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PERFORMANCE COMPARISON OF THREE VARIETIES OF AMARANTH (*Amaranthus Hypochondriacus L.*) AT DIFFERENT HARVEST TIME

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ABSTRACT

Amaranth is one of the native plants of Africa is that in addition to the relative tolerance to drought conditions, has high potential forage production. The experimental design was a randomized complete block with factorial method, three varieties of Amaranth forage consist of Loura, Cim and Kharkovski and to harvest time before and after flowering with four replications at the Seed and Plants Improvement Research Institute of Iran in 2015. The results showed that significant difference between the tested varieties in terms of total dry and fresh forage yield, but there was not any significant difference between harvest time and interaction effects. Compare average showed a figure Loura whit 161.0 cm in cut1 had the maximum height and the Cim and Kharkovski respectively, with 155.0 and 146.9 cm stem height ranked in next categories. The maximum stem diameter over the equivalent of 20.6 mm in class a belongs to Kharkovski rather than the other two varieties with average 16.9 and 16.8 mm. Finally the Laura with 9090.3 and 13.05 total fresh and dry forage yield and relative superiority of Crude protein, Crude fat, Digestibility, Relative Forage Quality and Relative Feed Value compared to the other two varieties were superior.

Contribution/ Originality: This research has been implemented with the participation of the private sector, Seed and Plant Improvement Institute and Animal Science Research Institute of Iran

1. INTRODUCTION

Amaranthus L. is one of the oldest food crops in the new world [1]. Earlier studies predicted that the grain *Amaranthus* L. was domesticated in the America [2, 3]. This crop has about 75 species of annual flowering plants distributed throughout the world's temperate and tropical regions [4]. Three species of Amaranths (*Amaranthus hypochondriacus* L., A. *cruentus* L. and *A. caudatus* L.) Were domesticated in the new world, but spread to the old world where they became important crop plants [5]. These crops have potential for higher nutritional value, better adaptability to various ecological zones, and better resistance to biotic and abiotic stresses than most other staple crops [1, 6]. Amaranth (*Amaranthus L.*) is a hardy, fast-growing pseudo-cereal with C4 metabolism and wide geographic and environmental daptability [5, 7]. One of the most important features of amaranth is less water

consumption for normal growth (42 to 47%) than to other crops [8]. Several studies were shown that Amaranth leaves have height, nutritional value and are a good food source for feeding ruminator [9-11]. Leukebandara, et al. [12] reported that the high crude protein and ash content in Amaranth species that suggests this crop may provide high quality forage for livestock. Forage quality parameters of Amaranth are similar or better than commonly used forages [13] therefore Amaranth would be a good alternative to the problem of inadequate supply of quality forage during the dry season [5]. The overall nutritive value of Amaranth as a forage is similar to the commonly used forage and has an excellent forage quality at certain stages of development [12]. This study was carried out to compare the three amaranth varieties forage yield quantity and quality in different two harvest time.

2. MATERIALS AND METHODS

The experiment was conducted at the Karaj research station belongs to Seed and Plant Improvement Research Institute of Iran in the spring 2015. This research located at 320 34' N, 280 32' S, the soil type at the experimental site was sandy loam. The experimental design was a randomized complete block with four replications in the factorial method with three varieties of Amaranth consists of Loura, Cim and Kharkovski and two harvest times was performed before and after flowering. All amaranth varieties belonging to species A. Hypochondriacs L. Plots consisted of six rows with 6 meter length, between and within row spacing were 0.6 and 0.1 meter respectively. Soil was prepared in early bloom and seeds planted on the firmed bed at 1-2 Cm depth in mid May. Fertilization, Irrigation weed and insect control were followed like to other leafy forage crop. Ten randomly selected plants were collected at harvest time to measure growth parameters consisting, plant stems, height and diameter, leaf to stem rate and tiller per plants. Two middle rows were used for the yield determinations. Dry weights were recorded after drying the fresh forage at 750C in the oven for 72 h. Crude protein, Crude fat, Digestibility, Relative Forage Quality and Relative Feed Value were determined in Iran Animal Science Research Institute laboratory. Analysis of variance for all traits was done by the MSTAT-C software and for means comparison used Duncan's multiple range tests.

3. RESULTS AND DISCUSSION

3.1. The Overall Growth Trend

The overall process average figures for germination about 5 days after planting and emergence 7-9 days after planting, step 3-leaf stage of the plant is about 15 to 17 days after planting happened. The rapid growth of the plant after step 5-leaf stage and about 22 days after planting. First harvest before flowering in Kharkovski about 62 days after planting, and in the other two varieties of 70 days after planting. The harvest time up after flowering in the Kharkovski was determined about 82 days after planting, and the other two in 85 days after planting was done. The second harvest before and after flowering Kharkovski variety, arrange 32 and 34 days after cut1, the figure is 41 and 48 days for Loura variety and 43 and 52 days after for Cim respectively. With regard to reducing the ambient temperature of the third cut Kharkovski figure is approximately 59 days after the second and the remaining two varieties arrange the figures 54 and 52 days after planting. Become rotten due to shoot and destroy the tillering after flowering in cut3 did not produce acceptable performance (Table 1).

Table-1. Growth and cutting time of amaranth varieties (2016)

Treatment	Harvest time 1	Harvest time 2	Harvest time3
Loura before flowering	12, Jul.	22, Aug.	15, Oct.
Loura after flowering	27, Jul.	13, Sep.	-
Cim before flowering	12, Jul.	24, Aug.	15, Oct.
Cim after flowering	27, Jul.	17, Sep.	-
Kharkovski before flowering	4, Jul.	5, Aug.	3, Oct.
Kharkovski after flowering	24, Jul.	27, Aug.	-

Source: seed and plants improvement institute

3.1. Vegetative Traits

The results of analysis of variance showed that there were significant difference in plant height, stem diameter and tiller per plants, but there were not any significant differences between stem diameter means in cut2 and leaf to stem ratio in each cut. The harvest time treatment had significant effects on stem height and diameter in consecutive cut and average number of tillers per plant, but this treatment had not any effects on leaf to stem ratio. The interaction figure stem diameter, leaf to stem ratio and tiller per plant means having no significant effect (Table 2).

Table-2. Mean square and of growth characteristics significant level

S.O.V	d.f	Plant height cut1	Plant height cut2	Plant diameter cut1	Plant diameter cut2	Leaves/stem cut2	Leaves/stem cut2	Tiller per plants
Rep	3	143.7	20.5	12.9	1.2	0.01	0.13	0.15
Varieties	2	402.8**	1315.3**	38.8**	3.3^{ns}	^{ns} 0. 72	^{ns} 0.05	5.02**
Harvest time	1	11704.2**	1584.4**	204.2**	66.7**	3.22^{ns}	^{ns} 0.07	2.80**
Var*H. time	2	364.3**	574.9**	5.5^{ns}	1.8^{ns}	^{ns} 2.22	^{ns} 0.01	$.09^{ns}$
Error	15	26.5	60.7	4.9	2.1	2.09	0.09	.05
C.V	-	3.3	6.0	12.3	12.5	24.4	19.5	5.7

ns, * and ** are nonsignificant and significant at 5% and 1% levels respectively

By comparison, the average height of the shoot showed Loura whit 161.0 and 139.0 cm stem height in cut1 and 2 produce the highest plant height and placed in class a. The lowest plant height in cut1 and 2, equivalent 146.9 and 116.3 cm were seen in Kharkovski variety and were placed in a separated class (Table 3).

Table-3. Amaranth growth characters comparison using Duncan's Multiple Rage Test

Varieties	Plant height cut1 (cm)	Plant height cut2 (cm)	Plant diameter cut1 (mm)	Tiller per plants
loura	161.0 ^{a}	139.0 ^{a}	16.8 ^{b}	4.72 ^{a}
cim	155.0 ^{b}	137.9 ^{a}	16.9 ^{b}	4.36 ^{a}
kharkovski	146.9 ^{c}	116.3 ^{c}	20.6 ^{a}	3.2 ^{b}

Means, in each Colum, followed by at least one letter in common are not significantly different at the 5% probability level

The plant height in harvest time before flowering treatment were less than to harvest time after flowering treatment and on the contrary was a more tiller per plants and stem diameter. The other researchers have also reported statistically significant difference among the amaranth varieties stems height [14]. There is a negative correlation between the stem diameter and height. The stem height usually reduces leads to an increase in diameter [15]. The stem diameter means comparison was specified that the highest stem diameter equal 21.0 mm were seen in cut1 and harvest after flowering. In contrast, stem diameter at the cut2 was due to stem decay, this issue also affected the leaf to stem ratio and forage quality (Table 4).

Table-4. Harvest time growth characters comparison using Duncan's Multiple Rage Test

Harvest time	Plant height cut1 (cm)	Plant height cut2 (cm)	Plant diameter cut1 (mm)	Plant diameter cut2 (mm)	Tiller per plants
Before flowering	132.3 ^{b}	123.0 ^{b}	15.2 ^{b}	13.3 ^{a}	4.43 ^{a}
After flowering	176.4 ^{a}	139.2 ^{a}	21.0 ^{a}	9.9 ^{b}	3.75 ^{b}

Means, in each Colum, followed by at least one letter in common are not significantly different at the 5% probability level

In this experiment, was not seen any significant difference between leaf to stem ratio, but leaf to stem ratio for Loura, Cim and Kharkovski were 1.65, 1.56 and 1.49 percent in cut1 and this trait in cut2 were 1.14, 1.28 and 1.29 percent respectively. Also, there was not any significant difference between the leaves to stem ratio of the point harvest time treatments and interaction effects. The high growth rate and tiller strength after cutting are the best traits for forage crops [16, 17]. The mean comparison was showed, that the Loura variety with 4.72 tillers per plant had the highest and Cim and Kharkovski with 4.63 and 3.20 tillers per plant were in the next category. The other research also reported that the harvest time had significant effects on tiller ability [9]. Delays in the harvest reduced tiller ability in cut2, because of a delay in harvest decrease soluble shoot assimilates and increase pest damage. The interaction effects showed Loura variety whit 5.05 tillers produce the highest tiller per plants in cut2 before flowering and the lowest amount equaling 2.75 tiller produce by Kharkoski after flowering treatment. The interaction effects were shown that the highest plant stem equals 179.3 cm produced in Loura vareity and harvest after flowering and the lowest stem height equals 117.0 cm were seen in Kharkovski and harvest time before flowering treatment. The highest stem height in cut2 after flowering for Cim variety was 155.8 cm and the lowest one was 113.8 cm in Kharkovski before flowering (Table 5).

Table-5. Varieties*Harvest time interaction growth characters comparison using Duncan's Multiple Rage Test

Var*H.time	Plant height cut1(cm)	Plant height cut2 (cm)
Loura before flowering	142.8 ^{b}	135.0 ^{b}
Loura after flowering	179.3 ^{a}	143.0 ^{b}
cim before flowering	137.0 ^{b}	120.0 ^{c}
cim after flowering	173.3 ^{a}	155.8 ^{a}
kharkovski before flowering	117.0 ^{c}	113.8 ^{c}
Kharkovski after flowering	176.8 ^{a}	118.8 ^{c}

Means, in each Colum, followed by at least one letter in common are not significantly different at the 5% probability level

3.2. Fresh and Dry Forage Yield

Analysis of variance showed significant difference between varieties, fresh and dry forage in consecutive cuts and total forage yield. The harvest time also had significant effects on fresh yield in consecutive cuts and dry yield in cut2 but had not any effects on total yield and finally interaction effects had significantly different effects for fresh and dry forage yield in cut2 (table 6).

Table-6. Mean square of fresh and dry yield in different cutting

S.O.V	d.f	Fresh yield cut1	Dry yield cut1	Fresh yield cut2	Dry yield cut2	Total fresh yield	Total dry yield
Rep	3	87.6	7.8	6.4	0.11	78.7	6.9
Varieties	2	296.3**	5.9**	13.8**	0.4 **	**428.9	* 8.8
Harvest time	1	216.0 *	4.1 *	64.6 **	1.4 **	45.0 ^{ns}	^{ns} 0.71
Var*H. time	2	16.4 ^{ns}	0.73^{ns}	16.1**	0.22 **	^{ns} 15.3	0.10 ^{ns}
Error	15	40.8	1.1	1.1	0.04	39.4	1.24
C.V	-	9.8	10.9	6.1	18.1	7.6	9.4

NS, * and ** are nonsignificant and significant at 5% and 1% levels respectively

The yield comparison showed that there were significant difference between varieties, fresh and dry yield in consecutive cuts and total yield. The highest fresh and dry yield in cut1 and 2 equally 72.08, 18.18 tons per hectare fresh yield and 10.43, 2.62 tons per hectare dry yield belong to Loura variety and the other two varieties were placed in the next class. The Loura total fresh and dry forage yield was 90.30 and 13.05 and it placed in class a, the total forage yield of two other varieties was less than Loura variety and were placed in common group b (Table 7).

Table-7. Amaranth varieties, fresh and dry yield comparison using Duncan's Multiple Rage Test

Varieties	Fresh yield cut 1 (ton. ha^{-1})	Dry yield cut1 (ton. ha^{-1})	Fresh yield cut 2 (ton. ha^{-1})	Dry yield cut 2 (ton. ha^{-1})	Total fresh yield (ton. ha^{-1})	Total dry yield (ton. ha^{-1})
Loura	72.08 ^{a}	10.43 ^{a}	18.18 ^{a}	2.62 ^{a}	90.30 ^{a}	13.05 ^{a}
Cim	63.68 ^{b}	9.12 ^{b}	17.30 ^{a}	2.50 ^{a}	80.99 ^{b}	11.62 ^{b}
kharkovski	60.24 ^{b}	8.82 ^{b}	15.60 ^{b}	2.19 ^{b}	75.86 ^{b}	11.00 ^{b}

Means, in each Colum, followed by at least one letter in common are not significantly different at the 5% probability level

In addition, the harvest time treatments had significant effects on fresh and dry yield. The harvest after flowering in cut1 whit 68.33 tons per hectare fresh yield was superiority because of this treatment growth period was 15 to 20 days longer than the before flowering harvest treatment. Finally, there was no significant difference between the total fresh and dry forage yield for harvesting time treatments. In this regard, the best treatment is determined considering the ease of harvest and forage quality (Table 8).

Table-8. Harvest time fresh and dry yield comparison using Duncan's Multiple Rage Test

Harvest time	Fresh yield cut1 (ton. ha^{-1})	Dry yield cut2 (ton. ha^{-1})	Fresh yield cut 2 (ton. ha^{-1})	Dry yield cut2 (ton. ha^{-1})
Before flowering	62.33 ^{b}	9.05 ^{a}	18.67 ^{a}	2.68 ^{a}
After flowering	68.33 ^{a}	9.87 ^{a}	15.39 ^{b}	2.19 ^{b}

Means, in each Colum, followed by at least one letter in common are not significantly different at the 5% probability level

The comparison of interaction effects was shown significantly different between fresh and dry forage yield in cut2. The most fresh and dry yield equations 21.45 and 3.04 tons per hectare were produced by Loura variety and harvest time before flowering (Table 9).

Table-9. Varieties*Harvest time fresh and dry yield interaction comparison using Duncan's Multiple Rage Test

Var*H.time	Fresh yield cut2 (ton. ha^{-1})	Dry yield cut 2 (ton. ha^{-1})
Loura before flowering	21.45 ^{a}	3.04 ^{a}
Loura after flowering	14.91 ^{c}	2.19 ^{c}
cim before flowering	17.98 ^{b}	2.70 ^{b}
cim after flowering	16.63 ^{b}	2.31^{c}
kharkovski before flowering	16.58 ^{b}	2.29 ^{c}
Kharkovski after flowering	14.63 ^{c}	2.08 ^{c}

Means, in each Colum, followed by at least one letter in common are not significantly different at the 5% probability level

Forage quality analysis showed that Loura variety whit 12% protein, 2.4% crude fat, 69.1% digestible, 171.5% relative feed value and 174.6% relative forage quality were superior to other varieties (Table 10).

Table-10. Chemical composition and mineral supplements Forage three varieties of amaranth (% dry matter)

Varieties	Crude protein	Crude fat	Digestibility	Relative Feed Value	Relative Forage Quality
loura	12.0^{a}	2.4^{a}	69.1^{a}	171.5^{a}	174.6^{a}
cim	11.8a^{b}	2.2a^{b}	68.5^{ab}	165.1^{ab}	167.5^{ab}
kharkovski	11.5^{b}	2.1^{b}	67.4^{b}	157.1^{b}	158.0^{b}

Means, in each Colum, followed by at least one letter in common are not significantly different at the 5% probability level

Some others researcher reported that amaranth forages have height levels of protein, fat and their silage have height relative forage quality for dairy cow and fattened sheeps [11, 13, 18, 19].

4. CONCLUSION

The results showed that the Loura amaranth variety whit 150 cm stem height, 14.5 mm stem diameter, 1.4% leaf to stem ratio, 4.72 tillers per plant, tow cuts and 111 days growth duration, can produce 90.30 and 13.05 tons per hectare fresh and dry forage yield, also Loura forage quality was superior to other varieties. The harvest time before flowering was better than harvest time after flowering. Compare the average harvest time in terms of the amount of forage produced showed that cut before flowering than cut after flowering in terms of the amount of dried fodder production excellence. The growth duration of harvest before flowering was 23 days less than harvest after flowering, this issue in terms of management and of having ample opportunity to prepare the ground for the next crop of tremendous importance.

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