The effect of density on yield and some agronomical and physiological traits of Amaranth (Amaranthus spp.)

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ABSTRACT: Grain Amaranth is a C4 crop with potentially increasing cultivation area. Yet, no standards exist for optimum plant density. The aim of this study was to determine crop possibilities and how crop density affects Amaranth agronomical, physiological and biological grain production and yield. A field experiment was conducted in Aliabad Gorgan in Golestan Province in 2010. Two genotypes (Amaranthus cruentus) Amar, (Amaranthus hypochondriacus) Anna, were established at four densities (17, 35, 70 and 140 plants m²) by hand thinning at a row spacing of 30 cm. Plant samples were hand-harvested for the determination of leaf area index and total shoot biomass. The results show that the effect of cultivar on seed thousand weight was significant. Seed thousand weight average for Amar was 0.61 and for Anna was 0.65, but the cultivar has no significant effect on seed yield. The effect of density on seed yield and seed thousand weight was significant and the most seed yield obtained from 140 plants per m² and the least from 17. Increasing plant population decreased thousand seed weight and in both cultivars, the most seed thousand weight was belonged to 17 plants per m² treatment. The results show that the effect of density on total dry matter, stem dry matter and leaf dry matter was significant and the most total dry matter, stem dry matter and leaf dry matter achieved from 140 plants per m². The effect of cultivar on leaf area index was not significant but the interaction between variety and density on leaf area index was significant.

Keywords: Amaranth, Cultivar, Density, Dry matter, Leaf area

INTRODUCTION

Amaranth is one of the rare dicotyledon plants with C4 photosynthetic pathway; its morphology and C4 metabolism caused to its numerous consumption in wide weather and moisture condition. C4 plants due to more effective and stronger nitrogen metabolism and special physiological and biological characters, have prominent advantages (17).

Researchers due to grain nutrient value have special attention to amaranth in rotation with graminia. Amaranth grains have high proteins content and its amino acid combination (high lysine cycle) use to heighten food quality. Optimum amino acid combination in amaranth grain lets it to be used in important products such as spaghetti, biscuits, cakes, pancakes and cookies and accomplished with graminia could balance the human diets (15). Optimum combination of Amaranth grains help to prevent diabetic and heart problems and it, s high fiber and starch contents had positive effect on digestive problems (12). Afhammer (1998) also mentioned that in third world countries with high rate population growth and food deficit, combination of amaranth flour with wheat and corn flour is a suitable solution to confront hunger. Franke (1997) emphasized on importance of this plant as graminia food complementary.
High nutrient and high minerals in amaranths is one of the most important reasons to cultivate amaranth in Iran. Some of amaranths cultivars cultivated as forage, due to high production in short time. In some areas of china, amaranth cultivated as forage crop. In Peru, plants residue after grain harvest uses in animal feeding (14). Plants density depends on cultivation time, soil moisture and local condition. General rules is if soil condition is not suitable, seed amount in unit area will increases (9). According to researchers amaranths belongs to dry and semidry areas and is resistant to drought condition. This plant has growth even in poor soils, so, due to its adaption can be evaluated for cultivation in dry areas. Introduction of amaranth and cultivation this plant in poor border fields which are not suitable for other plants cause to increasing in farmers' income, making jobs and prevent of rural immigration to cities and consideration of its good world market would be able to bring foreign exchange (10). The purpose of this study was to determine optimum plant density to produce the most amaranth grain yield.

**MATERIALS AND METHODS**

This experiment was conducted in Aliabad Gorgan with 54° and 45 minutes altitude and 36° and 54 minute longitude and height was 120 meter above sea level. Before experiment, soil sample was taken from 0-30 cm depth and the results indicated that soil texture is clay-loam. Fertilization was done according to suggested results from experiment. This experiment was conducted in the form of split plot based on complete randomized block in four replications. Cultivars were located in main plots and densities were located in sub-plots. For this purpose two amaranth cultivars (*Amaranthus cruentus* and *Amaranthus hypochondriacus*) were cultivated in 4 densities (17, 35, 70 and 140 plants per square meter) with 30 cm distances between rows. Densities were adjusted with plants distances in each line. Each plot had 5 meter length and 5 rows and planting was done in 3rd July. 25 days later when plants height reached to 15 cm, some of the plants eliminated and 10 days later final density was adjusted. In order to evaluate morphological characters and shoot biomass, every 12 days sampling was done and in each stage 6 plant were selected randomize from 50 cm area. 2 side row and 50 cm of each side of each line considered as border. Irrigation was done according to soil moisture content and furrows were considered to facilitate irrigation. Sampling was done with cutting plants from 10 cm above ground and first sampling was 45 days after cultivation. Every 2 weeks sampling were continued. Leaf area was evaluated with leaf area evaluator machine (delta model) and samples were putted in 650˚C oven for 72 hours and stem dry matter and root dry matter were calculated separately. Resulted data were analyzed using SAS software. Mean comparison of evaluated traits were calculated using LSD test. For regression calculation and graph drawing used Excel software.

**RESULTS AND DISCUSSION**

The results of data variance analysis are shown in table 1. In this study genotypes were main factor (a) and density were secondary factor (b). a×b is interaction between genotype and density and significance level of evaluated traits are presented in table 2.

Table 2 presented effect of density on evaluated. In this study, effect of density on leaf area index was significant, as with increasing in plant density, leaf area index from 1.6 for 17 plant per square meter reached to 12.5 for 140 plant per square meter (table 4).Increasing density had significant effect on stem dry matter, leaf dry matter and total dry matter (table 1). Stem dry matter reached from 560 kg/ha to 4200 kg/ha for 140 plants per square meter. Also, leaf dry matter for 17 plant per square meter were 190 kg/ha which with increasing in density reached to 1130 kg/ha. Also with increasing in density total dry matter reached to 2410 kg/ha. Increasing plant density lead to increasing in grain yield as for Anna cultivar with increasing in density from 17 to 140 plants caused to increasing in grain yield from 1197 to 8447 kg/ha and for Amar cultivar, these results were 982 to 6685 kg/ha. Understanding of plants response to density is essential for earning maximum yield (15). Yet, no optimum density introduces for Amaranth and studies for optimum density were indeterminate and different experiments had different results (7, 8).
In this study, increasing plant density from 17 to 140 plant per square meter lead to increasing in dry matter which Apaza (2002) suggested that this increasing might be due to better use of space. In study of the effect of plant density and cultivar on forage sorghum yield results show that with increasing in plant density total dry matter were increased. In this study plants height were not affected by plant density. In similar study Fiterer (1996) reported that in lower densities plants had stronger stems and in higher densities plants have less branches and stems are thinner. Population pressure can limited plants height (8.18) and increasing plant density can cause decreasing branches of each plant, grain number and Consequently would reduce each plant yield (6). Henderson (2000) reported in dry regions optimum plant densities was 20-30 plants per square meter. Guilen (1999) suggested 50 plants per square meter density as optimum density in arid and semi-arid areas. However Franke (1997) suggested that compressed densities in arid regions due to competition between plants for earning water cause to reduction in grain yield and from the other side will produce thinner and longer stems. In the experiment that conducted in Pakdasht Varamin, indicated that 30 plants per square meter is optimum density for the area. In this study increasing plant density from 17 to 140 plants per square meter lead to increasing stem dry matter, leaf dry matter, total dry matter and stems became thinner which is more proper for forage use. Seeds number in per square meter depends on genotypes, environment, soil fertility and crop pattern (19).

<table>
<thead>
<tr>
<th>cultivar</th>
<th>Height (m)</th>
<th>Leaf area index (m²/m²)</th>
<th>Stem dry matter (kg)</th>
<th>Leaf dry matter (kg)</th>
<th>Total dry matter (kg)</th>
<th>Leaf to stem ratio</th>
<th>Grain yield (kg/ha)</th>
<th>Seed weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anna</td>
<td>1.41a</td>
<td>5.95a</td>
<td>1.74b</td>
<td>0.59a</td>
<td>0.97b</td>
<td>0.64a</td>
<td>0.54a</td>
<td>0.61b</td>
</tr>
<tr>
<td>Anna</td>
<td>1.54a</td>
<td>6.69a</td>
<td>1.2a</td>
<td>0.61a</td>
<td>1.27a</td>
<td>0.5b</td>
<td>0.58a</td>
<td>0.65a</td>
</tr>
<tr>
<td>17</td>
<td>1.51a</td>
<td>6.1d</td>
<td>0.56d</td>
<td>0.19d</td>
<td>0.33d</td>
<td>0.58b</td>
<td>0.18d</td>
<td>0.73a</td>
</tr>
<tr>
<td>35</td>
<td>1.39a</td>
<td>4.21c</td>
<td>1.17c</td>
<td>0.37c</td>
<td>0.62c</td>
<td>0.6ab</td>
<td>0.29c</td>
<td>0.62bc</td>
</tr>
<tr>
<td>70</td>
<td>1.44a</td>
<td>6.96b</td>
<td>1.92b</td>
<td>0.70b</td>
<td>1.13b</td>
<td>0.64a</td>
<td>0.73b</td>
<td>0.59c</td>
</tr>
<tr>
<td>140</td>
<td>1.57a</td>
<td>12.5a</td>
<td>4.02a</td>
<td>1.13a</td>
<td>2.41a</td>
<td>0.47c</td>
<td>1.04a</td>
<td>0.58c</td>
</tr>
</tbody>
</table>

Numbers with similar letters had no significant difference.
Henderson (2000) emphasized on available water which can effect on grain yield response to density. They emphasized that grain yield response to density is affected by environmental factor just like other crops like soybean. Plants responses to density might be different in different years. This response might be due to available water and higher temperature which cause optimum germination (15). In the experiment that conducted by Henderson (2000) shoot biomass, grain yield and harvest index for 7, 17 and 27 plants per square meter were the same. They found that increasing density increasing density from 7 to 27 plants per m² had no significant effect on shoot biomass, grain yield and harvest index. In this experiment Anna cultivar with 140 plants per square meter had the most dry matter production.

REFERENCES