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ORIGINAL ARTICLE

Effect of Sowing Date and Density on Growth traits, yield and yield Components of Forage Amaranth

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ABSTRACT

Field studies were conducted at Agricultural Research Station of Marvdasht, Fars, Iran, during agronomic year 2013 to investigate the effects of planting date and density on morphophysiologic characteristics and yield of forage Amaranth. The experiments were conducted as split plot in a complete randomized design with 3 replications at two locations. Treatments included plant density (66000, 83000 and 110000 plants per hectare) and planting date (June 22, July 6, July 21). Combined analysis of variance indicated that planting density and date significantly affected number of leaves per plant , stalk diameter, weight of dry leaf, weight of dry stalk, hay production, RGR, CGR and LAI. so that the highest leaf count (393.38 leaves per plant), stalk diameter (7.16 cm), weight of dry leaf(2065.8 g m^{-2}), weight of dry stalk(7731.9 g m^{-2}), hay production (11279.7 g m^{-2}) and growth index were obtained in amaranth in 66000 plant per hectare plant density on July 6 sowing. The results showed that yield and growth index was reduced due with delay in planting date and increase in density. At last the results of this experiment showed that amaranth with density of 66000 plants per hectare at sowing date of July 6 was the best suggestion in Fars province.

***Kay words**: Crop growth rate, Hay production, Leaf area index, Leaf count, Relative growth rate.*

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INTRODUCTION

Amaranthus Crop (amaranth) belongs to family of amaranthaceae is used as livestock feed because of having suitable potential for cultivation and development in tropical zones [3]. At present by high percent of protein in seed and air bodies, it is used as seed, forage and vegetables and this diversity in consumption causes cultivating amaranth in recent decades in wide level of world such as China, eastern south of Asia, Africa and America [21].

In terms of botany, amaranth is in the group of pseudo-cereals and it is a plant by flat leaf with depth root and having one main stem which from flowering it is short day and usually self-pollinated. Furthermore it is one year and summer plant with high height (180 to 240 cm) which its photosynthesis system is four carbon type (C4) and it has high compatibility to tropical zone in sunny days and it is considered as one of the few plants with flat leaf by four carbon photosynthesis system[17].

amaranth produces high amount of forage in a short period that we can use it as dry forage or grain depot for ruminator and non- ruminator livestock [24]. In terms of quality, protein rate of amaranth plant forage in comparison with other non-legume plants and even some legumes plants is high[20]. One of the most important features of amaranth is using less water in comparison with other crops. As it is reported from China, water need of amaranth is 42-47 percent of wheat, 51-63 percent corn and 79 percent cotton

[11]. In survey for density effect and nitrogen amount on performance and the quality of amaranth (nitrogen fertilizer in the levels 60, 120 ,180 kg of net nitrogen per hectare and density 70000, 105000,104000 plants per hectare) the most yield of amaranth of treatment 180 kg per hectare nitrogen fertilizer and density 140000 plants per hectare are produced[1].
In general high grow speed of product means aggregation of high dry matter and more performance [13]. Therefore numbers which have high grow speed of product and their descending trend begins later, at last they have more forage performance so that we noted in survey of the effect of different planting dates on quantitative and qualitative performance of new amount of amaranth, it produced the most rate of dry forage at date July (to 1 August) Mercado value (to Slavaki, Pleasnet and Amont) and grow speed of product was more and being high of stalk weight was the main factor in development of this value[3].
Although there are crop numbers of this plant in most tropical zones of the world, but they are different because of features such as performance, survey period, height and seed quality and forage [18]. Finding suitable numbers and plant density and suitable date of cultivation are the main priorities for entrance to each plant to crop cycle. We can recognize suitable temperature of growth of plant by selecting suitable date for cultivation and also optimal density guarantees maximum production of a plant. But present research is performed for studying density effects of density and sowing date and the effect of these factors on growth indices and performance evaluation and the production of amaranth.

MATERIAL AND METHODS

This study was carried out at Agricultural Research Station of Marvdasht, Fars, Iran, in two regions, during summer and fall of 2013. Marvdasht County is located on longitude 52 48' 29'' latitude 29 52',with1595 meters above mean sea level; average rainfall during 2013 was 316.8 mm with the long time average of 365 mm per year. Average minimum temperature was 8.7°Celsius and average maximum temperature was 25.7° Celsius. According to Köppen climate classification this region belongs to temperate group. Physico-chemical properties of experimental (30 cm depth) are given in Table 1.

Table1: Macro and microelements content of experimental soil.

Element	Ph	Ec	Clay	Silt	Sand	N	P	K	Fe	Zn	Cu	Mn
Rate		(ds/m)	(%)				(mg/kg^{-1})					
First location	7.73	0.74	41	45	14	0.1	32.8	480	10.8	1.3	1.03	9.7
Second location	7.9	0.93	39.6	44.2	16.2	0.098	18	400	8.3	0.7	1.94	8.6

The experiment conducted as split-plot in a complete randomized design with 3 replications and in two different locations within an agricultural year. Main plots were planting density (66000, 83000 and 110000 plants per hectare) and sub- plots were planting date (June 22, July 6, July 21).
Fertilizer application was achieved according to the results of soil analysis, the fertilizers composed of ammonium phosphate (300 kg ha^{-1}) and urea (300 kg ha^{-1}); urea was added at three steps. Experimental plots were irrigated every 7 days. During the growth period plots were regularly hand weeded. Seedbed preparation consisted of spring disking and moldboard plowing. Amaranth seeds (*Amaranthus cruentus* L.) were planted 1-1.5 cm deep at different planting density in 60 cm spaced rows. The measured traits included hay yield , stalk diameter, number of leaves per plant, weight of dry leaf, weight of dry stalk, leaf area index(LAI),crop growth rate(CGR), relative growth rate(RGR). To measure quantitative traits like hay yield, stalk diameter and leaf count per pant, plants were randomly samples from each plot, Stalk diameter was measured by Vernier caliper. Number of leaves per plant was counted after they were dried for 72 h in oven at 65° C, to achieve dry biomass. To measure growth indices, sampling were done 30 days after plant every two weeks during the growth stages. The equations(1), (2) and (3) for evaluating leaf area index(LAI), crop growth rate(CGR) and relative growth rate(RGR) were used, respectively.

$$LAI=LA/GA1 \quad (1)$$

$$CGR=1/GA.(W2-W1)/(T2-T1) \quad (2)$$

$$RGR=(\ln W2-\ln W1)/(T2-T1) \quad (3)$$

That the equations included: weight of dry plant, T: time, LA: leaf area, GA: ground area.
Analysis of variance of all the traits and comparison of means(by Duncans multiple range test) were carried out by MSTAT-C software and the diagrams were drawn by Microsoft Office Excel 2007.

RESULTS AND DISCUSSION

Stalk diameter

Combined ANOVA indicated that the planting density and date had a significant effect on stalk diameter ($P < 0.01$, Table 2).

Comparison of mean interactions between planting density and planting date in both experimental locations showed that the highest stalk diameter (average 7.16 cm) was that of forage amaranth with planting date July 6 and planting density of 66,000 plants per hectare (Table 3). Stalk diameter is a measure of growth that is affected by factors such as planting density; with increasing plant density, stalk diameter is reduced due to severe competition [4]. Artega also reported that with increasing planting density, stalk diameter falls [2]. Kaul reported that increasing planting density of amaranth decreased stalk diameter and hay weight [12]. It appears that due to large size and large number of branches and leaves in crop amaranth, lowering planting density leads to more space per plant and decreases between-plant competition which augments stalk diameter and leaf numbers and enhances hay production.

Number of leaves per plant

Combined ANOVA indicated that the planting density and date had a significant effect on number of leaves ($P < 0.01$, Table 2). Comparison of mean interactions between planting density and planting date in both experimental locations showed that the maximum number of leaves (average 393.38 leaves per plant) obtained from amaranth with planting density of 66000 and planting date July 6(Table 3). In survey for effect of different planting date on qualitative and quantitative performance amatanth, were showed which the effect of planting date had significant effect on leaf number by square meter in amaranth and it had no good reaction to soon planting in the numbers A.Creuntus because it had most production of leaf in planting date July15 (to July1 and August 1) [3]. In survey planting density and row cropping on yield and yield components of amaranth were observed that the most number of leaf were in less density and also by increasing density, the number of leaf will be declined although less leaf is produced in high densities, but the size of leaf is bigger[10].

Weight of dry leaf

Combined ANOVA indicated that the planting density and date had a significant effect on weight of dry leaf($P < 0.01$, Table 2). Comparison of mean interactions between planting density and planting date in both experimental locations showed that the maximum weight of dry leaf (average 2065.8 g m^{-2}) was that of forage amaranth with planting date July 6 and planting density of 66000 plants per hectare. (Table 3)

In a survey, density effect and nitrogen fertilizer on qualitative and quantitative performance of amaranth was recognized when density is increased then the number of leaf and leaf weight will be declined[1].

Table 2: Combined analysis of variance for investigation traits of amaranthus in density and different sowing date in two location

S.O.V	df	MS				
		Stalk diameter	Leaf count per plants	weight of dry leaf	weight of dry steam	Dry hay yield
Location	1	0.196 n.s	2.47 n.s	34.40 n.s	4110358.20**	954860.23**
Replication	4	0.103	7.518	196.91	10102.62	1189.9
density	2	25.047**	102794.06**	731031.68**	18192731.07**	29497327.79**
Location ×density	2	0.087 n.s	493.48**	103733.84**	754478.57**	100263.2**
Error1	8	0.038	22.22	191.93	7087.56	1639.6
Sowing date	2	16.61**	101043.61**	1459943.49**	46640334.45**	102711781**
Location ×sowing date	2	0.2312*	2590.551**	119473.55**	2823669.68**	2514064.5**
Density × sowing date	4	0.873**	1728.0639**	203691.209**	4048540.84**	6502641.3**
Location× density × sowing date	4	0.0997 n.s	358.051**	78529.52**	658135.83**	2022289.6**
Error2	24	0.048	16.23	109.178	6947.9	1583
Coefficient variation(CV)%	-	4.9	3.6	5.7	6.2	4.6

ns:Non-significant. * and**: significant at 5% and 1% probability, respectively.

Weight of dry stalk

Combined ANOVA indicated that the planting density and date had a significant effect on weight of dry stalk ($P < 0.01$, Table 2). Comparison of mean interactions between planting density and planting date in both experimental locations showed that the maximum weight of dry stalk (average 7731.9 g m^{-2}) obtained from amaranth planted on July 6 with density of 66000 plants per hectare (Table 3).

In investigations on the effect of planting density on qualitative and quantitative performance of amaranth showed that amaranth stalk has significant reaction to density and when density is increased the stalk diameter, number of leaf and plant height will be declined[22]. The recognition of optimal density causes increasing stalk diameter, stalk weight and at last dry matter by suitable planting date and

providing good seedbed (environmental conditions) of growth and development of shoot of amaranth in optimal temperature. Results of these investigations had compatibility with findings [10].

Table 3: Means comparison of interaction effects of density sowing date on investigation traits in two location

Treatments		measured traits				
Density (Plant.ha^{-1})	Sowing date	Stalk diameter (cm)	Leaf count per plants	weight of dry leaf (gr.m^{-2})	weight of dry steam (gr.m^{-2})	Dry hay yield (gr.m^{-2})
66000	June22	5.3 b*	343.5 b	1644.3 c	3857.2 d	6079.73 d
83000	June22	3.96 d	277.33 d	1502.93 d	2749.2 f	4400.63 f
110000	June22	3.53 e	190.042 g	1459.88 e	2103.2 h	4010.05 h
66000	July6	7.16 a	393.38 a	2065.8 a	7731.9 a	11279.7 a
83000	July6	5.05 b	284.75 c	1826 b	4671.6 b	7720.07 b
110000	July6	4.02 d	222.33 f	1265.55 f	4341.88 c	6719.17 c
66000	July21	4.58 c	231.33 e	1266.3 f	2983.8 e	4492.87 e
83000	July21	3.36 e	137.66 h	1165.33 g	2747.07 f	4123.9 g
110000	July21	2.55 f	105.17 i	1049.58 h	2356.57g	3773.77 i

* Means in each column followed by similar letter(s) are not significantly different at 5% probability level using Duncan's Multiple Range Test

Dry hay yield

Combined ANOVA showed that planting density and planting date affected hay yield ($P < 0.01$, Table 2). Comparison of mean interactions between planting density and planting date in both experimental locations showed the highest hay yield (average 11279.70 g m^{-2}) obtained from amaranth planted on July 6 with density of 66000 plants per hectare (Table 3).

By increasing density and delaying planting date, the yield of dry forage of amaranth decreased [23]. It is reported that dry forage of amaranth to different density and date show multiple reactions and at suitable planting date, its forage is increased by optimal density so that the feed space of plant is not decreased. Ayenehb and noted that weight of dry leaf and stalk has most effect in increasing the yield of forage. These results have compatibility with observations of this investigation [3].

Leaf Area Index(LAI)

Inserted curves in figure 1 show the leaf area index (LAI) in different density and sowing date. All treatments had same trend which the maximum LAI happened 75 days after planting. It means that when the last leaf is appeared and flower will be obvious at the end of stalk. At first the period of growth season increasing leaf area index was so low but by spending time and plant growth and developing leaves, LAI will be increased and it is maximum. But at the last period of growth season it is declined again. The maximum rate of LAI was at density 66000 plants per hectare. In fact by increasing density, LAI is declined. Probably the reason of this affair is suitable distribution of plants, suitable overlapping of leaves and their less shading which causes better usage of environmental factors. The maximum LAI in planting date July 6 and the least LAI observed in planting date July 21. It is reported that planting date affects on temperature and also it can affect on ultimate number of leaves and development of plant covering [14]. Temperature can increase the speed of leaves appearance but necessarily it does not guarantee leaf surface and its durability [15]. In suitable LAI that can increase growth speed of product, photosynthesis speed, the production of higher matter and at last performance will be more which in this situation keeping leaf surface and its durability is important. By delaying planting date, senescence and defoliation of leaves happen faster and on the other hand because of the length of growth period, the time of expanding leaves surface is less and at last LAI is declined [5].

Crop Growth Rate (CGR)

Speed of crop growth is weight increase of a social plant per surface unit of time[9]. Figure 2 shows speed of crop growth in different density and date in amaranth. In the first stages of growth the value speed of growth crop is low and by spending time, it will be increased. These values in the time of flowering and the highest rate of LAI will be maximum. The highest speed of crop growth was observed in density of 66000 plants per hectare at planting date July 6(Figure 2). On the other hand by increasing density, the speed of crop growth will be declined. High planting density causes increasing shading in plant and through limitation in light absorption rate in plants could are affected plant growth and at last performance[19]. Increasing planting density causes increasing plants competition and at last lack of food elements and declining CGR [8]. In general high speed of crop growth means aggregation of high dry matter and more performance. Therefore treatment which has more speed of crop growth and its descending trend begins later, at last it has the performance of more forage [13].

Relative Growth Rate (RGR)

Relative growth rate shows added dry weight to first weight in an interval [9]. The curves of figure 3 show that by increasing plant age, relative growth rate is declined linearly. Maximum relative growth rate was observed in density of 66000 plants per hectare at planting date July 6. Since by increasing plant age, adds on structure tissue of plant which these structure tissue have no share in growth, relative growth rate will be negative during the time and increasing breath at the last season of growth[16]. It is showed in multiple reports that relative growth rate of crop will be declined through growth season by shading arising planting density and by delaying planting date and increasing temperature and the severity of breathing [6],[7]. Azizi and Mahrokh in their studies on corn found that increasing density causes declining growth indices such as RGR[5].

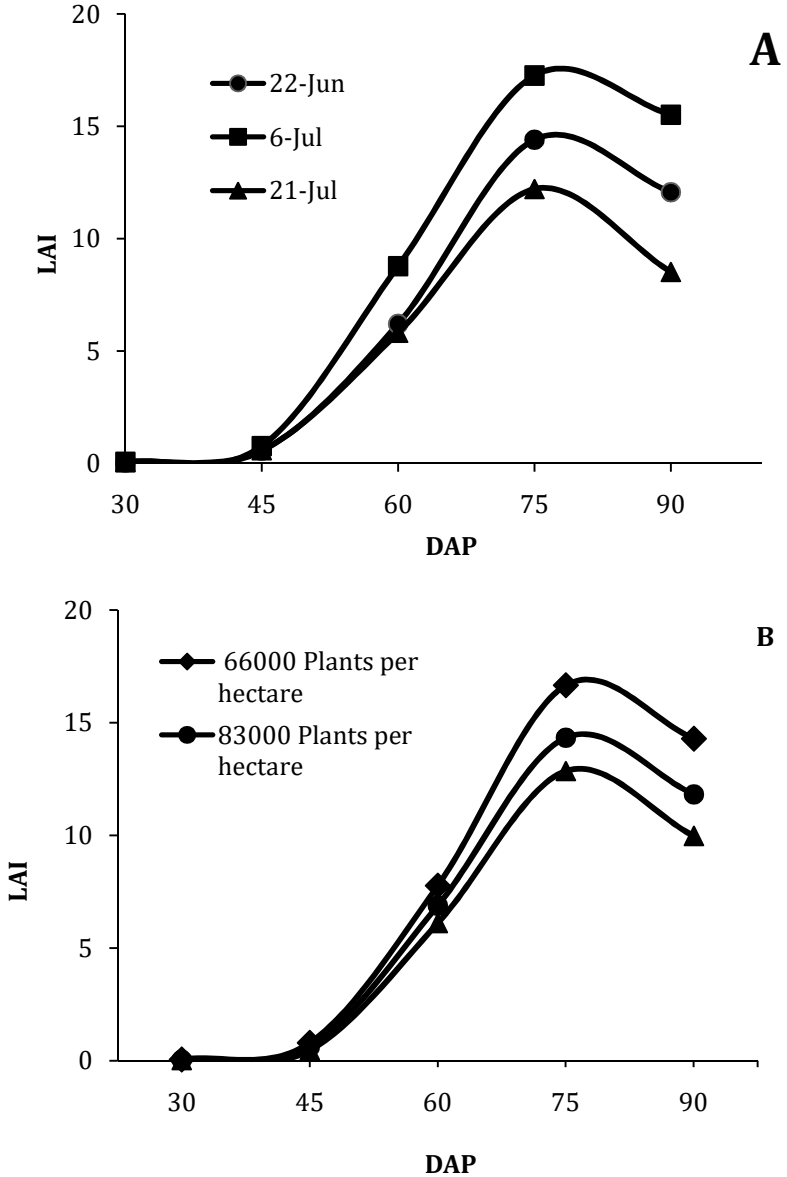


Figure 1- Process of change in leaf area index (LAI) of amaranthus in (A) sowing date and (B) density.

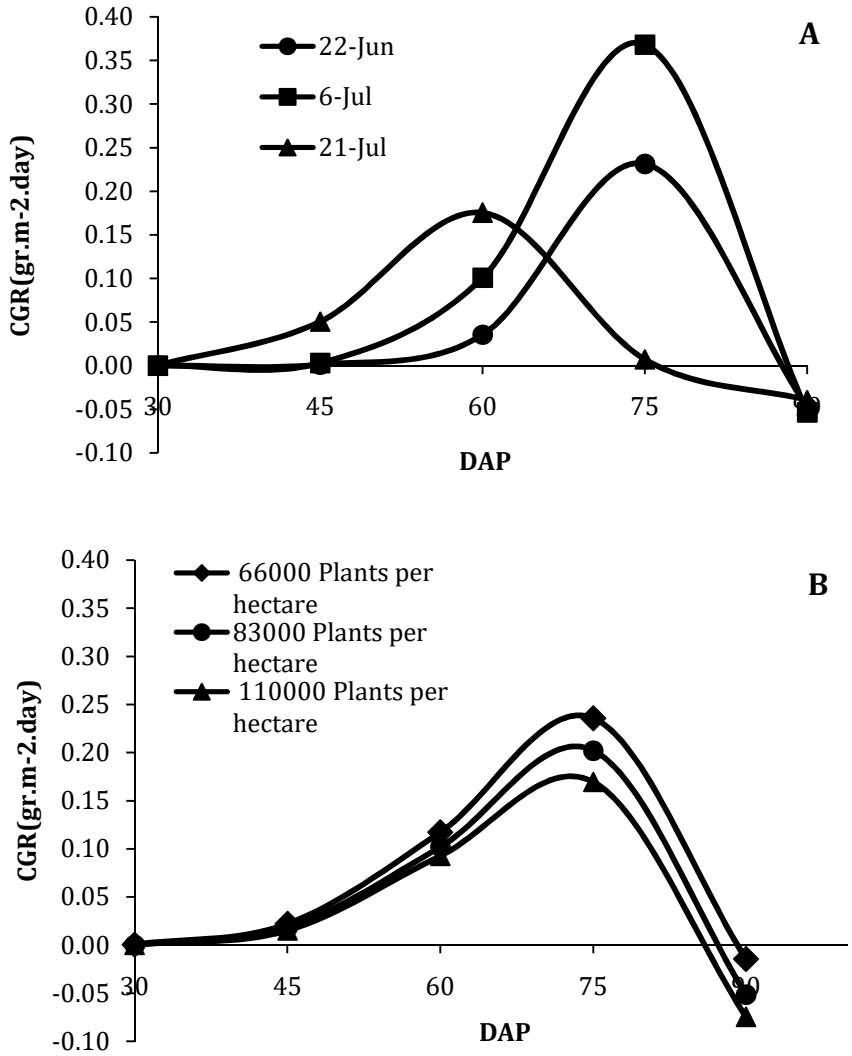
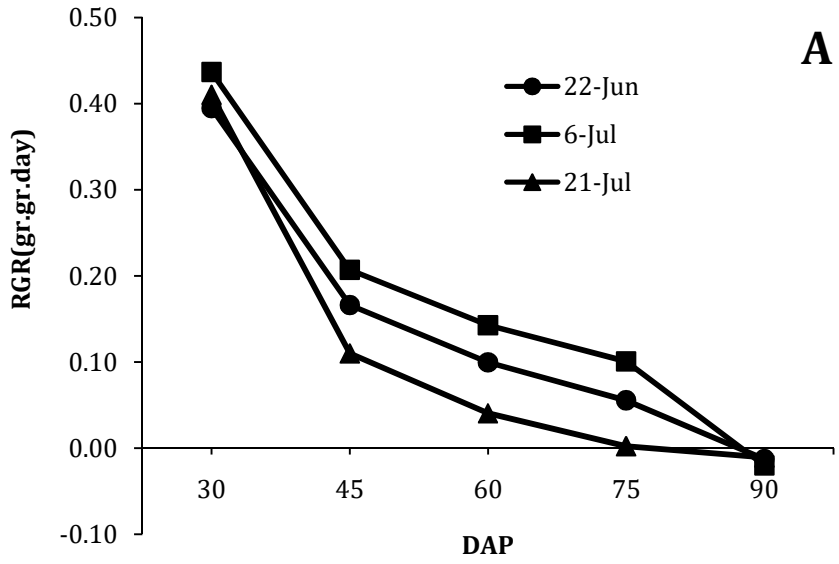


Figure 2 - Process of change in crop growth rate(CGR) of amaranthus in (A) sowing date and (B) density.



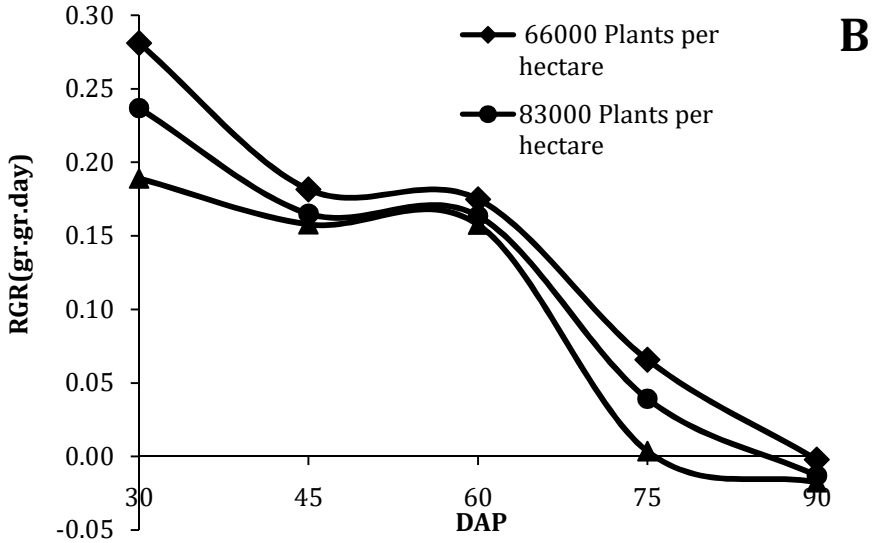


Figure3- Process of change in relative growth rate (RGR) of amaranthus in (A) sowing date and (B) density.

CONCLUSION

In general the results of this study showed that the effect of environmental factors can be effective on process of change of growth indices considerably and by suitable selection of planting density and sowing date along with producing high growth indices, at last it resulted in producing more performance. The best proposed interaction for producing highest forage performance in amaranth is on planting date July 6 with density of 66000 plants per hectare which this treatment has more LAI,CGR and RGR.

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