choloroethyl trimethyl ammonium chloride), is the commercial name for chlormequat chloride. It regulates plant growth by interfering with the action of the growth hormones within the plant; thereby slowing stem elongation; result is height control and compact appearance of plant. B-Nine/Alar (Succinic acid 2, 2-dimethyl hydrazide), is the commercial name for daminozide. It is highly mobile in the plant and will rapidly move from the point of application to all parts of the plant. It is generally considered safe because it has short-term effect (Berberich and Anderson, 2007). In the changing requirement of interior decoration, landscape,

there has been growing demand of dwarf varieties and cultivars for picturesque effect. Application techniques also have a huge impact on the effectiveness of a growth retardant on the crop thereby, modifying its present ability.

Plant growth regulators are widely used in cutting producing farms in Ethiopia without any scientifically justified concentration levels for Ethiopian condition. Surprisingly, the application of growth retardants carried out irrespective of cultivar types (personal observation and communication). Due to the above mentioned facts, growers frequently receive complaints from their clients on matters pertaining to the product quality (personal observation and communication) which includes poor rooting performance and stretching growth during propagation. One of the limitations of chemical growth retardants is misapplications leading to catastrophic results, which in turn lower plant quality and yield. Common consequences include phytotoxicity, delayed flowering, ruined growth habit, and stunted growth (Cavins *et al*., 2001). Hence, growers should adjust application of growth retardants to the existing conditions. In the absence of specific recommendation the grower must run a trial (Cox, 2007). Determining the effect of growth retarding chemicals on the growth responses of poinsettia plants and quality of cuttings obtained from stock plants and establishing the optimum application rate is mandatory to intensify production in terms of quality and quantity through viable and economically feasible manner and to be competitive in the global market. Moreover, it will encourage other investors to join this emerging business. Thus, this study was initiated to determine the effect of Cycocel and Alar on growth and cuttings quality of poinsettia and to determine the optimum rates of cycocel and alar for the cutting productivity.

2. MATERIALS AND METHODS

2.1 Description of the Study Site

The study was conducted at Red Fox Ethiopia P.L.C. from June 2018 to December 2018 under greenhouse condition. Red Fox Ethiopia P.L.C is located at Koka, East shoa zone Lume woreda Oromia region, , 110 km away from Addis Ababa. Geographically, the area is situated at 8°, 26'N latitude and 39°, 02' E longitude at an altitude of 1595 meters above sea level (m.a.s.l.). The mean annual rainfall is 700 mm while the mean minimum and maximum temperatures are 10.4 and 29.7 ^{0}C, respectively (Wikipedia, 2018). In the greenhouse the temperature and relative humidity was kept in the range of 18 to 30°C and 55 to 70%, respectively using a computerized system found at the farm.

2.2 Description of Experimental Materials

Rooted cuttings of poinsettia were used for the study to develop into stock plant. The two plant growth retardants which used for the experiment were Cycocel and Alar. Red ash was used as media for growing the stock. Red ash is selected because the farm practically uses this media for production of poinsettia and the other crops. The important features of red ash are providing pore space for aeration and good ability to absorb water. All the necessary materials for the experiment were supplied by Red Fox Ethiopia plc.

2.3 Treatments and Experimental Design

The experiment was conducted by using complete randomized design (CRD) consisting of two different growth retardants (each with four different levels) in three replications. The two growth retardants used for the study were Alar (daminozide) at concentrations of 0 gL^{-1}, 1gL^{-1}, 2gL^{-1}, and 3gL^{-1} and, Cycocel (chlormequat chloride) at concentrations of 0mlL^{-1}, 0.5mlL^{-1}, 1mlL^{-1}, and 1.5mlL^{-1}. In total, there were sixteen treatments factorial combinations of two growth retardants with different levels. The concentration levels for both Alar and Cycocel were based on the farms actual practice, previous small scale trials and different studies.

Table 1: Details of Treatments Combination

Treatments	**Cycocel (mlL^{-1})**			
Alar (gL^{-1})	0x0	1x0	2x0	3x0
	0x0.5	1x0.5	2x0.5	3x0.5
	0x1	1x1	2x1	3x1
	0x1.5	1x1.5	2x1.5	3x1.5

2.4 Experimental Procedures

Rooted cuttings were planted on rectangle plastic pots having a capacity of (35cm x35cm x20 cm) filled with red ash as a growing media. Each pot was accommodating 6 rooted cutting and there were ten pots per treatment per replication and 30 pots for a

single treatment. Hence, the total number of pot for the whole treatment were four hundred eighty (4x4x3=48, 48x 10 =480 pots). The experimental pots in each replication were arranged close to each other but with 30cm gap between each plot.

When the rooted cuttings developed sufficient foliage and when the leaves fully expanded to the edge of the pot (6 weeks after planting), the potted plants were sprayed with the randomly assigned treatments. Spraying of the treatments were done using hand sprayers. Each plot was sprayed uniformly with respective treatments until the foliage of the plants became sufficiently wet. The spray of stock plants with plant growth retardants were done early in the morning at a week interval for ten consecutive weeks. As stated by Glady *et al*,(2004) that weekly application of plant growth retardants can be adequate to manage vegetative stock plants for cutting propagation. Application was done in the morning merely because of cooler condition in the morning which is reportedly know to increase the effectiveness of Cycocel and Alar sprays due to slow evaporation and full turgidity of plants (Cox, 2007). Apart from this, early morning application generates effective height control since a large percentage of the daily stem elongation occurs early in the day just after sunrise (Dole and Wilkins, 2005). Other management practices and follow-ups were implemented uniformly to all the stock plants as per the operational procedures of the farm at Red Fox Ethiopia plc. Fertilizers were applied through fertigation using the micro tube (spaghetti) system based on the recommended rate of the farm.

2.5. Data Collection and Measurements

Data regarding the growth of the stock plants were taken at weekly interval for ten consecutive weeks starting a week after the first application of the treatments. However, data such as shoot fresh and dry weight and root fresh and dry weight were collected only once (at the end of the 10th week) after uprooting the sampled plants. Data were collected as per the procedures mentioned as follows:

Internodes length (cm): The distance between nodes of the main stem of six stock plants were measured using a ruler and the average value was recorded.

Main stem length (cm): Main stem length of six stock plants was measured using a ruler from the crown (the point where the root and stem meet) to the uppermost point of the stem.

Stem diameter (mm): The stem diameter of the main stem was measured from the base of six stock plants using standard (digital) Verneir Caliper. Measurement was taken 5cm above from the surface of the media.

Number of main branches and secondary braches: Number of main and secondary branches on the main stem and secondary stems of six stock plants were counted and the average value was counted.

Average leaf area (cm^2): Leaf area was measured and averaged by arbitrarily taking ten leaves from top & medium positions of the stock plants. Measurement was taken using square paper from intact leaves without detaching from the stock plants.

Canopy diameter (cm): Canopy diameter or width of stock plants was measured at the widest point using hand meter. Measurement was done from both north to South and East to West directions and the average value was taken.

Number of cuttings: From ten randomly selected stock plants in each experimental plot, total numbers of available cuttings were taken one time in a week interval. The first picking of cuttings was done one week after the last application of the treatments. For analysis, the total number of cuttings of the month was taken into consideration.

Root fresh weight (g): Root fresh weight of stock plants was measured using digital sensitive balance (EX-2000, maximum precision level of 0.1mg) after uprooting and thorough washing of the roots.

Root dry weight (g): The measured roots for fresh weight were placed into an oven (70oC) for 24 hour for drying to a constant weight and then the dried roots were weighted using digital sensitive balance (EX-2000, maximum precision level of 0.1mg).

Shoot fresh weight (g): Shoot fresh weight (above ground portion excluding only the roots) of stock plants was measured using digital sensitive balance (EX-2000, maximum precision level of 0.1mg).

Shoot dry weight (g): After taking the fresh weight of the shoots, the samples were subjected for drying to a constant weight using an oven (70oC) for 24 hour then shoot dry weight was measured using digital sensitive balance (EX-2000, maximum precision level of 0.1mg).

2.6. Statistical Analysis

The data of all parameters considered in the study were subjected to the Analysis of Variance (ANOVA) using SAS version 9.2 computer software (SAS Institute Inc., 1999). Mean separation of the significant parameters was done using Least Significant Difference at 5% probability levels.

3. RESULTS AND DISCUSSION

3.1 Effect of Cycocel and Alar on Growth of Stock Plants

3.1.1 Main stem length

A highly significant (P<0.01) differences were observed among the different concentrations of Cycocel and Alar treatments in relation to main stem length. In contrast, the interaction effect between Cycocel and Alar was not statistically significant (P< 0.05) in respect of main stem length (Appendix Table 3). The longest main stem length (23.36cm) was recorded from non-treated stock plants. On the other hand, the shortest main stem length (17.41cm) was observed from the application 3 g^{-1} L Alar. The longest main stem length (21.66cm) was recorded from non-treated stock plants. On the other hand, the shortest main stem length (18.86cm) was observed from the application 1.5ml^{-1} L Cycocel which is in par with 1ml^{-1} L and 0.5ml^{-1} L treated stock plants. Furthermore, an increase in alar growth retardants decreased the mean length of main stem of the treated stock plants (Table 2). Similar results were reported on *Verbena canadensis* (Burnett *et al.*, 2000) and *Verbena* 'Obsession Lilac' (Blanchard *et al.,* 2008) and *Verbena rigida (*Andersen and Davis, 1989a) using combined application of Alar and Cycocel. Several authors have pointed out such an effect in other bedding or ornamental plants including *Poinsettia* and *Pansy* (James *et al.*, 2002), and *Veronica* 'Sunny Border Blue', *Sedum* 'Autumn Joy', *Monarda didyma* 'Marshall's Delight', and *Phlox paniculata* 'David' (Baden *et al.,* 1999) with Alar and Cycocel mix application. Karlovic *et al.* (2004) also obtained similar result on *Chrysanthemums* by applying only Alar. The observed reduction in plant height might be due to anti-gibberellins activity of Alar and Cycocel which facilitates inhibition of cell division frequency and cell elongation in the sub apical meristematic zone of the stem. This fact is in conformity with James *et al.* (2002), Banko and Stefani (1988) and Barbosa *et al.* (2005). According to Basra (2000), shorter stems have been related to decreased cell number, short cortical cells, and reduced xylem length. These may result from the combined effect of the two factors. Less height increase in the treated plants might also be due to reductions in the internode elongation. As internode length shows certain decline, stem length is also expected to decrease (Barrett and Nell, 1983).

Table 2. Main Effect of Alar and Cycocel concentration on main stem length

Treatments	**Main stem length (cm)**
Alar (gm)	
0	23.36[a]
1	19.43[b]
2	18.61[b]
3	17.41[c]
LSD(0.01)	0.99
P-Value	<0.0001
Cycocel(ml)	
0	21.66[a]
0.5	19.11[b]
1	19.19[b]
1.5	18.86[b]
Mean	19.70
LSD(0.05)	0.99
P-Value	<0.0001
CV (%)	5.82

ns, non-significant; *,** ,very highly significant at P < 0.05 and 0.001, respectively. Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

3.1.2 Number of main and secondary branches

Branch number is a major consideration in growing of stock plants for the purpose of producing more number of cuttings. More cuttings are expected from stock plants having more number of branches. In this study, a highly significant (P<0.05) interaction effect was observed among the different concentrations of Cycocel and Alar (Appendix Table 3). Significantly maximum number of branches (24.02) was observed from treatment combination of 1 ml L-1 CCC and 3 g L-1 Alar, which however was not significantly different from combined application of 1.5 ml L^{-1} CCC and 2 gL^{-1} Alar, 1.5 ml L^{-1} CCC and 3 gL^{-1} alar and 0.5 ml L^{-1} CCC and 3 gL^{-1}

alar . Conversely, the minimum number of main branches was observed from stock plants without treatment (17.3) which however was at par with treatment of 1g L^{-1} Alar and 0 ml L^{-1} CCC and 0 g L^{-1} Alar and 0.5 ml L^{-1} CCC(Table 3). This finding is in line with the observations on *Rosa damescena* (Abbas et al., 2007) and *Hebe fransiscana* (Adriansen and Kristensen, 1988) from individual application of Alar and Cycocel and on *Tagetes patula, Impatiens walleriana*, and *Petunia hybrid* using only Alar. The increase in the number of main branches per plant as a result of the combined application of Alar and Cycocel might be attributed to the synergetic effects of the two growth retardants in checking the apical dominance through reduced levels of endogenous production of auxins which in turn induced the sprouting of vegetative buds. Plant growth retardants work by interrupting apical dominance, which triggers lateral buds to grow and fill in the plant. In apical dominance, the shoot apex can prevent lateral bud growth. Such possible explanation was also forwarded by other workers (Abbas et al., 2007; Amarander, 2007; Carey, 2008).

Table 3. Number of main and secondary branch affected by different concentration of Alar and Cycocel

		Alar concentration				
		0	1	2	3	**Mean**
Cycocel Conc.	0	17.3^{h}	18.26^{gh}	19.93^{ef}	21.18^{cde}	19.17
	0.5	17.71^{h}	20.29^{def}	20.77^{de}	23.24^{ab}	20.50
	1	19.29^{fg}	20.68^{de}	22.12^{bc}	24.02^{a}	21.53
	1.5	20.49^{def}	21.41^{dc}	23.04^{ab}	23.42^{ab}	22.09
Mean		**18.70**	**20.16**	**21.47**	**22.97**	**20.82**
P-Value =		**0.0138***	**LSD=**	**1.35**	**CV(5%)**	**3.89**

Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

3.1.3 Canopy diameter

An essential aspect of any crop production system is the development of a crop canopy that optimizes the interception of light, photosynthesis, and the allocation of dry matter to harvestable parts. A highly significant ($P<0.01$) differences were observed among the different concentrations of Alar treatments in relation to canopy diameter. However, Cycocel effect was not significant among the different concentrations. In contrast, the interaction effect between Cycocel and Alar was not statistically significant ($P<0.05$) in respect of canopy diameter (Appendix table 3). The untreated stock plants produced the highest canopy diameter (21.37cm). On the other hand, significantly the lower canopy diameter was observed from application of 3 g L^{-1} Alar (18.09cm) which is statistically not significant with 2 g L^{-1} (18.66cm) treated stock plants (Table 4). This finding is in agreement with observations reported on *Verbena canadensis* (Burnett *et al*., 2000) from combined application of Cycocel and Alar, and also Alar application *on Zinnia elegans* (Banko and Stefani, 1988). The apparent results were probably due to the dwarfing effect of Cycocel and Alar, reducing both plant height and width. Comparable justification is also made by Carvalho *et al*. (2008).

Table 4. Main Effect of Alar and Cycocel concentration on canopy diameter

Treatments Alar (gm)	Canopy Diameter(cm)
0	21.37^{a}
1	19.39^{b}
2	18.66^{bc}
3	18.09^{c}
Mean	19.38
LSD(0.05)	0.88
P-Value =	**<.0001**

CV (%)	**5.32**

Note:-ns, non-significant; *,** ,very highly significant at P < 0.05 and 0.001, respectively. Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

3.1.4 Number of cuttings

The sustainability of cutting producing farms depends upon the total volume of cuttings produced. The yield of cuttings is very crucial to ensure the profitability of the floriculture business. From the conducted experiment, highly significant (P<0.01) difference was observed among the different concentrations of Cycocel and Alar. On the contrary, there was no significant (P<0.05) interaction effect between Cycocel and Alar in respect of the number of cuttings produced per stock plant (Appendix Table 3). Glady *et al*. (2004) reported increment in the number of cuttings in *Salvia nemorosa*, *Coreopsis*, *verticillata* and *Veronica spicata* using Cycocel as did Carpenter and Carlson (1972) in Geranium. The observed variation in the number of cuttings could be as the result of more branching response of the stock plants from Alar and CCC treatment. As the number of branches increase, a rise in the number of cuttings would be obvious. The results in Table 5 revealed among concentrations of Cycocel significantly maximum number of cuttings was obtained from stock plants treated with 1.5ml L^{-1} CCC (21.72) followed by 1 ml L^{-1} CCC (20.39). On the other hand, stock plants with no application of CCC (0ml L^{-1}) exhibited significantly the minimum number of cuttings (17.65). Concerning Alar, significantly the maximum number of cuttings acquired from 3g L^{-1} (20.95) followed by 2 gL^{-1} Alar (20.21). Meanwhile the minimum number of cuttings (18.33) was obtained from treatments without Alar (0g L^{-1}). The number of cuttings showed a trend of increment with increasing concentration of both retardants.

Table 5. Main Effect of Alar and Cycocel concentration on number of cutting.

Treatments	Number of cuttings
Alar (gm)	
0	18.33^{d}
1	19.35^{c}
2	20.21^{b}
3	20.95^{a}
LSD(0.05)	0.52
P-Value	<.0001
Cycocel(ml)	
0	17.65^{d}
0.5	19.06^{c}
1	20.39^{b}
1.5	21.72^{a}
Mean	19.71
LSD(0.05)	0.52
P-Value	**<.0001**
CV (%)	**3.09**

Note:- Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

3.1.5 Shoot fresh weight

According to the present study a significant interaction effect of Cycocel and Alar was observed for shoot fresh weight (P<.0001; Appendix Table 3). The minimum shoot fresh weight (33.67g) was recorded from the combined application of 3g L^{-1} Alar and 0.5ml L^{-1} CCC stock plants which nevertheless was not significantly different from the application of 1.5ml L^{-1} CCC X 3g L^{-1} Alar (36.67g)(Table 6). In contrast, the maximum shoot fresh weight (66.0g) was observed from non-treated stock plants. The results of this study confirmed that shoot fresh weight was inversely proportional to the concentration of both Cycocel and Alar. Each additional amount of Alar and Cycocel applied resulted in an additional reduction of shoot fresh weight (Table 6). The current finding is in agreement with the previous reports of Andersen and Davis (1989a) on *Verbena rigida* by Alar and Cycocel combined application, Laubscher *et al.* (2010) on *Dombeya burgessiae* and Poole and Ying (1965) on *Chrysanthemum morifolium* after

application of Cycocel. The observed reduction in fresh weight was probably due to the synergic effect of the two growth retardants in causing dwarfness by reducing plant height and width.

Table 6. Shoot fresh weight affected by different concentration of Alar and Cycocel

		Alar concentration				
		0	**1**	**2**	**3**	**Mean**
Cycocel Conc.	**0**	66^{a}	43^{cde}	44^{c}	39.67^{def}	48.17
	0.5	51^{b}	42.67^{cde}	40.33^{cdef}	33.67^{g}	41.92
	1	49^{b}	43.33^{cd}	43.67^{cd}	39^{ef}	43.75
	1.5	43.33^{cd}	42.67^{cde}	38.33^{f}	36.67^{fg}	40.25
Mean		**52.33**	**42.92**	**41.58**	**37.25**	**43.52**
P-Value		**<.0001**	**LSD(0.05)**	**4.31**	**CV(5%)**	**5.95**

Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

3.1.6 Root fresh weight

As depicted in Appendix Table 3 the effect of the interaction among the different concentrations of Cycocel and Alar on root dry weight was found to be significant (P<.0001) (Appendix Table 3). As indicated in Table 7 the maximum root fresh weight (11.58g) was obtained from non-treated stock which was significantly different from treated plants. Whereas, significantly the minimum root fresh weight (5.49g) was obtained from combined application of 1.5 ml L^{-1} CCC and 2 g L^{-1} Alar, which was still not significantly different from 1.5ml L^{-1} CCC X 2 g L^{-1} Alar (5.69g), and 1.5ml L^{-1} CCC X 3g L^{-1} Alar (5.77g). These results are found to be in compliance with findings reported on *Dombeya burgessiae* (Laubscher *et al.,* 2010), genus *Salvia* (Latimer *et al*., 1999) from mixed use of Alar and Cycocel, and *Verbena rigida* (Andersen and Davis, 1989a) from individual application. In all these cases, the authors have indicated the reduction of root fresh weight due to the effect of different growth retardants. According to Dalbro and Jindal (1977) plant growth retardants can modify endogenous auxin level in treated plants. Such effect can have a significant role in root development of treated plants. The interaction between Cycocel and Alar could influence the level of auxin that brings limited root growth. As a result, the obtained reduction in root fresh weight could be related to the limited root growth. Despite the above mentioned explanations, contradictory reports have also been mentioned. For instance, according to Latimer (1991) and Grossman (1990) root growth is less affected, or slightly promoted with main roots often longer and thicker by growth retardants application. Such discrepancies in respect of the effect of growth retardants on root fresh weight might arise from the concentration, type, frequency and time application of growth retardants.

Table 7. Root fresh weight affected by different concentration of Alar and Cycocel

		Alar concentration				
		0	**1**	**2**	**3**	**Mean**
Cycocel Conc.	0	11.58^{a}	9.22^{b}	8.96^{b}	8.42^{c}	9.55
	0.5	7.48^{de}	6.63^{fg}	6.16^{h}	5.49^{i}	6.44
	1	7.54^{d}	7.21^{e}	6.9^{f}	6.35^{gh}	7.00
	1.5	7.46^{de}	7.31^{de}	5.69^{i}	5.77^{i}	6.56
Mean		**8.52**	**7.59**	**6.93**	**6.51**	**7.39**
P-Value		**<0.0001**	**LSD(0.05)**	**0.29**	**CV(5%)**	**2.38**

Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

3.1.7 Shoot dry weight

There was a highly significant (P<0.01) interaction effect between different concentrations of Alar and Cycocel on shoot dry weight (Appendix Table 3). Untreated stock plants attained significant superiority from the rest of the treatments by exhibiting the

maximum shoot dry weight (16.33g) (Table8). In contrast, the minimum shoot dry weight was obtained from the combination of 0.5ml L^{-1} CCC and 3g L^{-1} Alar (4.67g) which yet was non-significant with 1.5ml L^{-1} CCC X 3 g L^{-1} Alar (5.67g), 1 ml L^{-1} CCC X 2 g L^{-1} Alar (6.0 g) and 1 ml L^{-1} CCC X 3 g L^{-1} Alar (6.33 g). The reduction in shoot dry weight obtained by Cycocel and Alar agreed with the results obtained on *Verbena rigida* by Alar and Cycocel combined application (Andersen and Davis, 1989a), *Zinnia elegans* with a treatment of Alar (Banko and Stefani, 1988), and *Chrysanthemum morifolium* by Cycocel (Poole and Ying, 1965). The observed variation in dry weight can be associated to less biomass accumulation in the plant tissue. This can be attributed to the reduction in average leaf area because of increasing concentration of Cycocel and Alar. Plants with higher leaf area are expected to have more vigorous growth since they can absorb more sunlight which can promote the process of photosynthesis than those having less leaf area (Akram and Soltani, 2007). Hence, with lower Average leaf area the plants are expected to intercept less solar energy which leads to limited or reduced production of carbohydrate. After all the plants will manage less biomass accumulations which will favor reduction in shoot dry weight.

Table 8. Shoot dry weight affected by different concentration of Alar and Cycocel

		Alar concentration				
		0	1	2	3	Mean
Cycocel Conc.	0	16.33^{a}	7.67^{cde}	8^{cd}	6.67^{cdef}	9.67
	0.5	10.67^{b}	7.67^{cde}	7^{cdef}	4.67^{g}	7.50
	1	10.33^{b}	7.67^{cde}	8^{cd}	6.33^{defg}	8.08
	1.5	8.33^{c}	8^{cd}	6^{efg}	5.67^{fg}	7.00
Mean		11.42	7.75	7.25	5.84	8.06
P-Value		**<0.0001**	**LSD(0.05)**	**0.193**	**CV(5%)**	**14.43**

Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

3.1.8. Root dry weight

The effect of the interaction among the different concentrations of Cycocel and Alar on root dry weight was found to be significant (P<.0001) (Appendix table 3). The maximum root dry weight (3.27g) was obtained from the non-treated stock plants. On the other hand, the minimum value was observed from combined application of 1.5ml L^{-1} CCC and 2 g L^{-1} Alar (0.96 g) which however was not significantly different from combined treatments 1.5ml L^{-1} CCC X 3g L^{-1} Alar (1.02g), and 0.5ml L^{-1} CCC X 3g L^{-1} Alar (1.02g)(Table 9). The reduction of root dry weight due to the different combination levels of Cycocel and Alar has already been noted in genus *Salvia greggi* and *Salvia leucantha* (Latimer *et al*., 1999) and *Dombeya burgessiae* (Laubscher *et al.,* 2010). The reduction in dry weight with increasing levels of Cycocel and Alar can be related to the limited growth of root system and also with limited production of carbohydrate because of reduced leaf area with increasing level of the treatments.

Table 9. Root dry weight affected by different concentration of Alar and Cycocel

RDW		Alar concentration				
		0	1	2	3	Mean
Cycocel Conc.	0	3.27^{a}	2.32^{b}	1.86^{cd}	2.03^{c}	2.37
	0.5	1.83^{cde}	1.49^{fgh}	1.31^{h}	1.02^{i}	1.41
	1	1.84^{cd}	1.66^{def}	1.62^{efg}	1.39^{gh}	1.63
	1.5	1.83^{cde}	1.7^{def}	0.96^{i}	1.02^{i}	1.38
Mean		2.19	1.79	1.44	1.37	1.70
P-Value		**<0.0001**	**LSD(0.05)**	**0.23**	**CV(5%)**	**8.11**

Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

3.2. Effect of Cycocel and Alar on Cutting quality of Stock Plants

3.2.1. Internode length

There was a highly significant (P<0.01) effect among different concentrations of Alar and Cycocel on internodes length of stock plants but their interaction effect was non-significant (Appendix Table 1). The longest internode length (3.26cm) was recorded from non-treated stock plants (Appendix Table 2). On the other hand, the shortest internode length (1.29cm) was observed from the combined application of 0.5 ml L^{-1} CCC and 3 g^{-1} L^{-1} Alar. Increasing beyond 2 g L^{-1} of alar chemical did not show significant increase internode length. Application of 1 and 2 g L^{-1} significantly reduced the internodes length by 33% and 42%, respectively as compared to the control. Furthermore, an increase in alar level decreased the mean length of stem internodes of the treated stock plants. But with an increase of Cycocel level reduced mean internodes length up to certain 0.5 ml L^{-1} concentration with without statistical differences between those applied with Cycocel.

The findings of this study was in line with the effect already seen in *Verbena hybrida* 'Obsession Lilac' (Blanchard *et al.*, 2008) from combination of Cycocel and Alar, *Zinnia elegans (*Barbosa *et al.,* 2005) from individual application of Alar and Cycocel where decline in internode length was observed. The reduction of internode length suggests that the activity of subapical meristematic area in the stem, which is responsible for internode elongation, is influenced. Internode elongation is based on two cellular processes: cell division (based on cell number) and cell expansion or elongation which are mainly driven by gibberellins. Gibberellins are strongly influenced by growth retardants (Rademacher, 2000; Puglisi, 2002). Since Cycocel and Alar are antagonistic to gibberellins (GAs), the result obtained may also be attributed to the reduced level of gibbrerelins. Erwin and Warner (2003), Blanchard *et al.* (2008), and Carvalho (2008) also forwarded similar explanations for the occurrence of reduced internode length. To better understand the elongation process, cell number and cell length were recorded in fully developed internodes of genus *Lilium* and *Campanula* grown under different concentrations of plant growth retardants by Carvalho *et al.* (2008). The study demonstrated that plants with higher concentrations had reduced stem elongation due to decreased cellular elongation as a result of both smaller cell length and cell width. On the other hand, Grossman (1990) was able to demonstrate the number of mitotic figures on stems of *chrysanthemum* that, after treatment with growth retardants, the cell division activity in the subapical meristems was diminished which can support the reduction of internode length is due to cell division.

Table 10. Main Effect of Alar and Cycocel concentration on internode length

Treatments	**Internode length (cm)**
Alar (gm)	
0	2.74[a]
1	1.84[b]
2	1.59[c]
3	1.44[c]
P-Value	**<0.0009**
Cycocel(ml)	
0	2.18[a]
0.5	1.79[b]
1	1.83[b]
1.5	1.81[b]
Mean	1.91
LSD(0.05)	0.19
P-Value	**<0.0001**
CV (%)	**11.65**

Note:-Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

3.2.2. Stem diameter

A highly significant (P<0.01) differences were observed among the different concentrations of Cycocel treatments in relation to stem diameter. Regarding Alar, significant variation (P<0.05) was among the different concentrations. In contrast, the interaction effect between Cycocel and Alar was not statistically significant (P<0.05) in respect of stem diameter (Appendix Table 1). The result in Table 11 indicated that stem diameter was directly proportional to the concentration of both Cycocel and Alar. With higher concentrations,

higher stem diameter was obtained. Among concentrations of Cycocel, application of 1.5 ml L^{-1} produced significantly the maximum stem diameter (6.67 mm). Stock plants with no application of Cycocel (0 ml L^{-1}), on the other hand, resulted in significantly lower stem diameter (5.5 mm) followed by application of 0.5 ml L^{-1} (5.89 mm). In case of Alar, application of 3 g L^{-1} gave significantly higher stem diameter (6.42 mm) nevertheless it was not significantly different from application of 2 g L^{-1}(6.26mm). Significantly the least stem diameter (5.68 mm) was observed from non-treated stock plants (0 g L^{-1}).

An increase in stem diameter due to the influence of Alar and Cycocel agreed with the results obtained by Barras-Ali *et al.* (2007) in chrysanthemum using Alar. The result achieved may be due to the facts that as plants have limited vertical growth they tend to store more food or carbohydrate in their stem, because they use less energy for upward growth. Since the different concentrations of Cycocel and Alar had brought reduced stem length, the plants have resulted in higher stem diameter. Barras-Ali *et al.* (2007) justified that increase in stem diameter might be due to transverse cell expansion and division in the sub apical tissues which deviates from the custom orientation of plants cells during cell expansion.

Table 11. Main Effect of Alar and Cycocel concentration on stem diameter.

Treatments	**Stem diameter(mm)**
Alar (gm)	
0	5.68[a]
1	5.97[b]
2	6.28[c]
3	6.42[c]
P-Value	**<0.0001**
Cycocel(ml)	
0	5.50[d]
0.5	5.89[c]
1	6.28[b]
1.5	6.67[a]
Mean	6.09
LSD(0.05)	0.20
P-Value	**<0.0001**
CV (%)	**3.86**

Note:- Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

3.2.3 Average leaf area

A highly significant (P<0.01) differences were observed among the different concentrations of Cycocel and Alar treatments in relation to average leaf area. In contrast, the interaction effect between Cycocel and Alar was not statistically significant (P<0.05) in respect average leaf area (Appendix Table 1). The result on Table 12 confirmed average leaf area was indirectly proportional to concentrations of Alar. There was a decline in leaf area as the concentration of Alar increased from 0 g L^{-1} (28.24 cm^2) to 3 g L^{-1} (20.42 cm^2). However 1 g L^{-1} (23.31 cm^2) and 2 g L^{-1} (22.88 cm^2) were not significantly different from each other. Likewise, a decline in leaf area was noticed as the concentration of Cycocel increased from 0 ml L^{-1} (25.24 cm^2) to 1.5 ml L^{-1} (22.96 cm^2). However 0.5 ml L^{-1} (23.14 cm^2), 1ml L^{-1} (23.5cm^2) and 1.5 ml L^{-1} (22.96 cm^2) were not significantly different from each other. A similar result was reported by Gibson and Whipker (2004) from application of Cycocel on *Fuchsia* x *hybrid, Pelargonium* x *hortorum,* and *Lantana hybrid* as Barras-Ali *et al.* (2008) did on *Chrysanthemum morifolium* from application of Alar. In contrary, Amarender and Veena (2007) observed gradual increase in leaf area after application of Alar and Cycocel. The result obtained from this investigation may probably be attributed to the inhibiting effect of Cycocel and Alar on gibberellins biosynthesis. In line with this context, Grossman (1990) and White (2003) pointed out the role of gibberellins in regulating longitudinal shoot and leaf growth. Leaf area is a determinant factor in radiation interception, photosynthesis, biomass accumulation, transpiration and energy transfer by crop canopies. Therefore, leaf area is measured in many different studies and its accurate measurement is necessary for understanding crop responses to experimental treatments (Akram, and Soltani, 2007).

Table 12. Main Effect of Alar and Cycocel concentration on average leaf area

Treatments	Average Leaf Area(cm^2)
Alar (gm)	
0	28.24[a]
1	23.31[b]
2	22.88[b]
3	20.42[c]
LSD(0.01)	1.40
P-Value	**<0.0001**
Cycocel(ml)	
0	25.24[a]
0.5	23.14[b]
1	23.50[b]
1.5	22.96[b]
Mean	23.71
LSD(0.05)	1.40
P-Value	**<0.0116**
CV (%)	**6.90**

Note:- Means within a column followed by the same letter(s) are not significantly different according to Least Significance Difference (LSD, 0.05).

4. CONCLUSION AND RECOMMENDATION

Cognizant with the findings of the study, Alar and Cycocel influence the growth of Poinsettia (*Euphorbia pulcherrima*) stock plants and cutting yield without causing a significant reduction on subsequent rooting performance of cuttings. Based on this aspect application of 2 g^{-1}L Alar and 1.5 ml^{-1}L Cycocel, which demonstrated positive influence on cutting production, can be recommended for use by commercial growers. Moreover, the combined application of Alar and Cycocel which showed a potential influence should be comprehensively studied to come up with a pertinent recommendation by including other production factors like frequency and type of application of retardants, rooting media influences, and economic factors.

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