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Effect of organic fertilizer and cutting height on growth, shoot yield and nutrient uptake of amaranth (*Amarantus Cruentus*)

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ABSTRACT

The productivity of amaranthus (Amarantus cruentus) can be increased by using organic fertilizer in combination with good agronomic practices. The significance of this *strategy was tested in pot and field at Ladoke Akintola University of Technology, Ogbomoso, Nigeria in 2003. Three cutting heights (10, 15 and 20 cm); three rates (2, 4 and 6 t / ha) of crop residue compost and non -fertilized plants and those that were not cut constituted the treatments. The treatments were replicated thrice and laid out in a randomized complete block design. Growth parameters such as plant height, girth, number of leaf /plant and leaf area were assessed at first cutting (four weeks after sowing) while dry matter, shoot yield and shoot N, P and K uptake were determined at each cutting interval. The cumulative dry matter yield, shoot yield and N, P and K uptakes respectively were obtained by adding their values obtained at different harvest time.*

Plant grown with 4 t ha $^{-1}$compost had significantly taller plants, stem girth, leaf area, leaf number per plant as well as higher dry matter shoot yield and tissue, P and K concentration. Generally, the results of the pot and field trials were similar, however field grown plants performed better than pot grown ones. Cutting height significantly influenced the dry matter, shoot yield and shoot N, P and K uptake. Cutting of plants at 20 cm above soil level led to a higher accumulation of dry mater. The highest reduction in shoot yield and NPK uptake came from the 10 cm cutting height and this became more marked at low compost rates. In the pot trial the shoot yield of 10, 15 and 20 cm cutting heights were 7. 3, 7. 4 and 8. 2 t ha $^{-1}$ respectively. The shoot yield of non – cut plants (17.3 t ha^{-1}) was similar to that got from plants cut at 20 cm. Results revealed that repeated cutting of amaranthus re – growth improved its productivity and that the higher the amount of nutrients in the soil for plant uptake the greater the advantage. It is apparent that, cutting amaranthus at 20 cm above soil surface in combination with 4 t compost ha $^{-1}$ could be good agronomic practices for optimum performance of the crop.

Key Words: *Cutting height, compost, Amaranthus, Dry matter shoot yield, Nutrient uptake.*

INTROUDCTION

Amaranthus (*Amaranthus cruentus*) is a vegetable of high dietary value produced and consumed in most parts of Nigeria. Nutritionally, the leaves are rich in vitamin A and potassium (Tindal, 1986, Akanbi and Togun, 2002). The leaves can also be processed into many food items, supplements and additives (NIHORT, 1986; Ojo and Olufolaji, 1987). Amaranth grains has also been reported to contain high lysine (6.2% the total protein) and methione (2.3 %) (Olufolaji, 1989). Denton (1992) reported that amaranthus is extensively cultivated in Nigeria and can survive in mixture with other crops. Despite the popularity of this vegetable in traditional cropping system its yield per unit area is still very low. For instance an average yield of 8 t./ha was reported by Denton ((1992)) in the survey of farmers' cropping system conducted in South Western Nigeria as against between 24 – 30 t /ha shoot yield realizable under research conditions. Some of the reasons for this poor output are inadequate application of fertilizer in combination with poor agronomic practices.

It is now clear that the prospect of obtaining enough chemical fertilizers to meet the requirement of the teeming farming population in the tropics is remote (Ojo and Olufolaji, 1987)). This is due to the inadequate supply, high cost and inadequate knowledge of fertilizer application among the peasant farmers that constitute the bulk of producer. In view of this, efforts to develop and use fertilizer that will boost agricultural production and at the same time be friendly to the environment need be encouraged. The beneficial effects of using organic fertilizer (compost) have being reported by many researchers. Akanbi *et al (2002)* reported an increase in yield of amaranth when fertilized with maize stover compost. In another studies Togun and Akanbi (2003) reported over 200% increase in fruit yield of tomato when treated with organic fertilizer. In most of these reports, application of organic fertilizer is found to produce better results over the use of mineral fertilizer and this becomes more pronounced when considering the effect of the practice on post cropping soil physical, chemical and biological properties.

Amaranth, like other leaf vegetables can be harvested either by uprooting (NIHORT, 1986) or repeated cutting back of the shoots until when inflorescences appears on the main trunks. Repeated cutting when done at adequate height and interval was observed to produce higher shoot yield of *Corchorus* sp. per unit of land (NIHORT, 1986). This is more economical and produces higher returns when compared with the situation in which the plants were uprooted once. Spreading of harvest over time also stabilizes produce market price and hence higher returns. Under the cutting back method, the cutting height and frequency of cutting affect realizable cumulative shoot yield (NIHORT, 1986; Robert and Andrew, 1989; Togun and Akanbi, 2003). Cutting height determines the number of functional nodes from which shoot re – growth could occur. It also determines the quantity of available nutrients (accumulated and stored) which serve as feeder source to the newly produced re – growth (NIHORT, 1986; FPDD, 1990). The quantity of available nutrients in the plant and their re – growth is also a function of nutrients available in the soil for plant uptake. Where the soil nutrient is low, all other things being equal, the nutritional value of the harvest will be poor. Hence, crucial effort should be given to the height of cut and soil nutrient content when leaf vegetable are to be harvested by cutting.

There is scanty literature on the combine effect of organic fertilizer and cutting height on the productivity of amaranth. Hence, this study was carried out to examine the response of amaranth to organic fertilizer in combination with different cutting heights.

MATERIALS AND METHOD

Pot and field experiments were conducted at the Teaching and Research Farm of Ladoke Akintola University of Technolgy, Ogbomoso, Nigeria. The experimental site has two rain periods with an average annual rainfall of 1104.0 mm collected during the year of the experiment. Pre – cropping soil sample was done and chemical laboratory analysis shows that on the average it has pH, 5.8 (1: 2.5 soil: water), total N, 0.06 g kg^{-1}; available P, 2.6 mg kg^{-1} and 2.3, 0.4, 7.4, and 0.10 mg kg^{-1} for exchangeable Ca, Mg, Na and K, respectively. The chemical analysis of the organic fertilizer used indicated pH 6.4 and 9.6, 2.5, 1.32, 0.50, 1.46 and 0.21 % for organic matter N, P, K, Na, Ca and Mg, respectively. The nitrogen content of the compost and the N recommendation (50 – 75 kg N /ha) for the test crop in South western Nigeria (6) were used to estimate the compost rates used in this study.

The treatments consisted of three cutting heights (10, 15 and 20 cm) in combination with three rates (2, 4 and 6 t /ha) of crop residue compost. The treatments were arranged in Randomized complete block design with three replicates. Plots that received no compost and that were not cut served as control. Prior to planting, the site was ploughed once and harrowed.

Pot experiment

Seeds of amaranth were sown in 240 plastic pots (5 litre capacity having 20 cm rim diameter) each containing 4.0 kg soil obtained from the plot where the field trial was to be carried out. Planting was done on 4th February 2003. Three days before this, compost treatments were applied by thoroughly mixing them with the soil to achieve some homogeneity. The resulting seedlings were thinned to two stands per pot two weeks after sowing. Five pots were used for each of the sixteen treatments combinations and there were three replicates giving a grand total of 240 pots for the study. The pots were arranged in randomized complete block lay- out Water supply and weeding were carried out as required.

Sampling and measurement

Sampling commenced four weeks after sowing and continued at fortnightly there after. At the first sampling time, four plants per treatment were evaluated for plant height, girth, leaf area and nmber of leaves per plant. Harvesting of plants was by cutting the plants were by cutting the plants at 10, 15 and 20cm above soil surface. This was repeated fortnightly until when inflorescence appeared (10 weeks after sowing) on the non- cut plants or on the side shoots of the cut plants. A total of four cuttings were made from 12 tagged plants. The cumulative shoot yield was determined at the end of the last harvest for all the treatment with the exception of the non- cut plant treatment in which shoot harvesting was done once at 10 weeks after sowing and used to estimate its shoot yield .

For dry matter yield and tissue analysis, five out of the tagged plants /plot were uprooted and separated into roots and shoots at each harvesting. For non – cut plants, sampling was done once at 10 weeks after sowing (WAS). The plant samples were bagged in brown envelope and dried in oven at 80^0 C till constant weight. From this, periodic dry matter yield (for the cut plants) and total dry matter yield (for non – cut plants) were obtained. The cumulative dry matter yields and tissue nutrient concentration of the cut plants were obtained by adding together individual value obtained at each harvest. The dried plant samples were ground with a Willy mill to pass through 0.5mm sieve. Total N was determined by the macro kjeldahl procedure as described by 11TA (1982). P concentration was determined by vannado molybdate yellow colorimetric method and K with flame photometer after wet digestion of the samples with mixture of nitro perchloric acid. Plant nutrient uptakes were calculated using the formula:

Nutrient uptake = dry matter x nutrient content of plant (%).

Field experiment

The experiment was carried out at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso. The layout consisted of three blocks each of which contained 16 plots with the dimension 1.2 m x 1m. The blocks were separated by 2 m gaps while the plots were separated by 0.5 m space. Compost treatments were applied uniformly and incorporated into the soil a day before planting.

The seeds were sown on 10th July 2003. The seeds were drilled in rows spaced at 20 cm apart. Thinning was done 10 days after sowing to give 20 cm inter row spacing resulting in a population of approximately 250, 000 plants /ha. The plots were weeded at 2, 5 and 7 weeks after sowing by hand pulling the weeds out of the beds. In order to keep the plants pests and disease free a fungicide Benlate at the rate of 0.4 kg a. i. /ha and an insecticide – karate EC at the rate of 2 mls /liter of water were sprayed on weekly basis starting 2 weeks after sowing till when the plants were four weeks old. Application of the treatment, plant sampling and method of data were as in the pot experiment.

Statistical analysis

The data gathered from the pot and field trials were separately subjected to analysis of variance. Comparison of the various treatments were done using Duncan multiple range test at the 5% level of significance.

RESULTS AND DISCUSSION

Table 1 summarizes the effects of compost rates on plants height, stem girth, number of leaves and leaf area at 4 WAS. It is obvious from the results that field grown plants consistently produced crops with higher number of leaves and leaf area as well as greater heights than pot grown plants. On the average, at 4 WAS; pot grown plants were 33. 6 cm tall compared to the field grown plants which had an

Table 1: Effect of compost rates on the growth attributes of amaranths (4 WAS) in pot and field experiments

Compost rate (t. /ha)	Plant height (cm)		Stem girth (cm)		Number of leaves /plant		Leaf area /plant (cm^2)	
	Pot	Field	Pot	Field	Pot	Field	Pot	Field
0	18. 0b	24.2c	0.9b	0.9b	8.3c	13.2b	48.1c	107.4c
2	29.4ab	40.6bc	1.3a	1.4ab	16.2b	22.1b	221.6b	372.1ab
4	42.0a	68.3a	1.6a	2.1a	26.4a	32.4a	301.1a	502.8a
6	44.8a	69.8a	1.6a	2.4a	26.9a	34.2a	324.7a	491.0a
Mean	**33.6**	**50.7**	**1.4**	**1.7**	**19.5**	**25.5**	**224.1**	**368.3**

Means followed by same alphabet in each column are not significantly different by Duncan Multiple Range Test at 5 % probability level.

average height of 50. 7 cm. Similarly pot grown plants had an average number of leaves and leaf area of 19.5 and 224. 1 cm^2 respectively while those grown on the field had 25.5 and 368.3 cm^2 respectively during the same growth period. It can be said therefore that pot grown plants suffered some growth restrictions which may be due to the limited soil volume available in the pot. Akanbi (2003) reported similar growth restriction in pot grown okra. Soil is the medium for root growth and any physical restriction in the ability of roots to ramify the soil will definitely limit root assess to growth factors. Hence, in this experiment the field grown plants that have larger root –soil volume from where growth factors could be obtained performed better. Amaranths plants performed better with application of compost fertilizer compared to non- fertilized plants, irrespective of whether they are grown in pot or in the field.

The plant height increased from 18.0cm to 44.8 cm in pot experiment when compost rates increased from 0 to 6t ha $^{-1}$. This is not surprising as amaranths plants grown with 4 or 6t/ha compost have more nutrient for uptake, and biosynthesis and accumulation of photosynthates. This invariably led to the production of plants with higher number of leaves and wider leaf area. According to Togun and Akanbi (2003), better plant performances are associated with plants that received adequate amount of fertilizer. This made available adequate amount of nutrients required for plants to successfully complete its vegetative and reproductive phases. This might be the reason for the observed poor performance of plants that were not fertilized and those that received 2 t ha $^{-1}$ compost.

The main and interactive effects of cutting height and compost rates significantly influenced the test crop dry matter and shoot yield ($P \geq 0.05$). Cutting height had significant effect on pot and field grown amaranthus plant (Fig. 1). Cutting plant at 10 cm above soil surface produced the least dry matter of 13.6 and 20.3g /plant respectively, for pot and field experiments. The non – cut plants however gave the highest value. Among the cutting height, 20 cm above soil surface treatment proved to be generally more effective in both pot and field trials than all other cutting heights. This is in line with the submission of NIHORT (9) and Robert and Andrew (1989) that repeated cutting of shoot produced higher cumulative dry matter and shoot yield than harvesting at once by uprooting. This height of cut probably contains higher nutrients reserved which favour re-growth development.

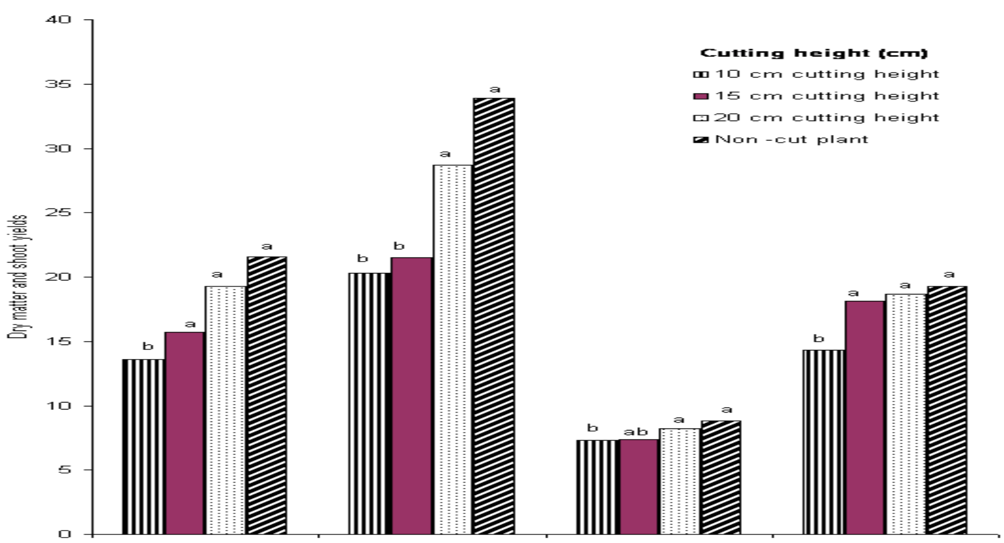

Fig. 1: Effects of cutting height on amaranth dry matter yield (p /plant) and shoot yield (t./ha) in pot and field experiment

* Values for non -cut plants were taken once at 10 w.a.s.
Alphabets on the bars represent Duncan Multiple Ranking at 5% probability level

Dry matter pot = plant shoot dry matter of pot grown plants

Dry matter field = plant shoot dry matter of field grown plants

Application of compost had significant influence on the dry matter production and shoot yield of Amaranths. Generally, in both pot and field experiments these two parameters increased with increase in compost rates from 0 to 4 t. /ha and thereafter declined (Fig. 2). The only exception to this is dry matter production in the pot experiment where the highest compost rate gave the best dry matter yield. Nonetheless, the dry matter yield produced in both pot and field experiments separately by 4 and 6t./ha compost treatments were similar. This observation supported the report of Togun and Akanbi (2003). In their report, linear relationship was observed between compost rate and fruit production of tomato. This was likened to the facts that adequate availability of plant nutrients enhanced greater biomass production and partitioning into the economic yield of plants.

The influence of interaction of cutting heights and compost rates on Amaranths cumulative dry matter and shoot yield are shown in Table 2. In the pot experiment, the highest dry matter yield of 30 - 42g/plant was obtained from non – cut plants fertilized with 6t /ha compost. This compared favourably and not significantly different from 24. 4 g /plant dry matter yield obtained from plant that received 4 t /ha compost and cut at 20 cm above soil surface. Similar trend was observed on the field grown plants. In as much as amaranths cumulative shoot yield in response to cutting height and compost rates is concerned, plants that were cut at 20 cm and fertilized with 4 t /ha^{-1} compost produced the best results in both pot and field experiments. As noted earlier, repeated cutting of shoot produced higher dry matter and shoot yield in leaf vegetables. From this experiment, non – cut plants gave higher dry matter. This is contrary to the earlier report (NIHORT, 1986). Among the cutting height, 20 cm treatment performed best. This might be due to accumulation of higher nutrients and presence of more functional nodes from which side shoot re – growth could occur. Thus, enhanced nutrition and increased number of functional nodes have positive effects on the dry matter production and shoot yield. This supported the report of Robert and Andrew (1989) and Ojo and Olufolaji (1987). Ojo and Olufolaji (1987) opined that where the soil is inherently low in essential nutrients, the uptake and other physiological processes that culminated into biomass production will be affected. This might be the reasons for observed low dry matter and shoot yield production for plants that were not fertilized

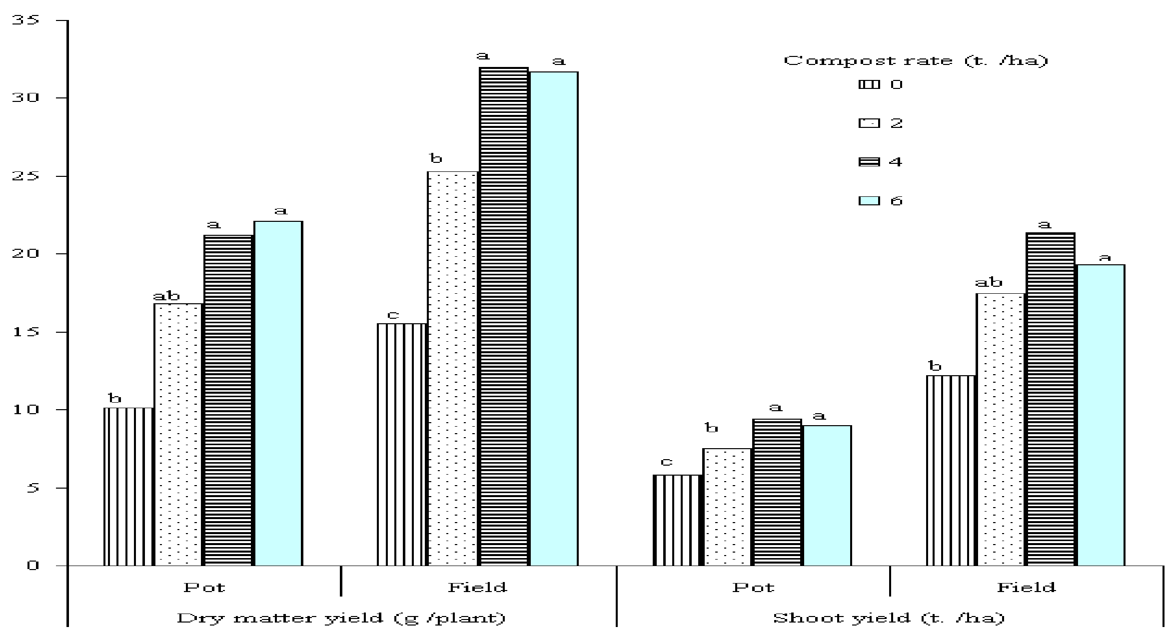

Fig.2: Effects of compost rates on amaranth dry matter yield and cummulative shoot yield in pot and field experiment

* Values for non-cut plants were obtained once at 10 w.a.s.

Alphabets on the bars represent Duncan Multiple Ranking at 5% Probability level

Table 2: Effect of cutting height and compost rate interaction on cumulative dry matter and shoot yield of amaranths in the pot and field experiments

Cutting height (cm)	Compost rate (t. /ha)	Cumulative dry matter yield (g. /plant)		Cumulative shoot yield (t. /ha)	
		Pot	**Field**	**Pot**	**Field**
10	0	8.8 C	14.4 bc	5.9 C	10.4 C
	2	14.7 b	14.6 bc	6.1 C	12.5 b
	4	16.2 ab	23.6 b	8.3 b	12.5 b
	6	14.8 b	28.4 ab	8.8 b	19.4 b
15	0	7.6 d	10.8 c	6.4 d	14.3 d
	2	17.6 ab	24.1 b	8.0 b	19.1 ab
	4	17.2 ab	24.8 b	7.9 b	20.8 a
	6	20.3 a	26.4 ab	7.4 bc	18.2 bc
20	0	15.2 b	21.9 b	4.9 c	11.4 c
	2	14.9 b	24.0 b	7.7 b	17.8 ab
	4	24.4 a	38.6 a	10.8 a	25.2 a
	6	22.7 a	30.2 ab	9.3 b	20 .4 a
Non – cut*	0	9. 10 c	14.7 bc	6.0 c	12.8 b
	2	20.11 a	38.6 a	8.1 b	20.7 a
	4	26.90 a	40.8 a	10. 4 a	24. 6 a
	6	30.42 a	41. 6 a	10.6 a	19.1 ab

Means followed by same alphabet in each column are not significantly different by Duncan's Multiple Range Test at 5 % probability level. * Values for non- cut plants were taken once at 10 w.a.s.

and those that received 2 t ha $^{-1}$ compost. Also the amount of reserved nutrients in the plant stump or root stock influences the potential to produce more off shoot and the subsequent development of the off shoot produced (Robert and Andrwe 1989). In the present study, 20 cm cutting height stored essential nutrients adequate for off -shoot production and development. Hence better dry matter and shoot yield production of this cutting height over other cutting heights.

Results of the effects of the main and various interactions between cutting height and compost rates in amaranths N, P and K uptake are indicated inTables 3 and 4. For both pot and field experiments, nutrients uptake increased with increase in height of cutting reaching maximum at 20 cm cutting height. The exception to this is K uptake in the field experiment where 15 cm cutting height produced the best result. Compost rate also influenced N, P and K uptakes. In most cases and in

Table 3: Main effect of cutting height and compost rates on amaranths cumulative nutrient uptake in pot and field experiments

Treatment	N uptake		P uptake		K uptake	
	←		(g. / plant)		→	
	Pot	Field	Pot	Field	Pot	Field
			Cutting height (cm)			
10	7.4 b	8.8 b	2.1 c	2.1 b	2.0 b	3.3 b
15	8.5 a	10.2 a	3.1 a	2.8 a	4.0 a	4.5 a
20	9.4 a	10.9 a	3.2 a	3.7 a	4.0 a	3. 6 ab
Non – cut*	7.7 b	8.5 b	2.6 b	2.8 b	3.7 b	3.6 ab
			Compost rate (t. /ha)			
0	4.7c	5.6 b	1.8 b	1.5 b	2.5 b	3.1ab
2	7.7 b	9.7.ab	2.3b	3.0a	2.9 ab	3.2 b
4	10.5 a	11.7 a	3.6 a	3.6 a	4.0 a	4.6 a
6	9.8 a	11.5 a	3.3 a	3.4 a	4.3 a	4.1 a

Means followed by same alphabet in each column are not significantly different by Duncan Multiple Range Test at 5 % probability level. * Values for non- cut plants were taken once at 10 WAS both and field experiment application of 4 t /ha compost rate and 20cm cutting heights were significant on N, P and K uptake. In general, non – cut plants absorb and accumulated less amounts of nutrients as compared with cut ones. Among the cut once, combination of 20 cm cutting height with 4 t /ha compost produced the best result.

CONCLUSION

Productivity of amaranths can be improved through adequate fertilizer application in combination with other good agronomic practices. In the studies, repeated cutting of shoot produced higher shoot yield. These positive effects are more pronounced when the plants were cut at 20 cm above soil surface and fertilized with 4 t ha-1 compost.

Table 4: Effects of cutting height and compost rates on amaranths cumulative N, P and K uptake in pot and field experiments

Cutting height (cm)	Compost rate (t. /ha)	N uptake		P uptake		K uptake	
		(g. /plant)					
		Pot	Field	Pot	Field	Pot	Field
10	0	4.2d	3.8c	1.6b	0.9b	0.3c	1.4b
	2	4.9d	6.4 bc	2.1 a	2.4 a	1.4b	3.1 ab
	4	10.4ab	12.4a	2.4a	2.6 a	2.0b	4.1a
	6	9.9b	12. 6a	2.4a	2.6 a	4.3a	4.4a
15	0	4.8d	5.9c	2.1b	1.1 b	3.4b	3.8b
	2	8.4b	10 .8b	2.9b	2.9 ab	3.6b	4.9a
	4	12.8a	10.8b	4.7a	4.2 a	5.2a	4.7a
	6	10.4ab	12.1a	3.9a	4.0 a	4.8a	3.4ab
20	0	4.8d	5.9c	2.1b	1.1 b	3.4b	3.8b
	2	8.4b	10 .8b	2.9b	2.9ab	3.6b	4.9a
	4	12.8a	10.8b	4.7a	4.2a	5.2a	4.7a
	6	10.4ab	12.1a	3.9a	4.0a	4.8a	3.4ab
Non – cut	0	6.0c	4.2c	1.4b	1.4c	3.1b	3.1a
	2	7.1c	9.1b	2.4b	2.6b	3.7a	2.4b
	4	8.4b	10.2a	3.0a	3.8a	3.9a	4.6a
	6	8.2b	10.4a	3.4a	3.4a	3.9a	4.1a

Means followed by same alphabet in each column are not significantly different by Duncan's Multiple Range Test at 5 % probability level. * Values for non- cut plants were taken once at 10 w.a.s.

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