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Effect of Plant Population and Variety on Yield and Yield Related Traits of Sweet Potato (*Ipomea Batatas*) Under Irrigated Areas of Middle Awash Valley of Ethiopia

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This experiment was conducted at Werer Agricultural research center for two consecutive years (2011/12-2012/13) with the objective of determining optimum plant population of sweet potato for irrigated areas of middle Awash valley. Two varieties of sweet potato; Koka-6 and Kudadie having different growth morphology and factorial combination of inter row (60, 80, 100, 120 cm) and intra row (30, 40, 50 cm) spacing were evaluated in split plot design replicated three times with varieties as a main plot and spacing as a sub plot. The combined analysis of variance over two years revealed that tuber, above ground biomass and average tuber weight were not significantly (p<0.05) affected by variety. However, plant spacing from 60*30 cm to 120*50 cm significantly (p<0.01) affected marketable tuber yield and average tuber weight. Lower marketable tuber yield were recorded when plant population reduced from 60*30 cm to 120*50 cm spacing. The highest tuber yield (16.6 t/ha and 15.7t/ha) were obtained at a closer spacing of 60*40 and 60*30 cm, respectively, having higher yield advantage of 26.9% than the spacing so far used in the area. The lowest yield (9.9t/ha) was obtained at wider spacing of 120*40 cm. A closer spacing of 60*30 cm had the lowest unmarketable yield (10.4t/ha). Greater above ground biomass yield (38.6t/ha) was obtained at wider spacing of 120*30 cm and lowest yield (31.1t/ha) was obtained at closer spacing of 60*30 cm. In general, appropriate plant population is critical to maximize sweet potato yield. This finding disproved the spacing so far used in the middle Awash valley (100*40 cm between rows and plants, respectively). Hence, it is necessary for agro-pastoralist in middle Awash valley and areas with similar agro-ecology to use a spacing of 60*30 cm for higher marketable yield.

Key words: plant population, yield, variety, tuber size

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INTRODUCTION

Sweet potato (*Ipomoea balatas* L.) is one of the most widely grown root crops in the world and an important crop for food security. It has the ability to produce high yield in marginal land with little investment. It is a short duration crop and can be eaten in various food forms (Alvin et al., 2007). It is widely adapted in the tropics, sub-tropical and warm temperate regions where it is grown by smallholder farmers on marginal land, tolerant of a wide range of edaphic and climatic conditions and grown with limited inputs (Muluken and Abiyot 2015, and Wassu et al., 2015). Despite the crop is the third most important root crop next to Enset [*Ensete ventricosum* (Wele) Cheesman] and Potato (*Solanum tuberosum* L.), its productivity in farmers' field is considered very low. Sweet potato covers about 81000 hectares of land in Ethiopia with an average national yield of about 9 t ha^{-1} on farm and 25-36 t ha^{-1} on research centers (CSA, 2011). This is mainly because of unavailability of improved cultivars, proper agronomic practice, pest and poor management practices.

The agro pastoralist in the middle Awash valley cultivate sweet potato for dual purpose, the edible tubers as human food and the above ground biomass for animal fodder. Research work on sweet potato at Werer agricultural research center dates back to the 1970's focusing on varietal improvement, optimum planting date and determining the amount and frequency of irrigation water for high and quality tuber yield. However, no research has been done to determine the optimum plant population in a given area. The spacing used so far (i.e. 100 cm x 40 cm between rows and plants, respectively) is the one recommended for Nazareth area (rift valley) and similar agro ecologies, which is entirely different from middle awash valley. The growth habit, morphology of the crop as well as environmental condition influence sweet potato yields to a greater extent. As a result, recommendation on plant population for one cultivar in a particular environment may not be appropriate to another, or plant population of different cultivar may not be suitable to that particular environment. Therefore, this study was initiated with the objective to determine optimum plant population and to recommend appropriate spacing that can increase yield and quality of sweet potato production in irrigated areas of middle awash valley and others areas with similar agro-ecology.

MATERIALS AND METHODS

The study was conducted at Werer agricultural research center for two consecutive years (2011/12-2012/13), under irrigation. The area has an altitude of 740 meter above sea level, m.a.s.l, with 34 °C mean annual temperature and 560 mm annual rainfall at 2600 mm evapotranspiration. Two varieties of sweet potato; Koka-6 (an intermediate vine and medium maturing cultivar) and Kudadie (erect short vine and early maturing cultivar) with a factorial combination of four inter row spacing (60, 80, 100 & 120 cm) and three intra-row spacing (30, 40 & 50 cm) were compared in split-plot design replicated three times. Varieties were considered as a main plot and spacing as a sub plot factor. The plot size was 6 m x 5 m. All other cultural practices were applied as per the standard recommendation. Roots were marketable if they fall between 100 and 500 g exclusively, otherwise considered unmarketable. Data were collected on yield and quality parameters (tuber and above ground biomass yield, average number of roots/plant, average root weight. Collected data was subjected to analysis of variance using Statistical Analysis Software (SAS, 2004).

RESULTS AND DISCUSSION

The result reveled that cultivation year was significantly different among tested parameters except unmarketable yield, above ground biomass yield and average root number per plant (Table 1). This indicates inconsistency of those parameters over the years. The presence of this considerable variation over the year might be due to the variation in soil fertility and salinity effect. The experimental land in 2012/13 cropping season was highly salt affected than the experimental land in 2011/12 and the lowest yield was recorded in 2012/13 as compared to 2011/12 yield. The analysis of variance indicated no significant difference among varieties for all tested yield and yield component parameters (Table 1). This is an indication that the two varieties are not significantly different from each other in yield response and other factors even though there is difference in their growth morphology, which helps the grower to use similar cultural practices (plant population) for both varieties.

Spacing showed significant difference (p<0.05) for tested parameters except above ground biomass yield and average root number per plants while interaction between variety and spacing had none significance for all tested parameters except average root weight (Table 2). However, the trend indicated that average root weight increased with increased plant spacing. Varying plant spacing from 60*30 cm to 120*50 cm significantly affecte total tuber yield (p<0.05), marketable tuber yield (p<0.01), unmarketable tuber yield (p<0.01) and average tuber weight (P<0.01) while there is none-significant difference in root number per plant with variation of plant spacing (Table 2). The result in a series of experiments indicated that unmarketable tuber yield was found higher than the marketable tuber yield primarily due to oversized tubers (>500 g) in wider plant spacing. Analysis of variance showed that total tuber yield increase with increasing plant spacing from 60*30 cm to 80*30 cm while from

Table 1. ANOVA table for mean square of yield and yield components of two sweet potato varieties evaluated at Werer (combined mean of 2011/12 and 2012/13), Ethiopia.

Source of variation	df	Mean squares					
		Total tuber yield (t ha^{-1})	Marketable tuber yield (t ha^{-1})	Unmarketable tuber yield (t ha^{-1})	Green top yield (t ha^{-1})	Average Root weight (kg)	Root number per plant
Year	1	12287.89**	11122.61**	65.48^{NS}	175664.54**	9.82**	0.81^{NS}
Variety	1	2.39^{NS}	315.27^{NS}	0.29^{NS}	63.64^{NS}	0.69^{NS}	3.48^{NS}
Spacing	11	394.49*	592.86**	182.17**	629.48^{NS}	0.63**	1.31^{NS}
Variety*Spacing	11	240.27^{NS}	27.40^{NS}	61.14^{NS}	423.88^{NS}	0.49**	3.02^{NS}
Error	88	222.48	94.57	72.67	415.66	0.20	2.35
Total	143	13147.5	12152.7	381.76	177197.2	11.83	10.97

*, **, Indicates significant at 0.05 & 0.01 probability level respectively, NS- non significant

Table 2. Combined effect of varieties and spacing on yield and yield components of two sweet potato varieties evaluated at Werer (2011/12-2012/13), Ethiopia.

Factors	Total yield (t ha^{-1})	Marketable yield (t ha^{-1})	Unmarketable yield (t ha^{-1})	Green top yield (kg ha^{-1})	Av. root weight (kg)	Root No. /plant
Varieties						
Koka-6	26.77a	14.12a	12.60a	341.26a	1.89a	6.6a
Kudadie	26.68a	13.19a	13.48a	337.12a	1.76a	6.9a
Mean	26.73	13.65	13.04	339.19	1.83	6.75
LSD (5%)	NS	NS	NS	NS	NS	NS
Spacing (cm)						
60*30	26.12e	15.75bc	10.37g	310.70g	1.41b	7.15a
60*40	28.71b	16.64a	12.08f	328.80f	1.63ab	6.67a
60*50	26.59de	14.77d	11.98f	340.30de	1.73ab	6.40a
80*30	30.46a	16.20ab	14.28ab	333.90ef	1.63ab	6.82a
80*40	27.94c	15.56c	12.41f	317.70g	1.78ab	6.46a
80*50	27.48c	13.62e	13.86cd	344.30d	1.76ab	6.88a
100*30	26.19e	13.88e	12.31f	372.70b	1.77ab	6.67a
100*40	26.61de	13.11f	13.53df	333.20ef	1.97ab	6.47a
100*50	25.49f	11.29h	14.04bc	334.90ef	2.07ab	7.48a
120*30	26.87f	12.29g	14.59a	386.40a	1.86ab	6.95a
120*40	23.68h	9.91i	13.30e	354.50c	2.20a	6.38a
120*50	24.56g	10.84h	13.70c-e	312.80g	2.11a	6.68a
Mean	**26.73**	**13.65**	**13.04**	**339.18**	**1.69**	**6.75**
Lsd (5%)	**5.99**	**4.84**	**4.53**	**7**	**0.59**	**1.08**
CV (%)	**17.65**	**22.52**	**20.66**	**19.01**	**24.72**	**22.7**

Means followed by the same letter is not significantly different from each other based on DMRT, *, **, Indicates significant at 0.05 & 0.01 probability level respectively, NS- non significant

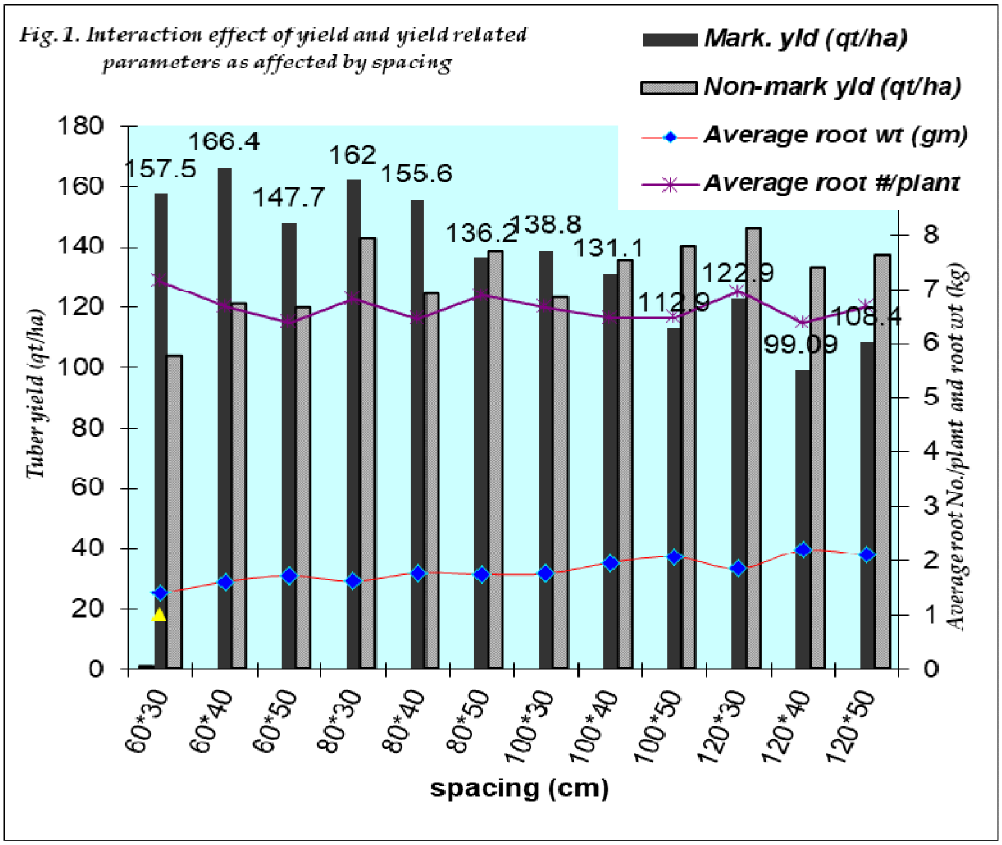

Figure 1. Interaction effect of yield and yield related parameters as affected by spacing.

80*40 cm yield has inversely proportional with plant spacing. This result is in partial agreement with (Alvin et al., 2007) who reported that increasing plant population resulted in increasing yield of tuber per area. Similarly, (Jamaati-e-Somarin et al., 2009) also reported that with increasing planting population, tuber yield per plant decreased while it increased per unit area. Decrease in mean tuber size due to increase in plant population was probably as a result of available nutrient and intra competition for other growth factors (Berga and Caeser, 1990).

Marketable tuber yield was significantly reduced when plant spacing increased from 60*30 cm to 120*50 cm, where the highest marketable tuber yield (16.6 t ha^{-1} and 15.7 t ha^{-1}) was obtained at closer spacing of 60*40 cm and 60*30 cm and the lowest yield (9.9 t ha^{-1}) at a wider plant spacing (120*40 cm). On the other hand unmarketable yield showed positive relation with increasing plant spacing and the highest (14.3 t ha^{-1}) was recorded at a wider spacing of 80*30 cm and lowest (10.4 t ha^{-1}) at a closer spacing of 60*30 cm. The root weight was large in size (2200 g) at wider spacing of 120*40 cm than at closer spacing of 60*30 cm (1408 g). Higher marketable yields can be achieved with closer plant spacing.

Closer plant spacing increased the yields of the most desired grade size and gives the grower the greatest monetary return. This study results revealed that there were strong association of root size which was higher in wider spacing. This result mainly happened due to the fact that wider spacing favors the possibility of few tubers to bulk without competition and became bigger in size, which reduce tuber yield at wider spacing. (Table 2, Figure 1). It was also observed that weed infestation tends to increase with increased plant spacing and more weed infestation was observed in the wider spacing than at closer plant spacing. This result is in agreement with Onunka et al., 2011 who reported that the lowest size of root was obtained from closer spacing. It showed that closer spacing produced sweet potato tubers with comparatively less weights. This study result also supported by (Teshome et al., 2011) who reported that a higher plant population led to a decline in the number and corresponding weight of large roots but the reverse was true for medium-sized and small roots. (Mooi and Tan, 2001) also reported that yields of sweet potatoes generally increased as in-row plant spacing reduced.

The main effect of spacing, variety and interaction effect of spacing and variety revealed non-significant difference on above ground biomass while the highest was at wider spacing (3.86 t ha^{-1}) of 120*30 cm than at closer spacing of 60*30 cm (3.11) t ha^{-1}. This result is consistence with

(Tenaw et al., 2001) who reported branching negatively associated to plant density and root yield. They also indicated that when there was high plant density the prevalence of inter and intra row competition for light, moisture and nutrient resulted to less number of branches which may be resulted to less above ground biomass at closer spacing.

CONCLUSION

Sweet potato needs optimum spacing (spatial arrangement) which enables growers to produce high quality tubers yield. There was a difference in yield, tuber size and uniformity with various combination of inter and intra spacing. Varieties gave better yield at closer spacing of between rows and between plants. In general, the findings of this experiment indicated that for better yield and quality of sweet potato production in middle Awash valley and areas with the similar agro-ecology has to employ closer spacing of 60 cm between rows and 30-40 cm between plants depending on the climate and soil fertility of the area. The spacing previously recommended for Nazareth areas (rift valley) for irrigated agriculture at spacing of 100*40 cm between rows and plants, respectively, was not found commendable to use in middle Awash valley. Similarly, this finding also disproved the spacing so far used in irrigated Middle Awash Valley . Therefore, it is essential for agro pastorals in middle Awash valley and other similar agro-ecology to use this recommended plant population.

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CONFLICT OF INTEREST STATEMENT

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

REFERENCES

Alvin, J.B., Mitchell, P.D., Copas, M.E. and, Drilias, M.J. 2007. Evaluations of the Effect of Density were on Potato Yield and Tuber Size Distribution. Crop Science, 47:2462-2472.

Berga L. and K. Caeser. 1990. Relationships between numbers of main stems and yield components of potato (Solanum tuberosum L) as influenced by different day length. Potato Res. 33: 257-267.

CSA (Central Statistical Authority). 2011. Ethiopian agricultural sample enumeration. Statistical bulletin, 146, Addis Abeba, Ethiopia.

Jamaati-e-Somarin, S., Tobeh A., Hassanzadeh M., Hokmalipour S. and Zabihi- ahmoodabad R. 2009. Effects of plant density and nitrogen fertilizer on nitrogen uptake from soiland nitrate pollution in potato tuber. R. J. Environ. Sci., 3(1): 122-126.

Mooi K.C. and Tan S.L. 2001. Effect of bed size and spacing on sweet potato yield. J. Trop. Agric. and Fd. Sc. 29(2): 151–157

Muluken Demelie and Abiyot Aragaw, 2015. Genetic Variability of Sweet Potato on Yield and Yield Related Traits at Werer Agricultural Research Center, Ethiopia. International Journal of Research in Agricultural Sciences, 5(2): 2348 – 3997.

Onunka, N.A., G.Antai, Onunka B. N. and Njoku S.C. 2011. Effect of Plant Density and Land Race on the Growth and Yield of Sweet potato in Northern Guinea Savanna of Nigeria. Journal of Agriculture and Social Research (JASR). 11(1): 164-172.

SAS Institute, 2004. SAS /STAT Guide for personal computers, version 9.0 editions. SAS Institute Inc. Cary, NC, USA.

Tenaw Workayehu, Debelle Tolessa, Tesfa Bogale, Wakene Negassa, Minale Liben, Tewodros Mesfin, Burtukan Mekonen and Waga Mazengia, 2001. Sweet potato production

Teshome Abdissa, Amenti Chali, Kassaye Tolessa, Fiseha Tadese and Geremew Awas, 2011.Yield and yield components of sweet potato as influenced by plant density: In Adami Tulu Jido Kombolcha District, Central Rift Valley of Ethiopia. American Journal of Experimental Agriculture. 1(2): 40-48.

Wassu Mohammed, Solomon Ali, Beneberu Shimelis and Simret Burga., 2015. Genetic Diversity of Local and Introduced Sweet Potato [Ipomoea batatas (L.) Lam.] Collections for Agro Physicochemical Attributes in Ethiopia. Science, Technology and Arts Research Journal, 4(1): 09-19.