Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.8, No.16, 2018 www.iiste.org

Performance of Amaranth (Amaranthus Cruentus L.) Genotypes for Leaf Yield in Ethiopia

Yosef Alemu[1*] Samuel Tilahun[2] Habtam Setu[3] Selamawit Ketema[1] Melkamu Hinsermu[1]
Jibicho Geleto[1] Tesfa Binalfew[1] Shimelis Aklilu[1] Gebeyehu Wendimu[1]
1.Melkassa Agricultural Research Center, Melkassa, Ethiopia
2.Holleta Agricultural Research Center, Holleta, Ethiopia
3.Assosa Agricultural Research Center, Assosa, Ethiopia

Abstract
Background: Production and utilization of Amaranth (Amaranthus spp.) is not well known in Ethiopia. Limited research work has been done so far to develop improved varieties and agronomic practices. The present experiment was conducted to evaluate vegetable amaranth genotypes for adaptation, leaf yield and quality. **Materials and Methods**: Five genotypes were evaluated at three locations Melkassa, Holleta and Assosa Agricultural Research Centers in 2015 and 2016 under rainfed and irrigated conditions. The experiment was laid out in RCBD with three replications with plot size of $6m^2$. Data on quantitative and qualitative characters were collected and subjected to environment wise analysis of variance followed by pooled analysis. **Results**: Genotypes were diverse in vegetative, leaf characteristics and yield responses. The overall combined analysis in the rainfed and irrigated conditions across locations and years showed significant difference in total leaf yield ($p<0.01$)among genotypes. Genotype Madiira-II was the superior genotype interms of leaf yield (15.82 t ha^{-1}) followed by genotype AC-NL (14.65 t ha^{-1}). There was also significant difference among genotypes in plant height, leaf length and leaf weight at $p<0.01$. The highest plant height was recorded from genotype Mandiira-II followed by AC-NL. **Conclusions**: In general, genotypes Mandiira-II and AC-NL were found superior in leaf yield and leaf characteristics and thus identified for release to be used as alternative vegetable source in the country.
Keywords: Amaranth genotypes, Leaf characters, Leaf yield , Performance

1. Background

The genus *Amaranthus* comprises 70 species among which 17 are vegetable amaranths with edible leaves, and three are grain amaranths with edible seeds while the rest are cultivated as ornamental plants and weeds. It is one of the oldest food crops in the world, with evidence of its cultivation reaching back to 6700 BC (Itúrbide and Gispert, 1994).

Amaranthus is considered one of the most commonly produced and consumed indigenous vegetables on the African continent (Grubben and Denton, 2004). Although not available in agricultural statistics, it may be the most popularly grown vegetable crop in the tropics. It has given considerable attention in many countries because of the high nutritional content in vege was applied table and grain (Srivastava, 2011). In the hot, humid regions of Africa, South East Asia (Malaysia and Indonesia), Southern China, Southern India, and the Caribbean, it is grown as soup vegetables or boiled salad greens. In Kenya, it is largely grown especially by women as source of income and nutrition (IPGRI, 2003). In Ethiopia, however, it is known locally and consumed in few parts of the country.

Its leaves and tender stems are highly nutritious rich in protein, minerals such as calcium, iron, vitamins A, C and K, riboflavin (B_2), niacin (B_3), vitamin B6 and folate. The crop is also used as a component for pharmaceutical and cosmetic industry. It is an annual fast-growing crop on a wide range of soils and climates (Wambugu, and Muthamia, 2009). It is most suitable for growing in small kitchen garden as it requires less attention and cultivation practices. It fits well in crop rotation because of its very short duration and high yield of edible matter per unit area.

The young leaves are boiled and consumed as a vegetable such as spinach. The seed can be popped and consumed as qollo (a snack food), while the flour from the roasted or popped seed is used to prepare gruel, besso (a snack food), the flour can be mixed with teff to make injera. Moreover, *Amaranthus* grain is used to prepare bread, spaghetti, breakfast foods, various cakes and cookies.

Production and utilization of the crop is not well known in Ethiopia. This might be due to lack awareness in importance of the crop, utilization, lack of improved varieties and agronomic practices. It is important to critically evaluate the available germplasms and selection of the improved genotypes with high leaf yield potential and good quality. The present experiment was undertaken to evaluate Amaranth genotypes for their adaptation, leaf yield and quality.

2. Material and methods

Multi location variety trials were conducted in 2015 and 2016 using five genotypes (Madiira-I, Madiira-II, AC-

NL, AM-25 and AH-TL) introduced from AVRDC. Field trials were conducted at three locations Melkassa, Holleta and Assosa Agricultural Research Centers (Table 1). The trials were conducted under rainfed conditions except at Melkassa Agricultural Research Center in 2016 conducted during the dry season using irrigation.

Seedlings were raised in seed bed and transplanted to the field after three weeks when seedlings produced 3-4 true leaf. The experiment was laid out in RCBD with three replications in plot size of $6m^2$. Each plot comprised six rows of 3m length with the spacing of 40cm x 20cm x 20cm between water furrows, rows and plants respectively. Fertilizers, DAP at the rate of 200 kg/ha was applied at planting and split application of Urea at a rate of 100kg/ha, 50% at 15-20 days after transplanting and the rest 50% at first harvesting was applied. All necessary cultural practices were applied to all plots uniformly.

Table 1: Altitude, rainfall, soil type and maximum and minimum temperature values of experiment sites

Location	Altitude (m)	Annual Rain fall (mm)	Soil type	Temperature (^{o}C) Min	Max
Melkassa	1550	818	Sandy loam	14	29
Holleta	2400	1144	Nitosols and Vertisols	6	22
Assosa	1580	1275	Dystric nitosols	14	39

2.1. Data collected and analysis

Data on quantitative traits (plant height, leaf yield, leaf length, leaf diameter, leaf number per plant, petiole length and leaf weight and qualitative traits (leaf color, branching index, spines in leaf axil, leaf margin, stem pigmentation, growth habit, stem pubescence, prominence of leaf veins, leaf color, petiole pigmentation and leaf shape) were collected from the plot following descriptors developed by the International Plant Genetic Resource Institute (IPGRI, 2003).

Quantitative data was subjected to environment wise (location) analysis of variance followed by pooled analysis. To compute the pooled ANOVA GENES 7.0 computer program (GENES, 2016) was used.

3. Results and Discussions

3.1. Leaf Yield

The overall combined total leaf yield in the rainfed and irrigated conditions across locations and years was highly significant among genotypes (*p<0.01*) (Table 2). The total leaf yield ranged from10.08 t ha^{-1} to 15.82 t ha^{-1}. Madiira-II was superior interms of leaf yield (15.82 t ha^{-1}) among genotypes followed by genotype AC-NL (14.65 t ha^{-1}); whereas AM-25was the least performing genotype (11.18 t ha^{-1}). Madiira -II and AC-NL gave 25.3% and 16% yield advantage over the grand mean (12.63 t ha^{-1}). Similarly, Omary Ijumaa Mbwambo (2013) reported significant difference in leaf yield among genotypes with the range of 12 t ha^{-1} to 21 t ha^{-1} from his studies on morphological characteristics, growth and yield of elite grain and leaf amaranth in AVRDC-RCA research station for two seasons in 2012.

The combined analysis for the two years 2015 and 2016 in the rainfed condition showed significant difference among the genotypes (*p<0.01*). The green leaf yield ranged from 10.18 t ha^{-1} to 16.59 t ha^{-1}. The highest yield was obtained from genotype Madiira-II (16.59 t ha^{-1}) followed by AC-NL (14.39 t ha^{-1}). The lowest yield was obtained from cultivar AM-25 (10.18 t ha^{-1}).

In 2015 rainfed cropping season, at Melkassa and Holleta agricultural research centers, there was highly significant difference among the test genotypes in leaf yield (*P<0.01*).The leaf yield ranged from 10.69 t ha^{-1} for genotype AH-TL to 20.28 t ha^{-1} for genotype Madiira-II. Similarly, in 2016 cropping season at Melkassa and Assosa there was significant difference among the genotypes in leaf yield (*p<0.05*). The leaf yield ranged from 8.49 t ha^{-1} for AM-25 to 12.89 t ha^{-1} for Madiira-II. According to Omary Ijumaa Mbwambo (2013) finding, amaranth genotypes responded differently in leaf yield to different seasons; and the leaf yield ranged from 16.55t ha^{-1} to 20.95t ha^{-1} and 6.25t ha^{-1} to 13.67t ha^{-1} for the first and second season respectively.

There was also significant difference in the total green leaf yield among locations in both 2015 and 2016 years. The highest leaf yield was obtained at Melkassa 15.61 t ha^{-1} and 16.12 t ha^{-1} in 2015 and 2016 respectively. Among the two years, 2015 (14. 37 t ha^{-1}) was higher yielding environment than 2016 (10.78 t ha^{-1}). This variation was due to the diversity between the genetic material and the test location.

The leaf yield performance of genotypes at Melkassa Agricultural Research Center under irrigated condition in 2015 was not significant (*p<0.05)* which ranged from 9.65 t ha^{-1} for genotype AM-25 to 15.69 t ha^{-1} for genotype AC-NL.

Table 2: Total leaf yield (t ha^{-1}) of Amaranth genotypes at Melkassa, Holleta and Assosa Agricultural Research Centers, under rain fed and irrigated conditions in 2015 and 2016.

Genotype	Rain fed							Irrigated	Over all mean
	2015			2016			Combined across years	2016	
	Melkassa	Holleta	**Combined**	Melkassa	Assosa	**Combined**		Melkassa	
Mandiira-I	11.2^{c}	12.02^{c}	**11.61^{c}**	15.64	5.73^{a}	**10.68^{ab}**	11.15^{c}	12.65	**11.45^{b}**
Mandiira-II	18.11^{a}	22.44^{a}	**20.28^{a}**	19.59	6.21^{a}	**12.89^{a}**	16.59^{a}	12.73	**15.82^{a}**
AC-NL	18.23^{a}	16.5^{b}	**17.37^{b}**	15.86	6.95^{a}	**11.41^{ab}**	14.39^{b}	15.69	**14.65^{a}**
AM-25	17.02^{a}	6.73^{d}	**11.87^{c}**	14.71	2.27^{b}	**8.49^{b}**	10.18^{c}	9.65	**10.08^{b}**
AH-TL	13.49^{b}	7.89^{d}	**10.69^{c}**	14.81	6.02^{a}	**10.42^{ab}**	10.56^{c}	13.46	**11.18^{b}**
Mean	15.61^{a}	13.12^{b}	**14.37**	16.12^{a}	5.44^{c}	**10.78**	12.57	12.84	**12.63**
CV	5	15	**10.47**	19.53	31	**22.38**	15.82	20.32	**18.14**
F-test	**	**	**	NS	*	*	**	Ns	**
LSD	15.6	37.821	**18.241**		31.63	**29.26**	16.44		**16.81**

3.2. Leaf characters

3.2.1. Quantitative leaf characteristics

The combined analysis in the rainfed and irrigated conditions across locations and years showed significant difference among genotypes in plant height, leaf length and leaf weight at $p<0.01$(Table 3). The highest plant height was recorded for genotype Madiira-II (106.77cm) followed by AC-NL (95.62cm). Regarding leaf length, genotype Madiira-I (15.67cm) gave the highest leaf length followed by Madiira-II (15.27cm). The fresh leaf weight ranged from 53.51g for genotype AM-25 to 78.3g for Madiira-II. Similarly, Omary Ijumaa Mbwambo (2013) reported significant difference in leaf length among genotypes pooled across seasons; and ranged from 18.09 cm to 20.55cm. There was no significant difference in leaf width, petiole length and leaf number per plant ($p<0.05$) among genotypes. But, Omary Ijumaa Mbwambo (2013) reported significant difference in leaf width among genotypes pooled across seasons; and ranged from 8.52cm to 11.19cm.

Table 3: Leaf characteristics of Amaranth genotypes across locations in 2015 and 2016.

Genotypes	PH	LL	LW	PL	LN	LWT
Madiira-I	92.15^{ab}	15.67^{a}	4.99	10.3	79.87	67.1^{abc}
Madiira-II	106.77^{a}	15.27^{ab}	5.67	9.58	57.85	78.3^{a}
AC-NL	95.82^{a}	13.82^{bc}	6.65	10.23	58.85	69.6^{ab}
AM-25	79.82^{b}	11.68^{d}	5.91	8.77	44.84	53.51^{c}
AH-TL	80.5^{b}	12.23^{cd}	6.09	9.63	59.1	57.27^{bc}
Mean	91.01	13.86	5.86	9.71	60.66	65.15
CV	18.12	22.93	22.93	14.65	35.7	28.72
F-test	**	**	NS	NS	NS	**
LSD	12.33	1.62	-	-	-	13.83

Note: PH=Plant height(cm), LL= Leaf length(cm), LW= Leaf width (cm), PL=Petiole length(cm), LN=Leaf number per plant, LWT= Single fresh leaf weight(gm).

3.2.2. Qualitative leaf characteristics

The qualitative leaf characteristics of Amaranth genotypes are presented in Table 4. All genotypes were similar in branching index, spines in leaf axil, leaf margin, growth habit, leaf color and petiole pigmentation. In terms of stem pubescence, 40% of the genotypes had low and none stem pubescence and 20% had conspicuous leaf pubescence. Moreover, there was high variation among the genotypes in terms of leaf veins, 60% of the genotypes had rogose and 40% smooth leaf veins prominence. In terms of leaf shape, 20% had lanceolate whereas 40% had rhombic and ovatainate leaf shape.

Table 4: Qualitative leaf characteristics of Amaranth genotypes.

Genotype	Branching index	Spines in leaf axil	Leaf margin	Stem pigmentation	Growth habit	Stem pubescence	Prominence of leaf veins	Leaf color	Petiole pigmentation	Leaf shape
Madir -I	branches all along the stem	absent	adulate	Green	Erect	conspicuous	Rogose	Green	green	Lanceolate
Madir -II	branches all along the stem	absent	entire	Green	Erect	Low	Rogose	Green	green	Rhombic
AC-NL	branches all along the stem	absent	entire	Green	Erect	Low	Rogose	Green	green	Ovatainate
AM-25	branches all along the stem	absent	entire	-	Erect	none	smooth	Green	green	Ovatainate
AH-TL	branches all along the stem	absent	entire	Green	Erect	none	smooth	Green	green	Rhombic

4. Conclusion and Recommendation

This experiment was undertaken to evaluate Amaranthus genotypes for their adaptation, leaf yield and quality. From this experiment the Amaranthus genotypes were found diverse in vegetative, leaf characteristics and yield potential under Ethiopian conditions. The overall combined analysis in the rain fed and irrigated conditions across locations and years showed highly significant difference among genotypes in total leaf yield ($p<0.01$). The performance of genotype Madiira-II was the superior in terms of leaf yield (15.82 t ha^{-1}) followed by AC-NL (14.65 t ha^{-1}). There was also highly significant difference at p<0.01 among genotypes in plant height, leaf length and leaf weight. The highest plant height was recorded from the same genotypes Mandiira-II and AC-NL. In general, genotypes Mandiira-II and AC-NL were found superior in leaf yield and leaf characteristics to be used as an alternative vegetable source in the country.

5. Acknowledgements

The authors acknowledge Ethiopian Institute of Agricultural Research (EIAR), Melkassa Agricultural Research Center (MARC) for financial support and facilitation. The authors are also grateful for researchers and technicians of vegetable research program at Kulumsa ,Debrezeit, Tepi, Pawe and Wondogenet Agricultural Research Centers for managing the variety verification trials.

6. References

GENES. (2016), "GENES statistical software version 6.0. for quantitative genetics and Experimental Statistics"

Grubben, GJH., Denton, OA. (2004), "Plant Genetic Resources of Tropical Africa 2: Vegetable", Wageningen, Netherlands: PROTA Foundation.

IPGRI. (2003), "Rediscovering a forgotten treasure", IPGRI Public Awareness Forum. Nairobi, Kenya. IPGRI/National Museums of Kenya. http//ipgripa. grinfo.net/index.php?itemid=101

Itúrbide, GA., Gispert M. (1994), "Grain amaranths (*Amaranthus spp.*)", In: Neglected crops: from a different perspective. J. E. Hernándo Bermejo and León, J. (Eds), Plant production and Protection series No. 26. FAO, Rome, Italy. p. 93-101.

Onyango, MC., Imungi, JK. (2007), "Postharvest handling and characteristics of fresh-cut traditional vegetables sold in Nairobi-Kenya", In: Crop research, technology dissemination and adoption to increase food supply, reducing hunger and poverty in Africa. 8th African Crop Science Conference Proceedings, Part 3 and 4, 27-31, El-Minia, Egypt.

Srivastava. (2011), "Nutritional quality of some cultivated and wild species of amaranthus L.", International Journal of pharmaceutical sciences and research, Vol. 2(12)

Wambugu, PW., Muthamia, ZK. (2009), "The state of plant genetic resources for food and agriculture in Kenya": KARI, National Gene bank of Kenya.