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Response of Seed Yield and Yield Components of Amaranths (Amaranths Spp L.) Varieties Under Different plant Density at Jimma

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ABSTRACT

The overall objective of this study was to identify suitable amaranth variety/varieties and optimum plant density for high seed yield at Jimma University College of Agriculture andVeterinary Medicine, Eladaleresearch farm under irrigation condition. Complete Randomized BlockDesign with factorial arrangement combination of six varieties with three differentplant density (111,111;66,666 and47,619) plants ha^{-1})in replication of three times. Data were collected from seed yield and yieldcomponents for analysis. The data were analyzed using SAS version (9.3) software. The maximum plant height (228cm) was registered by Madiira1 variety planted at 111,111plants ha^{-1} and the thickeststem diameter (2.79 cm) was recorded from Madiira 2 variety planted at 66,666 plants ha^{-1}.The maximum biological yield dry weight per plant (152.38 g) was registered by Madiira2planted at 47,619 plants ha^{-1}whereas, the maximum seed yield per plant (34.22 g and32.9 g) were registered by varieties TZMN102-SeL and AH-NL-Sel, respectively planted at 47,619plants ha^{-1}, whereas the highest seed yield per hectare (1802 kg ha^{-1} and 1786 kg ha^{-1})were recorded by TZSMN102-Sel and AH-NL-Sel, respectively planted at 111,111 plants ha^{-1}. Therefore amaranth varieties TZSMN102-Sel and AH-NL-Sel planted at 111,111 plants ha^{-1}plant density were found comparable for seed yield. Nevertheless to prove this result, it is suggestedthat further investigation be carried out in over locations in different seasons.

Keywords: *Amaranthusspp, Plant density, nutritional, seed yield*

INTRODUCTION

Amaranth *(Amaranthus spp)*, are among several neglected indigenous food crops such as anchote (*Cocciniaabyssnica*) *(*Anonymous, 2011), yam *(Dioscoreaspp*) [1],indigenous potatoes of Ethiopia (*Plectranthusedulis*) (Vatke) Agnew (syn. *Coleus edulis*) [2] are one of the potential crops to alleviate malnutrition and sustaining food security because they are known to have high nutritional value that contributes for human health [3, 4]. Amaranths are valued for leaves and seed from the same plant allowing smallholder farmers to exploit full nutritional benefits of the plant [5]. In developing countries like Ethiopia, food insecurity, malnutrition and hunger are often the major problems [6]. Amaranths are suggested that important food source as they are accessible to low-income communities and cheap sources of protein and micronutrients [7].

Amaranth leaves and seeds are rich in iron, calcium, zinc, phenolic compounds, vitamin C, vitamin A, lipids, proteins, carbohydrates and dietary fiber [8]. In addition the seed contains high levels of lysine and sulphur-containing amino acids which are lacking in many vegetables and cereal grains [9].Unlike other vegetables an amaranth leaf also contains more calcium, phosphorus and iron [8, 10]. In addition to nutritional benefits, it is also useful in animal feeding and medicinal value[11].

Amaranth (*Amaranthus spp*) comprises about 70 species belonging to genus of Amaranthus and

Amaranthaceae family[10]. It has long been part of indigenous African agriculture [5].In Ethiopia the crop partly grows as a wild and partly cultivated both as a sole as well as intercrop with crops such as maize and sorghum in home garden [12]. [13]revealedAmaranthus*spp*cultivated and used as seed and leaf in various parts particularly in west and south western parts of Ethiopia.

Besides [14] reported that *Amaranthus spp*. widely cultivated as food crop in the humid areas of the national regional states such as Oromia, BeneshangulGumuz,Gambella and South Nation, Nationality and People. In addition [14] the estimated amaranth crop production area reaches about2,125 hectare particularly in the Southwest of the country. The name of amaranth varies from place to place across the part of Ethiopia. For instance Konso people calls it *passa* , in Afan Oromo it is called *Iyaso* and *Jolili* , while in Amharicit is called *(lishalisho*, *Aluma*and *Ferenjitef)*, *Zapina*in Arigna and *Gegabsa*in Wolayita[11].

The knowledge of the effect of various cultural practices on the physiology, growth and development of the crop is essential to select appropriate cultural practices [15]. The identification of adaptable varieties and determination of optimum plant density are therefore very important for an improved performance of the crop in terms of growth and yield [16]. Variety and plant population have been identified as the major factors that contribute to poor plant development and lower yield [17].

Despite this fact, research focus on identification of improved varieties and optimum plant density for seed yield of amaranth in Ethiopia so far less. So to fill this gap optimum planting density and improved varieties are identified as research gaps. In view of this the present study was initiated with the objective to identify best performing amaranth variety and optimum plant density for seed yield.

Materials and Methods

Description of the Study Area

The experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM)at Eladale farm from January 28 to May, 2017 under irrigation condition. The study area is located at an altitude of 1710 m above sea level, well – drained clay to silt clay with pH of 5.5 , 7^0 42’ N latitude and 36^o48’ E longitudes and in Oromia National Regional State[18]. During the experimental period meteorological conditions of the study area was characterized by receiving an average rainfall of 100.9 mm, mean average relative humidity 62.02%, the mean maximum and minimum temperature are 28. 64^oCand 11.72^oCrespectively (Jimma meteorological station,2017)

Experimental Field Preparation and Management

Seedling bed was ploughed and well prepared with the size of 1.20 m x 5.00 m while preparation of ridges was done manually by using spade and hoe. Seed bed was partitioned 15 cm row distance and seed was sown at 1.30 cm depth and soil was covered carefully to facilitate good germination of the seeds. After seeds were sown and covered with soil, mulching was applied to regulate moisture content of the soil and reduce the evaporation rate of the soil. After six days, (10% germination) mulching was removed. Irrigation water was applied twice a day, in the morning and afternoon using watering cane to facilitate the germination of the seeds.After hardening of seedlings for a week, vigorous seedlings which have 3-4 true leaves were transplanted into experiment field on January 28/2017.

Experimental Materials, Design, and Treatments

Experimental materials were obtained from Asian Vegetables Research Development Center (AVRDC)Arusha, Tanzania. The identification of the materials, variety codes, name and origin are indicated (Table 1). Random complete Bock Design (RCBD) in factorial arrangement with six varieties (UG-AM-13, UG-AM-68, TZSMN102-Sel, AH-NL-Sel, Madiira1 and Madiira2) and three different plant density (111,111; 66,666; 47,619) plants ha^{-1}) 6 x 3 (18 experimental units) with three replications having a total of 54 experimental plots were used. Each plot with a size 3.60 m x 2.10 m=7.56 m^2 and distance between each plot was 0.50 m, while distance between each block was 1.00 m, making the total experimental area used 592.64m^2.

Table1. *Variety codes, name and origin amaranth experimental materials*

No	Codes	Variety name	Origin
1	RVI00057	UG-AM-13	Uganda
2	RVI00085	UG-AM-68	Uganda
3	VI062428	TZSMN102-Sel	Tanzania
4	VI060293	AH-NL-Sel	Tanzania
5	-	Madiira 1	Tanzania
6	-	Madiira 2	Tanzania

Source: Asian Vegetable Research Development (AVRDC), Eastern and Southern Africa Regional Office Arusha, Tanzania

Data Collected

The following growth yield and yield component variables were collected from randomly sampled fully-grown five amaranth varieties during the course of study.

Plant Height (cm)

Plant height was measured from the base of the plant to the top of the inflorescence at harvesting from randomly taken fully grown five plants of the central row

Stem Diameter (cm)

Stem diameter was measured 12 cm above the ground by using of vernier caliper (Model Number: 141)

Above ground fresh biological yield (g): The total above ground fresh biological yield from five randomly selected plants at full ripening stage of seed (when plant still green) was measured using sensitive balance (Model No. CTG-6H+)

Biological yield dry weight per plant (g): It was measured by harvesting randomly sampled fully-grown five plants of the central rows at harvest and from these samples stems and leaves were separately prepared after harvest. These were chopped and dried using an oven-drying chamber as at 65°C for 48 h.

Harvest Index (hi)

The harvest index was calculated as the contribution of seeds to total above ground dry biomass from randomly selected fully matured five plants of the central rows

Seed yield (g/plant): Seed harvesting was undertaken when inflorescences change to yellow color and inflorescences of each plant were cut, threshed and seeds cleaned.

Seed yield per hectare (kg ha-1): After harvesting of plants on harvestable rows of each treatment amount of seeds recorded were converted to the hectare.

Data Analyzed

The collected data on different seed yield and yield components variables were subjected to Analysis Of Variance (ANOVA) by using SAS (version 9.3) Statistical Analysis Software. All pairs of treatment means were compared using Least Significant Difference (LSD) test at 5% level of significant. Significant treatment means were separated using Tukey test at ($P<0.05$). All data normality test and correlation coefficient among those yield and yield components variables are performed.

Results and Discussion

Yield and Yield Component Variables

Plant Height (cm)

Plant height was significant ($P<0.05$) influenced by the interaction effect of amaranth varieties and plant density. The highest plant height (228 cm) was recorded with treatment combination of amaranth varieties Madiira1along with high plant density 111,111 plants ha-1and by Madiira1with medium plant density 66,666 plants ha-1 (225 cm) (Table 2).While the least plant height was recorded by combination of amaranth UG- AM-13 variety at low plant density 47, 619 plants ha-1 (63.20 cm).

In this result plant height increased with increasing of plant density 47,619 plants ha-1 to 111,111 plants ha-1 across all amaranth varieties evaluated. This explains that as the number of plants increased in a given area the competition among the plants for nutrients uptake and sunlight interception also increased. To overcome this competition plant provides available resources for height growth rather than developments of other parts such as branches, leaves and etc. Consistent with the findings of Yarnia (2010) in this study it was found that maximum plant height was registered with high plant density in search for solar radiation.

Stem Diameter (cm)

Different varieties and plant density showed significant ($P<0.05$) differences on stem diameter. Thicker stem diameter was observed with medium plant density (66,666 plants ha-1) for UG-AM-68, Madiira1, Madiira2 and AH-NL-Sel varieties while for UG-AM-13 and

TZSMN102-Sel higher values were observed at low plant density (47,619 plants ha-1) (Table 2).

Decreasing plant density from 111,111 plants ha-1to47,619 plants ha-1 for UG-AM-13 and TZSMN102-Sel increased stem thickness from 1.86 cm – 1.94 cm and 1.27 cm – 1.91 cm, respectively. In this study, higher value for stem diameter (2.79 cm) was recorded with amaranth variety Madiira 2 and Madiira 1 at medium plant density 66,666 plants ha-1. The lowest value for stem diameter (1.27 cm) was registered with TZSMN102-Sel at 111,111 plants ha-1 plant density (Table 2). There might be a genetic differences among amaranth varieties evaluated in response to plant density. These findings corroborated with the work of previous researchers [20],[21], [22] that the lower plant densities had stronger stems and vice versa.

Above Ground Fresh Yield Biomass per Plant (g)

The interaction effect of different plant density and varieties were significant (p<0.05) (Table 2). The highest (1071.50 g) above ground fresh biological yield per plant were recorded, followed by 933.00 and 912.40 g using Madiira 1 with plant density 66,666 plants ha-1and Madiira 2 and Madiira 1 planted at 47,619 plants ha-1plants density respectively (Table 7). On the other hand 812.20 g, 719.30 g, 669.60 g and 666.00 g above ground fresh biological yield per plant were registered with Madiira 2 planted at 47619 plants ha-1, AH-NL-Sel planted at 47,619 plants ha-1and 66666 plants ha-1, and Madiira 1 planted at 111,111 plants ha-1 plant density, respectively in the same (Table 2). The current study is in line with the previous findings of [23] who reported that increasing plant density to some extent would produce higher above ground fresh biological yield per plant. The lowest above ground fresh biological yield per plant (235.70 g and 286.80 g) were obtained from UG-AM-13 and UG-AM-68 with 111,111 plants ha-1 plants density respectively (Table 2).

Table2. *Interaction effect of plant density (plants ha-1) and variety on plant height (cm) and stem diameter per plant (cm) and above ground fresh yield biomass per plant (g) performance at Jimma*

plant density (plants ha-1)	Variety	Plant height (cm)	Stem diameter (cm)	Above ground fresh yield biomass per plant(g)
111,111	UG-AM-13	91.00^{ef}	1.85^{ef}	235.70^{k}
	UG-AM-68	91.70^{ef}	1.60^{fg}	286.80^{jk}
	TZMN102-Sel	102.90^{cd}	1.26^{h}	329.70^{ijk}
	AH-NL-Sel	102.40^{cd}	1.46^{gh}	359.40^{ij}
	Madira 1	228.10^{a}	1.92^{cdef}	666.00^{ef}
	Madira 2	109.30^{c}	2.01^{cde}	474.30^{gh}
66,666	UG-AM-13	75.20g^{h}	1.88^{def}	349.30^{ijk}
	UG-AM-68	83.90 ^{fg}	2.00^{cde}	411.30^{hi}
	TZMN102-Sel	101.00^{cd}	1.68^{efg}	563.40^{fg}
	AH-NL-Sel	91.00 ^{ef}	1.88^{def}	669.60^{ef}
	Madira 1	225.00^{a}	2.27^{bc}	1071.50^{a}
	Madira 2	99.00^{de}	2.79^{a}	812.20^{cd}
47619	UG-AM-13	63.20^{i}	1.94^{cdef}	378.50^{hij}
	UG-AM-68	72.20^{h}	1.86^{def}	360.70^{hij}
	TZMN102-Sel	95.80^{de}	1.91^{cdef}	557.10^{fg}
	AH-NL-Sel	96.00^{de}	1.80^{efg}	719.30^{de}
	Madira 1	199.70^{b}	2.23^{bcd}	912.40^{bc}
	Madira 2	96.50^{de}	2.43^{ab}	933.00^{b}
Means		112.43	1.935	560.57
LSD (5%)		4.72	0.19	0.06
CV (%)		2.5	6.20	6.6

Means in Columns Followed by the Same Latter (S) are Not Significantly Different Using LSD at P = 0.05 Level of Significance

Biological Yield Dry Weight per Plant (g)

Influence of plant density and variety on biological yield dry weightper plant was significant (*P<0.05*) (Table 3). In this study the maximum biological yield dry weight was obtained from low plant density while the least biological yield dry weight was recorded from high plant density. In like manner the highest biological yield dry weight(152.38 g and 127.71 g) was registered by Madiira2 and Madiira1 with low plant density (47619 plants ha^{-1}). Following these optimum figures of 102.78 g, 98.97g 92.05 g and 91.33 g were registered for Madiira 1 and Madiira 2 with66,666 plants ha^{-1}, and AH-NL-Sel and TZMN102-Sel with 47,619 plants ha^{-1} plant density respectively (Table 3). Lowest biological yield dry weight in the range of 36.03 g to 48.60 g was recorded by UG-AM-68, TZMN102-Sel, AH-NL-Sel and UG-AM-13 with high plant density111,111 plants ha^{-1} (Table 3). In the present result, biological yield dry weight per plant of amaranth varieties were increased across decreasing from high plant density (111,111 plants ha^{-1}) to lower plant density (47,619 plants ha^{-1}). In this result when crop arranged in order of 47,619 plants ha^{-1} plant density, the crop obtains chance to produce more biological yields such as leaves per plant, robust stem, primary and secondary branches, whereas reduction of branches, leaves and stem were recorded from 111,111 plants ha^{-1} high plant density.

Findings of the present study is agreed with the

previous research results of [22] who indicated that increasing plant density per square meter increased above ground dry weight of plants per square meter but with decreasing dry biomass per plant as a result of stem became thinner. This also is in line with the [19] finding who reported that reduction of dry matter of organs significantly reduced per plant at high crop density because of probable reduction in the biomass components as result of reduction of net assimilate accumulation in plant leaves, plant height and number of lateral branches.

Table3. *Interaction effect of plant density (plants ha-1) and variety on plant height (cm) and stem diameter per plant (cm) and above ground fresh yield biomass per plant (g) performance at Jimm*

Plant density (plants ha^{-1})	Variety	Biological yield dry weight per plant (g)	Harvest index (%)
111,111	UG-AM-13	48.6^{ijk}	23.89^{de}
	UG-AM-68	36.03^{k}	14.01^{fg}
	TZMN102-Sel	45.11j^{k}	35.99^{ab}
	AH-NL-Sel	45.29^{jk}	35.52^{abc}
	Madiira 1	85.05^{def}	
	Madiira 2	60.62^{ghij}	7.28^{h}
66,666	UG-AM-13	55.7^{hij}	22.74^{e}
	UG-AM-68	69.5^{fgh}	18.57^{ef}
	TZMN102-Sel	71.44^{fgh}	36.88^{a}
	AH-NL-Sel	75.78^{efg}	34.22^{abc}
	Madiira 1	102.78^{c}	6.89^{h}
	Madiira 2	98.97^{cd}	6.91^{h}
47,619	UG-AM-13	63.53^{ghi}	29.88^{bcd}
	UG-AM-68	65.5^{gh}	29.52^{cd}
	TZMN102-Sel	91.33^{cde}	37.48^{a}
	AH-NL-Sel	92.05^{cde}	35.76^{abc}
	Madiira 1	127.71^{b}	8.24^{gh}
	Madiira 2	152.38^{a}	5.71^{h}
Means		77.1	21.94
LSD (5%)		8.89	3.424
CV (%)		7	9.4

Means in Columns Followed by the Same Latter (S) are Not Significantly Different Using LSD atP = 0.05 Level of Significance

Harvest Index (%)

Harvest index was significant (*p>0.05*) affected by variety and plant density. Maximum percentage for harvest index (36.88 %) was observed in variety TZMN102-Selplanted at plant density (66,666 plants ha^{-1}) evidence that these varieties require high plant density for seed yield. On the other hand, Madiira2 HI of 5.71%- 7.28% when the plants arranged from low plant density (47, 619plants ha^{-1}) to high plant density (111,111 plants ha^{-1}) (Table 3). Such low harvest index showed low source to sink photo-assimilation would occur or high photo-assimilation would occur in the leaves or other biological yield. This finding was confirmed with that of [24] low harvest index describes plant capacity to allocate biomass (assimilates) more into leaves and biological yields rather than reproductive parts.

Our result corresponded with the previous finding of [25] reported similar situation with maize crops that at optimum plant density significantly increased harvest index of maize. According to[25] the report possible reason for such differential performance among varieties might be because of effective use of available nutrient existed between amaranths plants transplanted under optimum plant density. In the present study, result of harvest index ranged from 5. 71 % -37.48 %, and corresponded with the research report by [26] who identified harvest index range amaranth varieties 2.6 – 33.4% with seed yield ranges of 254 – 1799 kg ha^{-1} under North Dakota soils.

Seed Yield per Plant (g)

Seed yield per plant was significant (*P<0.05*) influenced by variety and plant density. In this research, the highest seed yield per plant was obtained from low plant density. The highest seed yield per plant (34.22 g and 32.9 g) were registered by amaranth varieties TZMN102-Sel and AH-NL-Sel, respectively planted at plant density 47,619 plants ha^{-1}, whereas the lowest seed yield per plant (4.4 g) and 4.6 g) recorded by Madiira 2 and Madiira1 in the same order planted at plant density111,111 plants ha^{-1} (Table 4). In this finding, it was observed that capacity of the varieties to produce seed per plant in creasedat low plant density. The probable reason might be that at high plant density photosynthetic capability of plants might be reduced due to the low light interception by the plants as a result of shading effects because of plant crowding at high plant density that negatively affected number of inflorescence per plant.The present study result was in agreement with the finding of [22] increasing plant density per meter square increase yield per meter square but decrease yield per plant. Similar to our findings, [27] also reported those at low planting density attained larger yields and vice versa Even though there was interaction of varieties and plant density were observed, but genetic variation among potential to produce seed yield per plant was recorded between amaranth varieties. For instance from variety UG-AM-13 (8.60 -12.58 g), UG-AM-68 (6.80 g-12.67 g), TZMN102-Sel (16.22 g- 34.22 g), AH-NL-Sel (16.22 g -32.9 g), Madiira 1 (4.60 -10.50 g) and Madiira-2 (4.60-8.67 g) are obtained. Similar finding was reported by [28,5] the variation of seed yield of amaranth species was due to genetic makeup and growth environments.

Seed Yield per Hectare (Kg Ha^{-1})

There was significant (*p<0.05*) difference in seed yield per hectare among amaranth varieties in response to plant density (Table 4). In this experiment the highest seed yield per hectare (1802 kg ha^{-1} and 1786 kg ha^{-1}) was observed by TZSMN102-Sel and AH-NL-Sel, varieties respectively at high plant density (111,111 plants ha^{-1}) possibly because of it accommodated more number of plants per hectare whereas, the lowest seed yield per hectare (413 kg ha^{-1}) was recorded from Madiira 2 with combination of47,619 plants ha^{-1} plant density (Table 4). This finding is in line with previous research result of [23] who asserted that increasing plant density to a certain extent would proportionally increase seed yield. In another study, [29] also reported seed yield increased per hectare linearly within the range of densities increase.

Table4. *Interaction effect of plant density (plants ha-1) Seed yield per hectare (kg) and seed yield per plant (g)at Jimma.*

Plant density (plants ha^{-1})	Variety	Seed yield per plant (g)	Seed yield per hectare (kg)
111,111	UG-AM-13	8.6^{gh}	956^{c}
	UG-AM-68	6.8^{hi}	756^{d}
	TZMN102-Sel	16.22^{de}	1802^{a}
	AH-NL-Sel	16.07^{e}	1786^{a}
	Madira-1	4.6^{i}	511^{e}
	Madira-2	4.4^{i}	489^{e}
66,666	UG-AM-13	18.9^{cd}	839^{cd}
	UG-AM-68	19.23^{c}	844^{cd}
	TZMN102-Sel	26.35^{b}	1757^{ab}

	AH-NL-Sel	25.93^{b}	1728^{ab}
	Madira-1	7.05^{hi}	470^{e}
	Madira-2	6.75^{hi}	450^{e}
47,619	UG-AM-13	12.58^{f}	900^{cd}
	UG-AM-68	12.67^{f}	916^{cd}
	TZMN102-Sel	34.22^{a}	1629^{ab}
	AH-NL-Sel	32.9^{a}	1567^{b}
	Madira-1	10.5^{fg}	500^{e}
	Madira-2	8.67^{gh}	413^{e}
Means		15.14	1017.36
LSD (5%)		1.485	105.78
CV (%)		5.9	6.3

Means in Columns Followed by the Same Latter (S) are Not Significantly Different Using LSD at P = 0.05 Level of Significance

Summary and Conclusion

The results of present study was showed that yield components such as plant height and stem diameter were significantly difference (*P<0.05*) influenced by the interaction effect of amaranth varieties and plant density. The highest plant height (228 cm) was recorded with treatment combination of amaranth varieties Madiira1at plant density 111,111 plants ha^{-1}. In this result plant height increased with increasing of plant densityfrom47,619 plants ha^{-1} to 111,111 plants ha^{-1} across area probably due to competition among the plants for nutrients uptake and sunlight interception.

In this study the maximum biological yield dry weight per plant (152.38 g) was obtained from lowest plant density (47, 619 plants ha^{-1}) with the combination of amaranth variety Madiira2 while the least was recorded (36.03 g) from high plant density(111,111 plants ha^{-1}) with the amaranth variety UG-AM-68. In this present result, biological yield dry weight per plant of amaranth varieties was increased at low plant density (47,619 plants ha^{-1}) while decreased at high plant density (111,111 plants ha^{-1}) probably due to that at low plant density (47,619 plants ha^{-1}) crop obtain chance to produce more biological yields such as leaves per plant, robust stem, primary and secondary branches, whereas reduction of branches, leaves and stem was recorded from high plant density (111,111 plants ha^{-1}).

Seed yield per plant and hectare were significantly (*P<0.05*) influenced by variety and plant density. In this research, the highest seed yield per plant (34.22 g and 32.9 g) were registered by amaranth varieties TZMN102-Sel and AH-NL-Sel, respectively planted at low plant density (47,619 plants ha^{-1}), whereas the highest seed yield per hectare(1802 kg ha^{-1} and 1786 kg ha^{-1}) were observed by TZSMN102-Sel and AH-NL-Sel, respectively from high plant density (111,111 plants ha^{-1}).This is probably due to when plant arranged at low plant density produces more number of branches and leaves per plant this leads to produce more inflorescence used for contains more seeds per inflorescence. The other probable reason might be that at a high plant density photosynthetic capability of plants might be reduced due to the low light interception by the plants as a result of shading effects of the plant. In other hand seed yield per hectare increased because of possibly because of increased number of plants accommodated under high plant density arrangement.

The conclusion from this work is that amaranth varieties such as TZSMN102-Sel and AH-NL-Sel were recorded better seed yield per hectare when planted at plant density of 111,111 plants ha^{-1} under Jimma condition. Thus, further research work will be carried out in multi-locations in different seasons suggested to identify potential seed yields of the rest varieties.

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References

[1] M. Oli , 2006. Assessing diversity in yam (*Dioscoriea spp.*) from Ethiopia based on morphology, AFLP markers and tuber quality, and farmers' management of land races. Ph. D.

Thesis. George-August University Göttingen, Department of Crop Sciences.pp.155

[2] G. Wayessa, A. Tsegaye, B.Tesfaye and H. Mohammed, 2009. Variability and association of quantitative traits in *Plectranthusedulis* (Vatke) Agnew.*EAJS*.**3(1)**: 61-69.

[3] [3] E.G. Achigan-Dako, E.O. Sogbohossou and P, Maundu, 2014. Current knowledge on Amaranthus spp.: Research avenues for improved nutritional value and yield in leafy amaranths in sub-Saharan Africa. *Euphytic* ,**197(3):**303-317.

[4] A. S. Gerrano, S, W. J. van Rensburg, and P. O. Adebola, 2014. AGRO-Morphological Variability of Amaranthus Genotypes in South Africa.*ActaHortic* ,**10 (35)** : 183-187.

[5] O. Mbwambo, O. M. Abukutsa-Onyango, F. F. Dinssa and C. Ojiewo, 2015. Performances of elite amaranth genotypes in grain and leaf yields in Northern Tanzania. *J. Hortic.For*.**7(2):**16-23.

[6] O. Müller and M. Krawinkel, 2005.Malnutrition and health in developing countries.*CMAJ*, **173(3**): 279-286.

[7] E. Gotorand C. Irungu , 2010. The impact of Bioversity International's African leafy vegetables programme in Kenya.*IAPA*, ***28*(1):**41-55.

[8] A. Svirskis, 2003. Investigation of amaranth cultivation and utilization in Lithuania.*Agron. Res*. **1(2)**:253-264.

[9] F. I. Akaneme and G. O. Ani, 2013. Morphological Assessment of Genetic Variability among Accessions of *Amaranthushybridus.World Appl. Sci. J*. **28 (4):** 568-577

[10] Ebert, A.W., H. T. Wu and T. S. Wang, 2011. Vegetable amaranth (*Amaranthus L*.).AVRDC Publication, 11-754.

[11] A. S. Emire, S. A., and M. Arega, 2012: Value added product development and quality characterization of amaranth (*Amaranthuscaudatus* L) grown in East Africa. *Afr. J. Food Sci.*

[12] A.Martha and A. Shimelis, 2012. Value added product development and quality characterization of amaranth (*Amaranthuscaudatus* L.) grown in East Africa. *AJFST*, **3(6):** 129-141.

[13] A.B. Nigist, 2013. Growth and Yield of *Amaranthushybridus* L. sub sp. *cruentus*(L.) The.Grown on Fields Treated with Different Levels of Urea and Compost.M Sc Thesis.Addis Ababa University.

[14] A. F. Hailu , S. Alameraw and D. Belew, 2015. Cluster and Divergence Analysis in Amaranths Germplasm Accessions (Amaranthus Spp.) Under Mizan and TepiCondtions, South West Ethiopia. *International Journal of Pure and Applied Sciences and Technology*, *28*(1), p.34.Brien, G. K. and M. L. Price, 2008.Amaranth Grain & Vegetable types, (eds. by L. Yarger). North Fort Myers, USA.

[15] W.F. Whitehead , J. Carter and P. B. Sigh, 2002. Effect of planting date on vegetable Amaranth leaf yield, plant height and gas exchange.*Hort Science* .**37(5)**:773-777.

[16] T. L. Henderson, L.B. Johnson, and A .A. Schneiter, 2000. Row spacing, plant population, and cultivar effects on grain amaranth in the northern Great Plains.*Agron J.* **92(2)**:329-336.

[17] E .M. Madisa, T. Mathowa , C. Mpofu and T. A. Oganne, 2015. Effects of Plant Spacing on the Growth, Yield and Yield Components of Okra (*Abelmoschusesculentus* L.) in Botswana.*AJEA*.***6*(1):**7-14.

[18] G. Merkebu and B. Techale , 2015. Growth and Yield of Rice (*Oryza sativa* L.*)* as Affected by Time and Ratio of Nitrogen Application at Jimma, South-West Ethiopia .*IJAIR*, **4*(*1):** 176.

[19] M. Yarnia. 2010. Sowing Dates and Density Evaluation of Amaranth (Cv. Koniz) as a New Crop**.** *Adv. Environ. Biol*. **4(1)**: 41-46.

[20] D.M, Gimplinger , G. Schulte auf'mErley , G. Dobos and H.-P. Kaul. 2008. Optimum crop densities for potential yield and harvestable yield of grain amaranth are conflicting. *Europ.J. Agronomy*, ***28*(2)**: 119-125

[21] R.F. Guillen-Portal , D. D. Baltensperger and L. A. Nelson, 1999. Plant population influence on yield and agronomic traits in Plainsman grain amaranth.*Perspectives on new crops and new uses. ASHS Press, Alexandria, VA*, Pp. 190-193.

[22] A. Pourfarid , B. Kamkar and A. G. Akbari , 2014. The effect of density on yield and some agronomical and physiological traits of Amaranth) Amaranthus spp. *Intl J Farm &Alli Sci*. **3(12):** 1256-1259.

[23] T.A.J. Olofintoye, A. Y. Abayomi and O. Olugbemi , 2015. Yield responses of grain amaranth (*Amaranthuscruentus* L.) varieties to varying planting density and soil amendment.*Afr. J. Agric. Res*. **10(21):** 2218-2225.

[24] A.Wnuk , G.A, Górny ,J, Bocianowski and M, Kozak, 2013. Visualizing harvest index in crops.*CBCS*.**8(2)**: 48–59.

[25] M. Shafi, J. Bakht ,S. Ali, H. Khan, M.A. Khan and M. Sharif, 2012. Effect of planting density on phenology, growth and yield of maize (*Zea mays* L.*).Pak J Bot*. **44(2)**:691-696.

[26] T.L. Henderson, L.B. Johnson, and A .A. Schneiter, 1998. Grain amaranth seeding dates in the northern great plains. *Agron .J.* ***90*** **(3)**:339-344.

[27] K.G. Brien and M. L. Price, 2008. Amaranth Grain & Vegetable types, (eds. by L. Yarger).North Fort Myers, USA.

[28] S. Thanapornpoonpong, W. Somsak , E. Pawelzik . and S. Vearasilp, 2007. Yield component of amaranth (Amaranthus spp.) grown under northern Thailand irrigated area. In Proc. Tropentag 2007, Conference on International Agricultural Research for Development.,Witzenhausen, Germany . Pp 9-11

[29] V. Apaza-Gutierrez , A. Romero-Saravia, R. F. Guillen-Portal and D.D Baltensperger, 2002. Response of grain amaranth production to density and fertilization in Tarija, Bolivia.Trends in New Crops and New Uses. ASHS Press, *Alexandria*, 107-109.

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