BIBLIOGRAPHY

BETWAG, ANA FEB B. APRIL 2009. Rooting and Yield Response of Cabbage (*Brassica oleracea* var. *capitata* L.) Slips to ANAA Concentrations. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The rooting portion of the study was conducted at the Seed Technology Greenhouse, Vegetable Crops Division, Benguet State University, La Trinidad, Benguet while the yield performance was conducted at Abiang, Atok, Benguet from October to December 2008 to evaluate the effects of different ANAA concentrations on the rooting of cabbage slips, establish the best concentration for the vegetative propagation of cabbage slip cuttings, and assess the yield performance of the transplanted rooted cabbage slips.

Results revealed that the longest and higher number of roots measured and counted were significantly higher in cabbage slips cuttings treated with 750 ppm ANAA compared to the untreated control and those treated with lower concentrations; but were comparable to those treated with 1000 ppm. ANAA at 1000 ppm was comparable to 500 ppm in terms of root length but significantly longer than the untreated control and 250 ppm. On the other hand, 1000 ppm treated slip cuttings also produced more roots than the untreated control but comparable to those treated with 250 and 500 ppm.

Slip cuttings treated with ANAA at 750 ppm had significantly wider heads against the other concentrations but no significant differences were noted in terms of polar circumference and percentage field survival.

There were no significant differences on the average head weight among the various concentrations of ANAA evaluated but slips treated with 750 ppm had significantly higher marketable and computed marketable yields compared to the rest of concentrations used. All the heads harvested were marketable.

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SUMMARY, CONCLUSION AND RECOMMENDATION

INTRODUCTION

Cabbage is a cool season crop grown in the moderately cool highland of Benguet and Mt. Province and other highland areas in the country. Today, it still remains one of the leading vegetable crops of the world. Nutritionally, cabbage slip is a good source of vitamins A, C and calcium.

Cabbage slip is one of the most widely known and used herbs in modern cooking. Though it has a potential in the market, the problem of low productivity arises. Thus, the supply of this highly flavored tender annual herb is limited.

Very few people know how to grow cabbage slip. However, up to the present, no studies have been conducted to evaluate its rapid multiplication using auxin enhance of rooting of cabbage slips.

Mostly, cabbage plant are grown from seeds as an annual, though almost all types can be propagated from cuttings. Depending on the plant, cuttings can be taken from stems, leaves, and roots. The cuttings can be rooted in a number of different media, in a commercial rooting medium, in water, in an artificial mix, or in potting mix.

The use of stem cuttings in propagation is advantageous. It is an easy way to duplicate the attractive features of the original plants, since the new plant will be genetically identical to the original. Plants propagated by stem cuttings exhibit rapid vegetative growth and marketable leaf cuttings are harvested earlier than those from seeds. Through knowledge and proper implementation of appropriate technology lead to the success in the production of this valuable crop. Through this, farmers will benefit because earlier return of investments will be attained.

The rooting portion of the study was conducted at the Seed Technology Greenhouse, Vegetable Crops Division, Benguet State University, La Trinidad, Benguet while the yield performance was conducted at Abiang, Atok, Benguet from October to December 2008 to evaluate the effects of different ANAA concentrations on the rooting of cabbage slips, establish the best concentration for the vegetative propagation of cabbage slip cuttings, and assess the yield performance of the transplanted rooted cabbage slips.

REVIEW OF LITERATURE

Cuttings as Propagating Materials

Janick (1972) defined cutting as any detached vegetative plant part that can be expected to regenerate the missing part to form a complete plant.

According to Hartman and Kester (1975), softwood cuttings generally root easier and quicker than hardwood and semi-hardwood cuttings because they readily responded to treatments with root promoting substances. Furthermore, they stated that softwood cutting are made from stems of herbaceous plants which may be started in the greenhouse with specific requirements of moisture and temperature. Cuttings are usually made just below the nodes and inserted in the medium to a depth of about 2.54 cm, rooting occurs in 30 days depending upon the time of the year, the age of the wood used and the type of plant.

Edmunt *et al*. (1978) said that plants propagated by cuttings and other vegetative means are more economical than by seeds. Many seeds germinate with difficulty and the resulting plants do not often resemble their parents. In fact, valuable varieties that are perpetuated by vegetative production makes possible that production of high quality products. Furthermore, Smith (1982) mentioned that most in commercial establishments, growing plants aim to produce a crop that meets the quality standards of the market at the shortest possible time is possible through this method of propagation.

Apnoyan (1981) stated that propagation by cuttings has the advantage of making it possible to produce genetically identical rootstock of trees in contrast to the wide genetic variation found in seedlings. Thus, the cutting method would provide a means of multiplying superior rootstocks, if such rootstocks are developed.

Hartman and Kester (1975) pointed out that the advantage of using cuttings as a means of propagation are as follows: (a) many new plants can be started in a limited space from a few stock plants; (b) it is inexpensive, rapid, simple and does not require the spacial technique necessary in grafting and budding; (c) no problem if compatibility with rootstock or of poor graft union; (d) greater uniformity is obtained by the absence of the variation which sometimes appear due to the variable seedling rootstocks of grafted plants; and (e) the parent plant is usually reproduced exactly with no genetic change.

Rooting Hormones

The use of auxin to stimulate rooting in cuttings was the first practical application of hormones in horticulture (Salisbury and Ross, 1969). Synthetic hormones are largely used in stem cutting propagation. Primarily, the hormonal substance gibberellin is used as auxin. Their principal effect is to hasten the production of roots. In comparison, cuttings treated with an auxin will usually yield better than the untreated ones.

An exogenous source of auxin was nearly always essential on cuttings of hard to root species or cultivars. This could be because auxin act as rooting compounds which promote callus and root formation and improve establishments from cuttings (Weaver, 1972).

In 1982, Fletcher and Kirkwood stated that plant growth regulators have found a wide application in horticulture, particularly for the stimulation of rooting, fruit set and fruit thinning. Furthermore, Weaver (1972) and Hartman and Kester (1975) mentioned that the application of growth regulators to cuttings is important for the acceleration of rooting of cuttings. Example of these plant growth regulators that promote cell elongation and enlargement are gibberellic acid (GA_3) and auxin in the form of indolebutyric acid (IBA), indoleacetic acid (IAA) and μ-naphthaleneacetic acid (μ-NAA). Auxin generally promote rooting while GA_3 and cytokinins inhibit it.

Hartmann and Kester (1975) recommends the use of μ-NAA and IBA for general use in rooting stem cuttings of most plant species. They added that IBA was already tested for its activity in promoting roots in stem segments. It is now well accepted and has been often confirmed than an auxin naturally or exogenously, is a requirement for the initiation of adventitious roots in stem cutting.

Wright (1973) mentioned that the duration of planting will be hastened and growth will be faster in hormone-treated cuttings against those untreated. In fact, Bautista *et al*. (1983) stated that dipping the basal portion of the cutting in root promoting substances can hasten the rooting processes. They added that the effectiveness of stem cutting as a planting material is primarily related to factors such as root regeneration in line with the type of particular synthetic root regulators such as IBA and μ-NAA under aseptic conditions. In morphogenesis, the appropriate rates of an auxin and a cytokinin added to the culture media is essential, although the ratio of hormones required for root and shoot induction is not universally the same.

Janick (1972) mentioned that the rooting of cuttings is positively influenced by auxin. In cuttings, the natural auxin produced in the young leaves and buds naturally move down the plant and accumulate at the base along with sugars and other food materials. Also, the auxin level is closely related with adventitious rooting of stem cuttings. It was also noted that in a variety of such compounds, the greatest degree of success has been achieved with IBA.

Hormone Concentration

Bleasdale (1973) stated that hormones maybe used to overcome the inherent difficulties encountered in rooting cuttings but can also inhibit the growth of the cuttings if applied in inaccurate concentration. Although hormones are known to promote rooting in various kinds of cuttings, it is also necessary that these all applied at specific concentration ranges for each individual species and cultivars of plants.

In 1960, Butcher and Sreet worked on excised tomato roots and discovered that low concentrations of GA_3 and μ-NAA enhance the growth of main axis both by increasing the number and length of lateral roots. However, higher concentration of GA_3 enhanced the loss of meristematic activity and inhibited growth. In additio, Regina (1968) reported that 500 ppm of μ-NAA with 24 hours soaking produced the longest and greater number of roots in 'Doña Aurora' stem cuttings.

Furthermore, Anderson and Ellison (1969) mentioned that stem cutting from asparagus cultured aseptically initiated roots over a range of μ-Naa and IBA and that the optimum amount of μ-Naa was 5mg/L and 10mg/L of IBA.

Gonzales (1980) recommended 1000 ppm μ-NAA for hastening root inhibition of rose cv. Queen Elizabeth. It was further observed that cutting treated with 1000 ppm μ-NAA produced the highest number of roots, had rapid root elongation and earliest root formation.

Rooting in Relation to Plant Age

Ali and Fletcher (1979) stated that the effectiveness of any of the growth regulators applied in inhibiting or promoting growth is dependent on the age of plants. Likewise, Leopold and Kriedenmann (1975) claimed that with increasing root growth rate. Very young Lene culinari roots give small pocitive growth response while older roots are not stimulated to added auxins.

Hartmann and Kester (1975) emphasized that the root initials, which develop root primordial that later develop into an adventitious roots, in younger plants, originate near the outer side of the vascular system, but in older stems, they originated deeper often near the vascular cambium. They also added that naturally occurring auxin as a controlling factor for rooting is synthesized in apical buds and young leaves. Furthermore, they stated that cuttings from young seedling plants root much more readily than these taken from old mature plants. This was confirmed by Ingles (1994), and called this as the "juvenility factor."

Adriance and Brison (1955) mentioned that root formation in cuttings is not only affected by hormones alone but also by other factors like environment, rooting medium, chemical treatments, mechanical treatments and the plant itself as a factor. For instance, cuttings taken from younger cuttings is usually more active in the synthesis of food and cell development.

MATERIALS AND METHODS

Materials

The materials to be used in the study are cabbage slip cuttings (‘Lucky Ball’), tap water, ANAA, measuring and labeling materials, pruning shear, sandy loam soil, and seedling plugs.

Methods

Experimental design and treatments. The experiment was laid out in a randomized complete block design (RCBD) with four replications. There were sample 10 slips per treatment. The treatments were as follows:

Code	ANAA Concentration (ppm)
T_1	0 (control)
T_2	250
T_3	500
T_4	750
T_5	1000

Preparation of slip cuttings and planting The slips were carefully removed from the mother plants seven weeks after harvesting the heads, each having a length of 10 cm. They were cleaned and only the leaves from the base were removed. All the stem ends of sample slips were dipped for 30 minutes in the different ANAA concentrations. After the specified time, the cuttings were planted in seedling plugs previously filled with sandy loam soil.

Land preparation and transplanting. An area of 30 m^2 was thoroughly prepared and divided into four blocks. Each block was further subdivided into five plots having a dimension of 0.5 m x 3 m. Two week-old rooted slips were transplanted at a distance of 30 cm between hills in single row per plot.

Other cultural management practices. Except for the imposition of the various treatments, all the cultural management practices such as insect pests and diseases control, and irrigation, hilling up and were strictly followed.

Data gathering. The data gathered and subjected for variance analysis and mean separation test by Duncan's multiple range test (DMRT) were the following:

1. Average root length (cm). The length of roots in every cuttings were measured two weeks after visible root formation and the average was computed as follows:

$$\text{Average (cm)} = \frac{\text{Total root length}}{\text{Total root number}}$$

2. Average number of roots per cutting. All formed roots of every cuttings were counted and the average was computed as follows:

$$\text{Average} = \frac{\text{Total number of roots}}{\text{Total number of rooted cuttings}}$$

3. Field survival (%). This was obtained using the formula:

$$\text{Suvival (\%)} = \frac{\text{Number of dead cuttings}}{\text{Total number of cuttings}} \times 100$$

4. Yields. This wasassess by the following:

a. Equatorial polar head circumference (cm). This was taken using a tape measure.

b. Average marketable weight (kg). This was computed using the formula:

$$\text{Average (kg)} = \frac{\text{Total marketable plant weight}}{\text{Number of marketable plants}}$$

c. Marketable yield (kg/plot). All marketable plants without defect were weighed at harvest.

d. Computed yield (t/ha). The marketable yield per plot was converted to tons/hectare using the formula:

$$\text{Yield (t/ha)} = \text{Yield (kg/1.5m}^2\text{) x 6667 plots/ha}$$

5. Documentation through pictures.

Cabbage slips before treatment

Cabbage slips dipped in ANAA solutions

Plate 1. Overview of the experiment

Plate 2. Overview of the harvested heads from the various ANAA concentrations

RESULTS AND DISCUSSION

Average Root Length and Number

The average root length and number two weeks after treatment and sticking the slips in rooting media are presented in Table 1. The longest and higher number of roots measured and counted were significantly higher in slip cuttings treated with 750 ppm ANAA compared to untreated control and lower concentrations but comparable to 1000 ppm. ANAA at 1000 ppm was comparable to 500 ppm in terms of root length but significantly longer than the untreated control and 250 ppm. On the other hand, 1000 ppm treated slip cuttings also produced more roots than the untreated control but comparable to those treated with 250 and 500 ppm. This indicates that as the concentration increases, there is a corresponding increased in length and number up to 750 ppm but higher than this concentration, these parameters tend to decrease.

Table 1. Average root length and number

CONCENTRATION (ppm)	AVERAGE ROOT	
	Length (cm)	Number
0 (control)		2.25c 6.25c
250		

2.75c
8.00bc

500

3.38bc
7.38bc

750

6.38a
16.50a

1000

4.75ab
13.25ab

In a column, means with a common letter are not significantly different at 5% level by DMRT

Equatorial and Polar Head Circumferences

The equatorial and polar head circumferences are shown in Table 2. ANAA at 750 ppm significantly increase equatorial circumference against the other concentrations but no significant differences were noted in terms of polar circumference. Nonetheless, 750 ppm tends to increase polar circumference.

Field Survival

There were no significant differences noted among the various ANAA concentrations on the percentage of field survival (Table 3). Nevertheless, slips treated with 750 ppm tend to have the highest survival percentage.

<u>Average Head Weight, Marketable
and Computed Marketable Yield</u>

There were no significant differences on the average head weight among the various concentrations of ANAA evaluated but slips treated with 750 ppm had significantly higher

Table 2. Average equatorial and polar head circumferences

CONCENTRATION (ppm)	HEAD CIRCUMFERENCES (cm)	
	Equatorial	Polar
0 (control)	41.33b	39.65a
250	41.63b	40.13a
500	43.38b	42.20a
750	47.05a	44.23a
1000		

	42.48b
	41.03a

In a column, means with a common letter are not significantly different at 5% level by DMRT

marketable and computed marketable yields compared to the rest of concentrations used as presented in Table 4. The other concentrations were comparable with each other on the marketable and computed marketable yields. All the heads harvested were marketable.

Table 3. Percentage field survival

CONCENTRATION (ppm)	MEAN
0 (control)	99.00a
250	98.00a
500	97.25a
750	100.00a
1000	99.25a

Means with a common letter are not significantly different at 5% level by DMRT

Table 4. Average head weight, marketable and computed marketable yields

CONCENTRATION (ppm)	AVERAGE (kg/head)	MARKETABLE YIELD (kg/plot)	COMPUTED MARKETABLE YIELD (t/ha)
0 (control)	0.37a	3.25b	21.67b
250	0.38a	2.88b	18.78b
500	0.43a	3.50b	20.84b
750	0.51a	5.13a	34.17a
1000	0.38a	3.50b	23.33b

In a column, means with a common letter are not significantly different at 5% level by DMRT

SUMMARY, CONCLUSION AND DISCUSSION

Summary

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There were no significant differences on the average head weight among the various concentrations of ANAA evaluated but slips treated with 750 ppm had significantly higher marketable and computed marketable yields compared to the rest of

concentrations used. All the heads harvested were marketable.

Conclusion

Cabbage slip cuttings can be used as planting materials when treated with 750 ppm ANAA producing longer and more roots, wider heads and higher marketable and computed marketable yields.

Recommendation

Based from the preceeding results and discussion, 750 ppm ANAA is recommended as a treatment solution for rooting of cabbage slip cuttings.

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APPENDICES

Appendix Table 1. Root length (cm)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	1.50	3.00	2.50	2.00	9.00	2.25
T_2	1.50	3.00	3.50	3.00	11.00	2.75
T_3	1.50	6.00	2.00	4.00	13.50	3.38

T_4	4.00	7.50	9.00	5.00	25.50	6.38
T_5	2.00	6.00	6.00	5.00	19.00	4.75

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	3	25.900	8.633			
Treatment	4	44.675	11.169	8.01**	3.26	5.41
Error	12	16.725	1.394			
Total	19	87.300				

** = Highly significant Coefficient of variation = 30.27%

Appendix Table 2. Root number

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	4.00	10.00	5.00	6.00	25.00	6.25
T_2	8.00	10.00	6.00	8.00	32.00	8.00
T_3	1.50	10.00	9.00	9.00	29.50	7.38
T_4	11.00	14.00	22.00	19.00	66.00	

16.50

T_5

20.00 9.00
13.00 11.00
53.00

13.25

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	3	13.138	4.379			
Treatment	4	309.550	77.388	4.55*	3.26	5.41
Error	12	204.050	17.004			
Total	19	526.738				

** = Significant

Coefficient of variation = 40.13%

Appendix Table 3. Field survival (%)

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	97.0	100.0	100.0	99.0	396.0	98.00
T_2	100.0	99.0	97.0	96.0	392.0	98.00
T_3	98.0	100.0	98.0	93.0	389.0	97.25
T_4	100.0	100.0	100.0	100.0	400.0	

100.00

T_5	98.0	100.0	100.0	99.0	397.0	99.25

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	3	15.000	5.000			
Treatment	4	18.700	4.675	1.84ns	3.26	5.41
Error	12	30.500	2.542			
Total	19	64.200				

ns = Not significant

Coefficient of variation = 1.62%

Appendix Table 4. Equatorial circumference (cm)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	41.00	40.00	40.00	44.30	165.30	41.33
T_2	38.60	40.30	44.30	43.30	166.50	41.63
T_3	43.30	43.30	43.30	43.60	173.50	43.38
T_4	48.00	49.30	45.30	45.60	188.20	

47.05

T_5

43.30

44.30
41.30
41.00
169.90

42.48

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	3	2.214	0.738			
Treatment	4	85.482	21.370	5.14*	3.26	5.41
Error	12	49.586	4.157			
Total	19	137.582				

** = Significant

Coefficient of variation = 4.72%

Appendix Table 5. Polar circumference (cm)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	40.00	39.00	37.60	42.00	158.60	39.65
T_2	36.60	38.60	43.00	42.30	160.50	40.13
T_3	41.60	42.60	42.30	42.30	168.80	42.20
T_4	43.00	47.60	43.00	43.30	176.90	

44.23

T_5 42.60 43.60 39.30 38.60 164.10 41.03

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	3	6.977	2.326			
Treatment	4	53.757	13.439	2.49ns	3.26	5.41
Error	12	64.795	5.400			
Total	19	125.530				

ns = Not significant

Coefficient of variation = 5.61%

Appendix Table 6. Average head weight (kg)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	0.393	0.375	0.275	0.417	1.460	0.365
T_2	0.275	0.306	0.424	0.500	1.505	0.376
T_3	0.500	0.375	0.469	0.357	1.701	0.425
T_4	0.500	0.775				

0.475
0.300
2.050

0.512

T_5

0.438

0.375
0.375
0.333
1.521

0.380

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	3	0.010	0.003			
Treatment	4	0.059	0.015	1.04ns	3.26	5.41
Error	12	0.171	0.014			
Total	19	0.239				

ns = Not significant

Coefficient of variation = 28.96%

Appendix Table 7. Marketable yield (kg/plot)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
T_1	2.75	3.75	2.75	3.75	13.00	3.25
T_2	2.75	2.75	3.00	3.00	11.50	2.88
T_3	4.00	3.75	3.75	2.50	14.00	3.50
T_4	5.00	7.75				

	4.75
	3.00
	20.50
	5.13
T_5	3.50
	3.75
	3.75
	3.00
	14.00
	3.50

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	3	4.275	1.425			
Treatment	4	11.925	2.981	3.54*	3.26	5.41
Error	12	10.100	0.842			
Total	19	26.300				

** = Significant

Coefficient of variation = 25.13%

Appendix Table 8. Computed marketable yield (t/ha)

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	18.33	25.00	18.33	25.00	86.66	21.67
T_2	18.33	18.33	20.00	13.33	74.99	18.75
T_3	16.67	25.00	25.00	16.67	83.34	20.84
T_4	33.34	51.67	31.67	20.00	136.38	

						34.17
T$_5$	23.33	25.00	25.00	20.00	93.33	23.33

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	3	223.750	74.583			
Treatment	4	586.481	146.620	4.16*	3.26	5.41
Error	12	422.864	35.239			
Total	19	1233.095				

** = Significant

Coefficient of variation = 24.99%