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Research Article

Effect of Corm Size and Plant Population Density on Corm Yield of Taro (*Colocasia Esculenta* L.)

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ABSTRACT

Objective: Taro (*Colocasia esculenta* L. Schott) is a perennial root crop that belongs to Araceace family. It is widely cultivated as a staple food in Africa, Asia and pacific Islands. Despite its importance, there is limited information on many aspects of the crop. In order to obtain data that can support improved and sustainable taro production, a field trial was conducted to study the effects of corm size and plant population density on the growth and corm yield of taro (variety Boloso-1) was investigated during 2007 cropping season. **Methods:** The experiment consisted of five-corm size (50, 51-100, 101-150, 151-200 and 201-250 g) and five levels of planting densities (15037, 29629, 45454, 60606 and 74074 plants/ha) arranged in a factorial randomized complete block design with three replications. **Results:** The results indicated that corm size had a highly significant ($p<0.001$) influence on plant height, leaf number, shoot number , leaf area index, corm and cormels number/plant, corm and cormels yield/ ha of taro. All the parameters were increased with increased in corm size. Plant population density exert significant influence ($p<0.001$) on all the studied parameter except on plant height and number of leaf/plant. The interaction effect of corm size and population density was none significant on all the studied parameters. The highest average corm yield/ha (44.07 t/ha) was achieved at a population of 60,606 plants/ ha using seed corms having 51-100 g. These could be recommended for farmers in production area similar with the study site.

1.INTRODUCTION

Taro *(Colocasia esculenta* L. Schott*)* is a herbaceous, perennial root crop that belongs to Araceae family. The corm and cormels are the major economic part of the taro. Occasionally, the leaves, flowers and petioles are used for food depending up on the cultivars and the culture (Fred and Makeati, 2001). The national average yield of 8 t/ha in Ethiopia (CACC, 2003) which is by far greater than the global average yield of 6.5 t/ha, but lower than Asian average (12.6 t/ha) (Silva *et al.*, 1992). However, research conducted in different parts of the world (Goenaga and Chardon, 1995; Silva *et al.,* 1992) demonstrates that the yield of taro ranges between 21and 73 t/ha under intensive commercial management. One of the highest yielding cultivars (Boloso-1) Ethiopia gave an average fresh corm yield of over 67 t/ha, considerably exceeding the national average (Asfaw and

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Waga, 2004, unpublished) under experimental field condition. This demonstrates that taro yield obtained by farmers is far below the crop potential.

Some preliminary studies were conducted on the effect of population density on yield and yield component in Ethiopia (Jimma and Areka) however there is no adequate information on the yield response of taro to population density for different agro ecological zones of the country (Edossa *et al*., 1995; Simon, 1992; Mulugeta, 2007). The recommendation of 40,000 plant/ha, (50cm x 50 cm) spacing has been used for the variety Boloso–1 in the study area. However, this density was recommended without considering size of planting material. Most studies attempted to determine either the optimum density without specifying the size or vice versa. The combined effects of density and size of planting material on yield and relation between the two is not sufficiently studied. Therefore, the objective of this study is initiated to investigate the effect of size of corm and plant population density on the growth and yield of the taro and identify the optimum corm size and population density that maximize the yield and yield component of taro.

2.MATERIALS AND METHODS

2.1.Description of the study area

Field experiment was conducted on farm at Delbo watershed Southern Ethiopia. The site is located at 6°53.463' Latitude and 37°52.420' E Longitude. The altitude ranges from 1990 to 2061 masl. Based on ten year data from Sodo metrological station, the mean annual rainfall and temperature of the area were 1325mm and 19.9^0 c, respectively. The soil of the site was classified as drystic Nitosols. Which are formed from basaltic parent materials and are highly weathered, well drained, deep, highly leached (acidic), with low organic carbon, nitrogen and phosphorus content (EMA, 1988). The land for experiment was used for maize and teff during the previous two years.

2.2.Treatments and Design

The most widely used and best improved Varity of the taro namely boloso-1was used for this activity. The treatments consist of five corm sizes (≤50 g, 51-100 g, 101-150 g, 151-200 g, 201-250 g) and five different plant population densities (15037, 29629 45454, 60606, 74074 plants/ha were arranged in a factorial RCBD with three replications following the procedure of Gomaze and Gomez (1984). The experimental plots were prepared properly to have five rows and each row has five plants and a total of 25 plants were maintained in each plot. The experimental plots were ploughed and prepared as per the recommended practices.

2.3.Data collection

Data collection for field experiment was carried out by using five random samples from central rows of each plot. Data on plant height, shoot number/ha, leaf area/plant (cm^2), Leaf area index (LAI), corm length (cm) corm diameter (cm), corm fresh weight (g/plant), cormels fresh weight (g/plant), marketable corm yield (t/ha), unmarketable corm yield (t/ha), total yield, yield/ha (t/ha) were collected and analyzed.

Yield (t/ha): was walculated from harvestable plot and converted into yield/ ha and expressed as t/ha. It was estimated using the following formula.

$$\text{Yield per hectare in ton} = \frac{\text{Yield per net plot (kg)} \times 10{,}000}{\text{Net area of the plot (m}^2\text{)} \times 1{,}000}$$

2.4.Data analysis

Quantitative data were subjected to analysis of variance (ANOVA) using SAS PROC GLM (2002) at P<0.05. Differences between means were assessed using the least significance difference (LSD) test at P<0.05.

3.RESULTS AND DISCUSSION

Analysis of variance shows that corm size demonstrated a very highly significant effect (p<0.0001) on plant height, leaf number, shoot number, leaf area index, corm and cormels number/plant and corm and cormels yield/ha and highly significant (p≤0.001) effect on corm diameter (Table 1). Plant population density exerted very highly significant effect on number of shoot, leaf area index, number of corm and cormels per plant and corm and cormels yield per hectare and highly significant (p≤0.001) effect on corm diameter and a non significant effect on plant height and number of leaf (table 1). Interaction effects between population density and corm size were none significant at all months after planting (MAP) (Table 1).

Table 1.

Mean square value for plant height (cm), number of shoot /plant, leaf area index, Number of corm and cormels per plant and corm and cormles yield per ha of taro.

Source	DF	PH2	PH4	PH6	NL2	NL4	NL6	NS2	NS4	NS6	LAI2	LAI4	LAI6	NCCLPP	CCLYPHA(g)	CD
Rep	2	47.81^{ns}	76.52^{ns}	284.57^{ns}	28.1ns	2.61ns	2.14ns	0.45ns	0.14ns	0.36ns	0.002^{ns}	0.593^{ns}	0.05^{ns}	0.78^{ns}	7.89ns	2.51^{ns}
CS	4	419.10***	453.98***	292.83***	78.59***	117.6***	18.80***	2.45***	2.52***	4.26***	4.767***	6.969***	0.953***	26.11***	39.94***	1.99**
PD	4	62.67ns	20.73ns	106.23ns	1.60ns	9.75ns	6.71ns	2.92***	2.02***	1.38***	11.791***	19.460***	2.286***	20.99***	1949.67***	1.78**
CS*PD	16	67.60ns	45.82ns	43.79ns	2.13ns	6.05ns	1.37ns	0.44ns	0.08ns	0.349ns	0.65^{ns}	1.277^{ns}	0.216^{ns}	2.54^{ns}	6.56ns	0.46^{ns}
Error	48	54.27	80.97	42.01	4.77	6.75	1.59ns	0.29	0.12	0.211	0.132	0.307	0.036	2.64	6.44	0.41
CV		15.44	13	11.53	21.42	19.6	18.21	25.22	11.16	12.72	31.43	34.5	30.54	11.97	10.59	12.38
$LSD_{0.05}$		6.61	6.61	6.61	1.9	1.9	1.9	0.25	0.25	0.25	0.271	0.271	0.271	14.94	14.94	0.471

PD=Population density , CS= corm size , PH2=plant height at 2 months, PH4= plant height at 4 months, PH6 =plant height at 6 months, NL2= number of leaf at 2 months, NL4= number of leaf at 4 months, NL6= number of leaf at 6 months, NS2= Number of shoot at 2 months, NS4= Number of shoot at 4 months, NS6= Number of shoot at 6 months, LAI2= Leaf area index at 2months, LAI4= Leaf area index at 4months, NCCLPP= Number of corm and cormels per plant and CCLYPHA =corm and cormles yield per ha.

Table 2.

Effect of corm size on plant height, number of shoot /plant and leaf area index per plant number of taro

Corm size	Plant height			Number of leaf per plant			Number of shoot /plant			Leaf area index			NCCLPP	CLCYPHA(t)	CD
	2MAP	4MAP	6MAP	2MAP	4MAP	6MAP	2MAP	4MAP	6MAP	2MAP	4MAP	6MAP	9MAP	9MAP	9MAP
<50	39.75^{c}	63.01^{c}	49.25^{c}	7.20^{c}	9.81^{d}	5.53^{c}	1.64^{d}	2.08^{d}	2.68^{d}	0.467^{c}	0.868^{c}	0.307^{b}	11.90^{d}	26.27	4.65^{c}
51-100	45.82^{b}	66.13^{bc}	54.53^{b}	8.28^{c}	11.67^{cd}	6.09^{c}	1.85^{dc}	2.55^{c}	3.52^{c}	0.67^{c}	1.216^{c}	0.394^{b}	12.79^{dc}	26.69	5.00^{bc}
101-150	48.25^{ab}	67.84^{bc}	58.21^{ab}	10.11^{b}	12.85^{c}	7.19^{b}	2.15^{bc}	3.04^{cb}	3.66^{c}	1.31^{b}	1.596^{b}	0.811^{a}	13.53^{bc}	26.89	5.32^{ab}
151-200	51.84^{a}	72.27^{ab}	58.59^{ab}	11.64^{ab}	15.56^{b}	7.50^{b}	2.52^{ab}	3.28^{b}	4.08^{b}	1.57^{ab}	1.937^{b}	0.851^{a}	14.37^{ab}	27.84	5.56^{a}
201-250	52.95^{a}	76.99^{a}	60.36^{a}	13.21^{a}	16.99^{a}	8.33^{a}	2.56^{ab}	3.60^{a}	4.40^{a}	1.75^{a}	2.56^{a}	0.760^{a}	15.28^{a}	28.71	5.41^{ab}
$LSD_{0.05}$	6.61	6.61	6.61	1.9	1.9	1.9	0.25	0.25	0.25	0.271	0.271	0.271	14.94	14.94	0.471
Mean	47.72	69.25	56.19	10.08	13.37	8.33	2.14	3.05	3.67	1.153	1.635	0.624	13.57	27.28	5.19

Table 3.

Effect of plant population density on plant height, number of leaf per plant, number of shoot/plant, leaf area index per plant, number of corm and cormels per plant corm diameter and corm yield of taro

Density	Plant height			Number of leaf per plant			Number of shoot /plant			Leaf area index			NCCLPP	CD	CCLYPHA
	2MAP	4MAP	6MAP	2MAP	4MAP	6MAP	2MAP	4MAP	6MAP	2MAP	4MAP	6MAP	9MAP	9MAP	9MAP
15037	44.84	69.79	58.05	10.67	12.19	6.98	2.76a	3.63a	4.08a	0.199e	0.309e	0.145e	14.91a	5.69a	9.47
29629	48.31	70.89	58.69	9.91	12.57	6.95	2.37ab	3.15b	3.88ab	0.67d	0.798d	0.345d	14.65a	5.33ab	18.53
45454	46.77	67.85	52.65	9.39	13.89	6.66	2.09bc	3.01bc	3.62bc	0.943c	1.493c	0.624c	13.36b	5.17bc	27.63
60606	48.31	64.43	57.47	10.09	13.75	6.81	1.87dc	2.79dc	3.48bc	1.451b	2.287b	0.906b	12.77b	4.90bc	44.07
74074	50.32	68.28	54.08	10.37	14.47	7.24	1.63d	2.69d	3.28d	2.518a	3.29a	1.103a	12.18b	4.84c	36.71
$LSD_{0.05}$	6.61	6.61	6.61	1.9	1.9	1.9	0.25	0.25	0.25	0.271	0.271	0.271	14.94	0.471	14.94
Mean	47.12	69.25	56.19	10.08	13.37	8.33	2.14	3.05	3.67	1.153	1.635	0.624	13.57	5.19	27.28

Table 4.

Effect of corm size and population density on ratio of corm yield to weight of planting material of taro plant

	Density (plants per ha 1)					
Corm size(g)	15037	29629	45454	60606	74074	Means
	Ratio of corm yield to weight of planting material					
<50	3.67	3.64	3.46	3.57	3.56	3.58
51-100	7.28	2.25	6.97	6.99	6.9	6.08
101-150	2.51	2.49	2.38	2.39	2.33	2.42
151-200	1.95	1.89	1.89	1.81	1.84	1.87
201-250	1.55	1.59	1.57	1.56	1.46	1.54
Means	3.39	2.37	3.25	3.26	3.22	
over all means						3.1

LSD 0.05 0.45, corm size means=3.10

LSD 0.05 0.45, density means=3.10

CV=10.22

Table 5.

Association of taro yield and yield component

	DE	NL4	PH4	NS6	NSHA	LA4	LAI4	LAIC	CL	CD	NCPP	NCPH	WCPP	WCH	DM	LSN	GRN
DE	1	-0.44***	- 0.33**	-0.39***	0.18^{ns}	- 0.36**	-0.12*	- 0.22**	0.15^{ns}	0.27*	0.14^{ns}	0.14^{ns}	0.04^{ns}	-0.09^{ns}	0.52^{ns}	0.14^{ns}	-0.24*
NL4		1	0.31**	0.35**	0.33**	0.50***	0.39***	0.42***	-0.05^{ns}	0.10^{ns}	0.40***	0.35**	0.36***	0.25***	0.07**	0.26*	0.35**
PH4			1	0.56***	0.13^{ns}	0.33**	0.17^{ns}	0.21^{ns}	0.125^{ns}	0.35**	0.25*	0.02^{ns}	0.35**	0.02^{ns}	0.11^{ns}	0.01^{ns}	0.21*
NS6				1	-0.07^{ns}	0.25*	0.23^{ns}	-0.04^{ns}	0.22**	0.46***	0.47***	-0.25*	0.46***	-0.29**	0.19^{ns}	0.21^{ns}	0.04^{ns}
NSHA					1	0.59***	0.80***	0.84***	0.06^{ns}	0.21^{ns}	0.90***	0.90***	0.91***	0.91***	0.10^{ns}	0.89***	0.70***
LA4						1	0.89***	0.83***	0.21^{ns}	0.02^{ns}	0.122^{ns}	0.55***	0.17*	0.55***	-0.15^{ns}	0.51***	0.66***
LAI4							1	0.96***	0.23^{ns}	0.15^{ns}	0.13^{ns}	79***	80***	0.80***	0.12*	76***	0.76***
LAIC								1	-0.07^{ns}	0.135^{ns}	-0.17^{ns}	0.82***	-0.11^{ns}	0.84***	0.22*	0.83***	0.80***
CL									1	0.17^{ns}	0.14^{ns}	-0.1^{ns}	0.08***	-0.08^{ns}	0.07^{ns}	0.08^{ns}	0.06^{ns}
CD										1	0.33***	-0.3^{ns}	0.30**	-0.31**	0.08^{ns}	-0.21*	0.07^{ns}
NCPP											1	-0.2^{ns}	0.91***	0.41***	0.51^{ns}	0.39***	0.06^{ns}
NCHA												1	- 0.36**	0.92***	0.04^{ns}	0.86***	0.68***
WCPP													1	-0.22*	0.14^{ns}	-0.25*	0.04^{ns}
WCHA														1	0.48***	0.92***	0.67***
DM															1	0.25^{ns}	0.32^{ns}
LSN																1	0.25*
GRN																	1

DE= Day of emergence
NL4= Number of leaf at 4MAP
PH4= Plant height at 4MAP
CD= Corm diameter
NCPP= number of corm and cormles per plant
NCPH= Number of corms and cormels per hectare

Mean plant height averaged across population density increased with increasing in corm size at all months after planting (MAP) reaching a maximum 76.99cm with corm size of 250 g at 4 MAP. Corms with ≤ 50 g sizes had recorded lowest (63.01cm) mean plant heights at 4 MAP (Table 2). An increased in corm size from 50 to 250 g increased mean plant height plant^{-1} by 24.93, 18.16 and 18.41% at 2, 4 and 6 MAP, respectively. The response of plant height to size of corms in taro is similar to potato (Harris, 1978), yam (Misra and Nedunchezs, 2004) and cassava (Onwueme, 1978). In these crops, increasing seed size resulted in increasing plant height. The possible reason might be due to availability of more reserve food for growth in large corms which may help for largest height value.

Density had no effect on mean plant height of taro at all MAP (Table 3). The finding is similar to the observation of Lynch and Rowebery (1977) who did not record any changes in plant height due to difference in plant population for potato crop. The reason why plant population density had no effect on plant height of taro may be due to the fact that the plant grows laterally instead of vertically by producing more number of shoot (Table. 3).Mean shoot number/plant averaged across density increased with increasing in corm size at all the measurement months (Table 3). The highest mean shoot number/plant at all three growth periods were produced by seed corms with 201-250 g sizes. Shoots number/plant decreased with the decrease in size of corms and reached a minimum in seed corms with ≤ 50 g. An increase in corm size from 50 to 250 g increased mean shoot number/plant by 35.94, 29.17 and 26.72% at 2, 4 and 6 MAP, respectively. The largest number of shoot is produced by large seed corms. The finding confirms the results obtained by (Ameyaw *et al*., 1991) who reported that the number of shoot per plant increased as the size of sett increases in yam plant. Similarly, Onwueme (1978) reported that the number of sprout/sett in yam crop increased with sett size. The increase in shoot numbers is apparently due to greater number of potential buds and more assimilates being available in large sized seed corms. Likewise, large seed corms emerged earlier than smaller seed corms (Table 2).

Mean number of shoot/plant averaged across corm size increased with decrease in population density at all growth periods and the highest mean shoot number is being recorded in 15037 plant/ha while the lowest was obtained at 74074 plants /ha (Table 3). Increasing planting density from 15037 to 74074 seed corms/ ha resulted in a decrease in shoot number /plant value of 40.94, 25.89 and 19.61% at 2, 4 and 6 MAP, respectively. Similar results were also obtained by Harris (1978) and Tamiru (2005) for potato, Onwueme (1978) for yam and (Mulugeta, 2007) for taro. The finding also agrees with Gregory (2004) who obtained that closer spacing of taro significantly reduced the number of shoots per plant. Likewise, (Gendua *et al.*, 2000) reported that number of shoot/ plant decrease significantly with increased plant densities for taro crop. The decrease in shoot number /plant with increasing density is apparently due to increased intra- and inter-plant competition for light, water, minerals and assimilates from the mother corm and current production which may have prevented potential buds from developing or caused the suckers to die at early age.

Mean corm yield/ha avaraged across densities increased with the increase in size of corms. The maximum corm yield/ ha (28.71) was produced by seed corms with 201-250 g sizes. The smallest (26.27 t/ha) being recorded in corms with ≤ 50 g sizes (Table 2). An increase corm size from 50 to 250 g increased mean corm yield/ha by 8%. The corm yield/ ha increased from 26.27 to 28.71 t/ha when corm size increased from 50 to 250 g respectively. The result trend is in agreement with the result of (Ameyaw et al., 1991) who reported lager sett size produce heavier tuber weight/ ha than the smaller sett size for yam plant. Similarly, the greater the weight of the sett used to establish a yam plant, the greater the weight of tubers produces/ha (Onwueme, 1978). Possible reason for increase in corm yield/ha may be bigger corm size has more reserve food that lead to early canopy closure, maximum leaf area and leaf area index which help for the production of bigger weight of corms and cormels. In this experiment the optimum corm sizes for planting material was 51-100 g size class. Corm sizes greater than 100 g gave higher yield /ha as compared to the yield obtained from corm sizes lower than 100 g. However, as corm size increased above 100 g the amount of planting material required was higher and the economic return become lower for large size planting material. Also the ratio of corm yield to amount of planting material indicated that the corm size 51-100 g gave the maximum ratio (maximum yield) with the population density of 60, 606 plant/ ha (Table 4).

Mean corm yield /ha averaged across corm size increased with density. The highest mean corm yield/ ha (44.07 t/ha) was recorded in 60606 plant/ha while it was lowest (9.47 t/ha) in 15037 plants/ha (Table 3). Increasing planting density from 15037 to 60606 seed corms /ha resulted in increase corms and cormels weight/ha by 78.51 %. The corm yield per hectare increased from 9.47 to 44.07 t/ha when population density increased from 15037 to 60606, respectively, and decline to 36.71 t/ha at population density of 74074 seed corms/ ha. Also the ratio of corm yield to amount of planting material indicated that the density of 60606 gave the maximum ratio (maximum yield) with corm size of 51-100 g (Table 4).The yield level of taro on different part of the world was between 21 and 73 t/ha (Goenaga and Chardon, 1995; Silva *et al.,* 1992). The yield report (44.07t/ha) in this experiment as compared to Ethiopian average yield (8-39t/ha) this shows that by using the appropriate corm size and density, the yield level of taro can be maximized. Similarly (Ball *et al.,* 2000) indicated that increasing population density of haricot bean reduced yield per plant but increased yield/ unit area. Herbert and Hill (1978) also indicated as plant density increases, intensity of inter plant competition increases and yield per plant declines, although total yield per unit area may increase**.** Weight of corm and cormels per hectare was highly correlated with number of leaf (r=0.25**), number of shoot per hectare (r=0.91***), leaf area (r=0.55***), leaf area index (r=0.76***) and cumulative leaf area index (r=0.84***) (Table 5). In agreement with this (Enyi, 1967) obtained that yields of corms were positively correlated with LAI.

CONCLUSION

The current objective of modern agricultural science is to strengthen food security needs of the burgeoning world human population. Development and/or introduction of high yielding Variety and expansion of appropriate management strategies are among the strategies used. Appropriate corm size and plant population are among the most important concerns of the present farmers to optimize crop yields. An increasing size of planting material affected significantly and positively all the parameters. The findings showed that these aspects of taro can be influenced significantly by manipulating the size of seed corms used. The higher yield (47.07 t/ha) was achieved at 60606 plants per hectare using seed corms with 51-100 g size. There could be recommended for farmers in similar ecology of the study area. However, further research with the inclusion of population density above 60606 plants/ha and different corm size under varying growth environment will be required to verify the result and broaden the recommendation.

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