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Response of leaf yield and leaf mineral content to varying nitrogen rates on amaranth varieties

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Abstract
A field experiments was conducted during May to August of 2016, at the College of Horticulture, Bagalkot, Karnatak. The objective of an experiment was to determine the effects of N rates (0, 75, 100, 125 and 150 kg N ha^{-1}) on clipping amaranth varieties (Arka Suguna, Arka Arunima, Arka Verna, CO-3 and CO-5), for leaf yield and leaf mineral content at different clippings. The obtained result of the experiment, indicated that increasing N applied rate was accompanied with significant increases in leaf yield at all clippings. With regarding to amaranth varieties, Arka Arunima recorded significantly highest total leaf yield, while CO - 3 maintained yield levels after each clipping but rest of other verities exhibited gradual reduction in yield after each clippings. The interaction between the two studied factors showed, application of 150 kg N ha^{-1} to CO-3 appeared to be the most efficient combination treatment at different clippings, Moreover, leaf Ca and Mg content was significantly increased with increasing N applied rate up to 150 kg N ha^{-1}. With regarding to leaf Ca content, combination of 150 kg N ha^{-1} and Arka Verna gave highest result on leaf Ca content at 1st, 3rd and 5th clippings.

Keywords: Amaranth, clipping, nitrogen

Introduction
Amaranth (*Amaranth spp)* is an important nutritious leafy vegetable belonging to the family Amaranthaceae, it is a delicious vegetable with its considerable nutritional value around the globe and in particular, in parts of tropical and subtropical Asia, Africa and Central America. However, it chiefly grown during summer and rainy season, amaranth is an important and popular vegetable crop because of its cheapest price, quick growing character and higher yield potential (Hossain, 1996) [9]. Therefore, it is considered as a potential upcoming subsidiary food crop (Teutonic and Knorr, 1985) [20]. Simultaneously, the leaves and stems of amaranth are rich in protein, fat, calcium, phosphorus, riboflavin, niacin, sodium, iron and ascorbic acid. Additionally, it contains 43 food caloric which is higher than any other vegetables except potato and tomato (Chaudhury, 1967) [5]. A part from this, it is processed into table products like soup. Even it's seeds are used in making sweet rolls, crepes cookies crackers, etc., (Shanmugavelu, 1989) [18]. However, in India amaranth is chiefly grown in Himalayas from Kashmir to Bhutan and also in South Indian hills. It is gaining popularity in the north western plains of India. Mean while, nitrogen fertilizer is the most crucial input for crop production and had been recognized as the central element for agricultural production as it imparts a major role on the increase of quality, color and taste of vegetables (Monira, 2007) [12]. Available reports also indicate that chemical fertilizers specially the nitrogenous ones are not applied in balanced proportions (Anonymous, 1997) for vegetable production. Additionally, information on the use of appropriate levels of nitrogen fertilizer in particular to clipping amaranth cultivation under specific agro-climatic conditions is lacking in general. These facts suggest that there is an ample scope of increasing amaranth production with the appropriate use of nitrogen fertilizers. However, Clipping is an important factor, especially in the productivity of most C4 crops. Knowledge of the effects of clipping on the performance and quality of leaf amaranth, especially under small scale management, is still rudimentary. The objectives of this study were to determine the response of different *Amaranth* varieties to nitrogen and the influence of clipping on quality and yield of the vegetable amaranth.

Materials and Methods
The present investigation was carried out at the College of Horticulture, Bagalkot, Karnataka,

India, during *kharif* season of 2016. The treatments comprising of five levels of nitrogen fertilizer (0, 75, 100, 125 and 150 Kg ha^{-1}) and five varieties *viz.*, Arka Suguna, Arka Arunima, Arka Verna, CO 3 and CO 5, which were experimented in Factorial Randomized Block Design (FRBD) with two replications. Sowing was carried out at end of May in plot size of 2.4 × 1.8 m with spacing of 30 cm × 10 cm. A basal dose of 50 kg ha^{-1} each of P_2O_5 and K_2O along with half dose of nitrogen (50 kg ha^{-1}) was applied as basal dressing through single super phosphate, muriate of potash and urea respectively. The remaining N was applied as top dressing in two splits at 30 and 45 DAS. All recommended package and practices were followed to raise good crop. Leaf yield was determined by cutting plants 10 cm from base and separating leaves. Specified numbers of cuttings were taken at weekly interval. Then leaf samples collected at first, third and fifth clipping were oven dried at 60^0 C and crushed into powder form to determine the leaf mineral content. Di- acid digested plant samples were used for determination of leaf calcium and Mg content. The calcium and magnesium was estimated by complexometric titration method involving standard EDTA (Piper, 1966) [16]. The data on various biometric observations collected during the period of study were subjected to statistical analysis as per the procedure outlined by Sundararaj *et al.* (1972) [19] and result have been discussed at probability level of 0.05 or 5 per cent.

Result and Discussion

The leaf yield at first (harvested at 30 DAS) to fifth clipping varied significantly among varieties. At first clipping Arka Aunima exhibited significantly higher leaf yield per plant (26.44 g), While CO 3 recorded significantly lower leaf yield (9.91 g). The leaf yield at first clipping varied significantly in the order of Arka Arunima > Arka Suguna > Arka Verna > CO 5 > CO 3. Amaranth leaf yield at first clipping among all varieties were found very high compared to leaf yield at subsequent clippings.

During second clipping (at 37 DAS), Arka Arunima (15.91 g) recorded significantly higher leaf yield while, Arka Verna showed drastic reduction in leaf yield at second clipping. The leaf yield of amaranth at 3rd (44 DAS), 4th (51 DAS) and 5th (58 DAS) clippings found similar in magnitude i.e in the order of CO 3 ≥ Arka Arunima > CO 5 > Arka Suguna > Arka Verna. It was observed that the amaranth leaf yield recorded at 5th clipping in Arka Arunima and Arka Verna almost reduced to half of the yield of 1st clipping. However, CO 3 variety maintained almost same levels of leaf yield at all clippings. In case of CO 5 variety reduction in leaf yield was observed only during 5th clipping. Finally the total leaf yield per plant was determined by pooling individual leaf yield. The total leaf yields varied significantly among the varieties. Variety Arka Arunima recorded higher leaf yield per plant (76.33 g) followed by CO 3 (62.77 g), however, Arka Verna recorded least (38.95 g). Arka Suguna (52.10 g) and CO 5 (50.44 g) recorded medium yields and they were found on par with each other. These results are in general agreement with other studied that emphasized the variation in the leaf yield might be due to the environmental condition required for particular varieties differed and also be due to the genetic makeup (Mysers, 1996, Henderson *et al.*, 2000 and Aynehband, 2008) [13, 7, 8, 3].

Comparison of leaf yield at varied levels of applied N also indicated significant differences at different clippings. There was a linear increase in leaf yield from no nitrogen to application of 150 kg N ha^{-1} at all clippings. Highest leaf yield was recorded with application of 150 kg N ha^{-1} but which was found significantly on par with 125 kg N ha^{-1} at all clippings. Whereas, without nitrogen application recorded lower leaf yield (Table - 1). The enhancing effect of N on leaf yield of amaranth can be explained on the basis of the physiological fact that N plays a major role in protein and nucleic acids synthesis and protoplasm formation. Moreover, it stimulates the meristematic activity for producing more tissues and organs (Russel, 1973; Yagodin, 1984) [17]. These results, generally, agreed with those obtained by Addae-Kagy and Norman (1977) [1]; Osman (1981) [14] and Ara (2005) [2].

The combined effect of variety and nitrogen influenced significantly on leaf yield per plant at only third, fourth and fifth clipping. The highest leaf yield per plant was found from the treatment combination of variety CO 3 and at 150 kg N ha^{-1}. The lowest on leaf yield per plant was found from the treatment combination of variety Arka Verna with no nitrogen application. There are variations of on leaf yield per plant among the varieties that can be possible due to different levels of nitrogen. These finding for leaf yield per plant are in agreement with Henderson *et al*. (2000) [7, 8] and Joshi and Rana (1995) [10].

The leaf calcium content varied significantly with varieties at all stages of clippings. The maximum leaf calcium content was recorded in Arka Verna at 1st, 3rd and 5th clippings with respective value of 3.16, 2.65 and 2.36 per cent (Table 2). However, at first clipping Arka Arunima, Arka Suguna and CO 5 were found on par and medium calcium content while, CO 3 exhibited least calcium content. At third clipping Arka Verna was significantly superior to all other varieties viz., Arka Arunima, Arka Suguna, CO 5 and CO 3 (2.40, 2.16, 2.09 and 1.91 per cent respectively). At fifth clipping Arka Arunima and CO 5 (1.89 per cent) were observed with medium leaf calcium content. CO 3 (1.75 per cent) and Arka Suguna (1.72 per cent) recorded significantly lower but on par values for leaf calcium content. From the data, it was indicated that leaf calcium content was gradually reduced with advancement of clippings at all amaranth varieties.

The leaf calcium content also differed significantly with nitrogen application. Application of nitrogen increases the calcium content in amaranth leaves. Nitrogen treatment rate had a significant effect on the amounts of calcium content at first, third and fifth clipping in the leaves of amaranth. By increasing nitrogen level from 0 to 150 kg N ha^{-1}, the amounts of this elements was increased linearly. In this case, the highest values of calcium at 1st, 3rd and 5th clipping were obtained at N_4 (150 kg N ha^{-1}). This increase for calcium was about 3.13 %, 2.71 % and 2.43 % at 1st, 3rd and 5th clippings respectively compared to the least in N_0 treatment (2.27 %, 1.81 % and 1.66 % at 1st, 3rd and 5th clipping respectively).

In term of interactions, both variety and nitrogen levels influenced amaranth leaf calcium content significantly. Combination of treatments 150 kg N ha^{-1} with variety Arka Verna recorded the highest leaf calcium content (3.78, 3.22 and 2.84 per cent) at first, third and fifth clippings respectively but found on par with combination of 125 kg N ha^{-1} and Arka Verna (3.64 per cent) at fist clipping. This study clearly indicated that plant nutrient availability and uptake ability in soil can be enhanced by the overall N balance and on the amount of soil nitrogen reserves (Cassman *et al.*, 2002) [4]. Increased application of nitrogen fertilizer increases nutrient uptake response but may adversely affect crop quality. Nitrogen is utilized mostly for protein synthesis in plants and it is necessary for the synthesis of amino acids, proteins and other cellular components which play an important role in the protection of plants against stress and pests (De Kok *et al.*, 1999) [6].

With regarding to leaf magnesium content varieties and N levels differed significantly. The variety CO 5 recorded higher leaf magnesium content compared to all other varieties at first, third and fifth clippings (Table - 3). This is mainly due to genetic makeup on the varieties. These results broadly corroborate with that of results obtained Kachiguma *et al.* (2015) [11].

The effect of N fertilizer application on the leaf magnesium content significantly differed at first, third and fifth clippings. Data showed the lowest leaf magnesium content by the treatment without nitrogen application at first, third and fifth clippings, where as highest leaf magnesium content was observed with application of 150 kg N ha^{-1}. The increment of magnesium content under the influence of the increased nitrogen was accordance with Piotr, 2009 [15].

The combined effects of variety and different levels of nitrogen on leaf magnesium content at first, third and fifth clippings were found non-significant.

From the present study, it is concluded that among five amaranth varieties Arka Arunima exhibited highest leaf yield, however, CO – 3 maintained constant yield levels up to 5th clipping. With regarding to interaction combination of 150 kg N ha^{-1} to variety CO – 3 found high. Furthermore, the variety Arka verna have high Ca content, whereas CO 5 has highest leaf Mg content at 1st, 3rd and 5th clippings in amaranth.

Table 1: Effect of different levels of N (kg ha^{-1}) on leaf yield per plant at different clippings in *Amaranth* varieties

Varieties	**Leaf yield per plant at 1st clipping (g)**						**Leaf yield per plant at 2nd clipping (g)**						**Leaf yield per plant at 3rd clipping (g)**					
	N_0 0	**N_1 75**	**N_2 100**	**N_3 125**	**N_4 150**	**Mean (V)**	**N_0 0**	**N_1 75**	**$N_2$100**	**N_3 125**	**N_4 150**	**Mean (V)**	**N_0 0**	**N_1 75**	**N_2 100**	**N_3 125**	**N_4 150**	**Mean (V)**
V_1-Arka Suguna	10.09	18.40	23.63	27.69	31.11	22.18	3.58	7.30	10.26	12.44	13.66	9.44	3.19	6.88	8.60	10.44	11.67	8.15
V_2-Arka Arunima	19.50	23.88	28.00	29.98	30.84	26.44	10.37	14.40	16.08	18.54	20.17	15.91	6.58	12.22	14.14	16.12	18.14	13.44
V_3-Arka Verna	10.69	14.58	17.10	18.08	19.45	15.98	1.57	4.09	8.52	10.49	11.85	7.30	1.55	5.64	7.29	8.90	10.58	6.79
V_4-CO 3	5.55	8.50	9.46	10.69	11.77	9.19	5.27	10.93	14.84	15.97	17.56	12.91	2.60	14.79	16.94	18.08	19.25	14.33
V_5-CO 5	4.58	9.09	12.43	15.38	16.48	11.59	6.39	10.11	11.32	13.19	14.54	11.11	1.93	7.34	11.47	13.77	14.26	9.75
Mean (N)	10.08	14.89	18.12	20.36	21.93	17.08	5.43	9.36	12.20	14.12	15.55	11.33	3.17	9.37	11.69	13.46	14.78	
	S.Em±		CD at 5%		CV		S.Em±		CD at 5%		CV		S.Em±		CD at 5%		CV	
Factor V	1.13		3.32		20.94		0.53		1.57		14.93		0.47		1.40		14.38	
Factor N	1.13		3.32				0.53		1.57				0.47		1.40			
VxN	2.52		NS				1.19		NS				1.07		3.13			
	Leaf yield per plant at 4th clipping (g)						Leaf yield per plant at 5th clipping (g)						Total leaf yield per plant (g)					
	N_0 0	N_1 75	N_2 100	N_3 125	N_4 150	Mean (V)	N_0 0	N_1 75	N_2 100	N_3 125	N_4 150	Mean (V)	N_0 0	N_1 75	N_2 100	N_3 125	N_4 150	Mean (V)
V_1-Arka Suguna	2.24	5.20	7.63	8.34	9.40	6.56	2.97	4.51	6.33	7.27	7.74	5.76	22.05	42.28	56.44	66.18	73.56	52.10
V_2-Arka Arunima	7.42	10.76	12.32	14.92	15.88	12.26	2.79	6.60	9.20	11.00	11.85	8.29	46.65	67.85	79.73	90.55	96.87	76.33
V_3-Arka Verna	2.00	3.15	5.21	6.02	6.57	4.59	2.20	3.63	4.38	5.29	6.00	4.30	17.99	31.08	42.49	48.77	54.43	38.95
V_4-CO 3	3.98	12.11	16.76	17.30	18.78	13.79	2.37	10.13	15.34	16.65	18.26	12.55	19.77	56.46	73.32	78.69	85.62	62.77
V_5-CO 5	3.49	6.99	10.14	12.73	13.86	9.44	3.25	5.32	9.48	11.05	13.71	8.56	19.62	38.84	54.83	66.10	72.83	50.44
Mean (N)	3.82	7.64	10.41	11.86	12.90		2.72	6.04	8.94	10.25	11.51	7.89	25.22	47.30	61.36	70.05	76.66	56.12
	S.Em±		CD at 5%		CV		S.Em±		CD at 5%		CV		S.Em±		CD at 5%		CV	
Factor V	0.46		1.37		15.78		0.44		1.30		17.79		2.05		6.01		11.55	
Factor N	0.46		1.37				0.44		1.30				2.05		6.01			
VxN	1.03		3.06				0.99		2.91				4.58		NS			

A. – Arka V – Varieties N – Nitrogen NS – Non significant

Table 2: Effect of N (kg ha^{-1}) levels on leaf calcium per cent (dry weight bases) at 1st, 3rd and 5th clipping in amaranth varieties

Varieties (V)	**Leaf calcium content at 1st Clipping**						**Leaf calcium content at 3rd clipping**						**Leaf calcium content at 5th clipping**					
	N_0 0	**N_1 75**	**N_2 100**	**N_3 125**	**N_4 150**	**Mean (V)**	**N_0 0**	**N_1 75**	**N_2 100**	**N_3 125**	**N_4 150**	**Mean (V)**	**N_0 0**	**N_1 75**	**N_2 100**	**N_3 125**	**N_4 150**	**Mean (V)**
V_1-Arka Suguna	2.54	2.56	2.62	2.76	3.14	2.72	1.58	1.90	2.36	2.40	2.56	2.16	1.26	1.38	1.86	1.86	2.26	1.72
V_2-Arka Arunima	2.48	2.44	2.78	2.96	3.06	2.74	2.08	2.24	2.28	2.70	2.68	2.40	1.90	2.04	2.08	2.32	2.32	2.15
V_3-Arka Verna	2.16	2.68	3.54	3.64	3.78	3.16	2.16	2.28	2.68	2.93	3.22	2.65	2.06	2.06	2.32	2.54	2.84	2.36
V_4-CO 3	2.06	2.46	2.50	2.62	2.65	2.46	1.64	1.66	1.74	2.22	2.28	1.91	1.60	1.62	1.66	1.78	2.08	1.75
V_5-CO 5	2.12	2.44	2.74	2.92	3.00	2.64	1.58	1.68	1.86	2.52	2.80	2.09	1.48	1.68	1.68	2.04	2.58	1.89
Mean (N)	2.27	2.52	2.84	2.98	3.13		1.81	1.95	2.18	2.55	2.71		1.66	1.76	1.92	2.11	2.43	
	S.Em±		CD at 5%		CV		S.Em±		CD at 5%		CV		S.Em±		CD at 5%		CV	
Factor V	0.02		0.064		2.36		0.025		0.074		3.45		0.02		0.08		3.39	
Factor N	0.02		0.064				0.025		0.074				0.02		0.08			
VxN	0.05		0.14				0.056		0.166				0.06		0.18			

NS – Non significant V – Varieties N - Nitrogen

Table 3: Effect of N (kg ha^{-1}) levels on leaf magnesium per cent (dry weight bases) at 1st, 3rd and 5th clipping in amaranth varieties

Varieties (V)	**Leaf magnesium (%) content at 1st clipping**						**Leaf magnesium (%) content at 3rd clipping**						**Leaf magnesium (%) content at 5th clipping**					
	N_0 0	**N_1 75**	**N_2 100**	**N_3 125**	**N_4 150**	**Mean (V)**	**N_0 0**	**N_1 75**	**N_2 100**	**N_3 125**	**N_4 150**	**Mean (V)**	**N_0 0**	**N_1 75**	**N_2 100**	**N_3 125**	**N_4 150**	**Mean (V)**
V_1-Arka Suguna	0.59	0.61	0.61	0.61	0.62	0.61	0.55	0.57	0.57	0.57	0.58	0.57	0.53	0.54	0.55	0.56	0.57	0.55
V_2-Arka Arunima	0.56	0.56	0.57	0.57	0.57	0.56	0.54	0.55	0.55	0.55	0.56	0.55	0.52	0.55	0.56	0.56	0.56	0.55
V_3-Arka Verna	0.46	0.52	0.52	0.53	0.54	0.51	0.46	0.49	0.51	0.52	0.52	0.50	0.42	0.46	0.47	0.49	0.49	0.47
V_4-CO 3	0.47	0.53	0.54	0.54	0.55	0.53	0.46	0.51	0.52	0.52	0.53	0.51	0.45	0.51	0.51	0.52	0.53	0.50
V_5-CO 5	0.66	0.66	0.66	0.67	0.67	0.67	0.58	0.60	0.62	0.63	0.63	0.61	0.52	0.56	0.57	0.57	0.58	0.56
Mean (N)	0.55	0.58	0.58	0.58	0.59		0.52	0.55	0.55	0.56	0.56		0.49	0.53	0.53	0.54	0.54	
	S.Em±		CD at 5%		CV		S.Em±		CD at 5%		CV		S.Em±		CD at 5%		CV	
Factor V	0.006		0.019		0.330		0.006		0.019		0.726		0.003		0.008		0.949	
Factor N	0.006		0.019				0.006		0.019				0.003		0.008			
VxN	0.015		NS				0.014		NS				0.006		NS			

NS – Non significant V – Varieties N – Nitrogen

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