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Agronomic Research Achievements and Findings of Taro and Cassava Crops in Ethiopia: A Review

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ABSTRACT

Integration of root crops in the food system of Ethiopian people is an indispensable approach to achieve food self sufficiency and food security. In addition, with improved production and productivity, the sector can deliver high potential impact on the improvement of the livelihood of farmers. The high productivity per unit time and area for most root and tuber crops and their uses as food, feed and industrial row material sources are great promises for continued effort in research and development. Root and tuber crops research was started at Southern Agricultural Research Institute (SARI) of different Research Centers as component of the crop researches. The major research areas since the inception of the program were germplasms collection and/or introduction, maintenance, variety screening for better adaptation, yield and agronomic performance. Apart from developing and recommending different variety of root and tuber crops such as cassava, taro and yam, improved cultural practices such as suitable spacing/plant population and best types of planting material were also identified and recommended for the producers. This review, therefore, tries to present the effort that were made in the area of crop management so as to solve important production constraints of root and tuber crops (taro and cassava) in the farming system of Southwestern and Southern Ethiopia thereby assisting the ongoing food security endeavor. To exploit the food and income generating potential of these crops effectively, all research and development partners should enhance their joint efforts to strengthen the ongoing improved technology development endeavors to boost production, productivity and quality of these crops.

Key words: Cassava and taro, root crops, food self sufficiency, food security

INTRODUCTION

Ethiopia, with an area of 112.3 M ha, is the ninth largest and with about 86 million people, the third most populated country in Africa. The country is endowed with suitable climatic and edaphic condition for quality and quantity of production of various kinds of agricultural crops. In 2003, the agriculture sector accounted for about 42% of the country's Gross Domestic Product (GDP) and about 85% the export earnings. About 81% of the economically active population works in agriculture (Woldegiorgis *et al.*, 2008). The majority of Ethiopian population depends mainly on cereal crop as food source. The food potential of horticultural crops particularly that of root and tuber crops, has not been fully exploited and utilized despite their significant contribution towards food security, income generation, provision food energy and resource base conservation (Woldegiorgis *et al.*, 2008).

Food insecurity is increasing in Ethiopia with 55% of farmers reporting that their annual harvest is insufficient to maintain the family for more than six months. At least seven million people require food aid every year since efforts to address the problem through a grain-led approach has failed even to keep up with population increase. Of the different strategies that should be employed to attain national food self-sufficiency and food security, integration of horticultural crops in the food system is rated among the top. Among the potential horticultural crops for further exploitation, root and tuber crops are regarded as the most common starchy staples that could provide a low-cost energy in the daily diet of the society. In addition, these groups of crops are known for their appreciable amounts of proteins, essential vitamins and minerals. To this end, Scott (2000) had reported an average protein contents of 2-3% in cooked potatoes and yams.

However, the national agricultural production and productivity of root and tuber crops is by far lower than most neighboring and other developing countries due to lack of improved production technologies (agronomic practices). To solve the production constraints of these crops, research on root and tuber crops started as one of the components of crop research at southwestern SARI in different agricultural research centers (especially Jimma and Areka Agricultural Research Center). Among the various crop, taro, yam, sweet potato and cassava, have got major research focus. The main activities included collection and/or introduction of germplasms and maintenance and variety screening for better adaptation, yield and varied agronomic performances. As a result, different improved technologies (varieties and agronomic practices) have been developed and promoted to the users. This review study is therefore, studies with the objective of compiling and documenting the available agronomic research findings and achievements attained so far on root and tuber (taro and cassava) crops in Ethiopia.

TARO (*COLOCASIA ESCULENTA* L.)

Effect of population density on tuber yield and yield components of taro: To determine the spacing requirement of taro (*Colocasia esculenta*) crop, trials were conducted at Jimma research center for five consecutive years (1989-1994) using an improved variety, Denu. Corms and cormels were used as planting materials. A combination of five inter-row spacing (50, 60, 70, 80 and 90 cm) and five intra-row spacings (30, 40, 50, 60 and 70 cm) were used. Both plant and row spacing highly affected total tuber yield, even though, there was no interaction effect between them (Table 1). The highest yield of 75.1 and 75.7 t ha^{-1} were obtained from the narrowest inter-row spacing (50 cm) and intra-row distances (30 cm), respectively. The best combination for the highest yield (78.9 t ha^{-1}) was obtained from the plant spacing of 30 cm and row spacing of 70 cm (Etissa, 1996). This spacing combination was adopted in Jimma and other areas with similar agro-ecologies.

The same experiment was used to be conducted at Areka Agricultural Research Centre in the year 2003 and 2004 using the improved variety called 'Bolosso-one' with a combination of three inter-row spacing's (40, 50 and 60 cm) and five intra-row spacing's (50, 75 and 100 cm) used. Both plant and row spacing highly affected total tuber yield, even though, there was no interaction effect between them (Table 2).

Effect of different types of planting material on tuber yield and yield components of taro at jimma: Taro is a vegetative propagated crop, making use of tubers which is the consumable part; farmers are always experiencing shortage of planting material. To avert this problem, farmers' usually use cut corms, cormels (suckers) or intact (mother) corms which ever they get at their disposal, as a source of planting material, regardless of their yielding potential. Therefore, to select best planting material that can give better yield, a trial was conducted at Jimma between 1987 and 1992. Three types of planting materials were evaluated: Whole corms, cut corms and suckers (Table 3). Result showed that mother corms (whole corms) gave the highest mean tuber yield (66.3 t ha^{-1}) while sucker gave the lowest yield (49.9 t ha^{-1}). Cut corms or setts gave the second highest yield (61.9 t ha^{-1}) (Etissa *et al*., 1995).

Effect of type of planting material and population density on corm yield and yield components of taro (*colocasia esculenta* L.) at Areka: Taro (*Colocasia esculenta* L.) is a major staple food crop in many parts of humid tropics and the sub tropics. In Ethiopia, it is grown in south and Southern Western parts of the country including Wolaita area. Shortage of planting material and lack of optimum plant population density are among the major production constraints of taro. To address these constraints an experiment was conducted to examine the effect of type of planting material and plant population density on the yield and its components.

The experiment was conducted using of: (1) Four inter (50, 70, 90 110 cm) and intra row spacing (35, 50, 65, 80 cm),

Table 1: Tuber yield of taro (t ha^{-1}) as affected by intra-and inter-row spacing at Melko-Jimma

	Inter-row spacing (cm)					
Intra-row spacing (cm)	50	60	70	80	90	Means
30	75.6	76.4	78.9	72.3	75.1	75.7
40	77.4	76.7	75.8	70.9	74.0	74.9
50	76.4	76.1	76.4	72.3	72.7	74.8
60	74.0	69.5	69.6	62.6	67.2	68.6
70	72.0	72.9	68.3	62.4	63.5	67.8
Mean	75.1	74.7	73.8	68.2	70.7	72.4

CV (%): 16.22, Source: Etissa (1996)

Table 2: Tuber yield of taro as influenced by intra row and inter row spacing

	Inter-row spacing (cm)			
Intra-row spacing (cm)	50	75	100	Mean
40	32.60[a]	25.65[bc]	24.60[abc]	27.6
50	33.60[ab]	21.90[bc]	21.30[bc]	25.6
60	24.80[abc]	16.62[ac]	22.13[abc]	21.2
Mean	30.33	21.40	22.70	

SE: 2.21 CV (%): 21.78, Value with different alphabets in the same column showing significant difference among them

Table 3: Mean tuber yield of taro using different types of propagules at Jimma

	Mean tuber yield (t ha^{-1})					
Type of propagule	1988	1989	1990	1991	1992	Means
Cormlets (suckers)	72.9	35.6	58.6	49.1	33.3	49.9
Intact (mother) corms	83.4	65.1	57.6	58.9	48.1	66.3
Cut corms	72.4	58.6	70.2	53.6	55.0	62.0
LSD 0.05	7.3	21.2	9.1	12.9	12.5	
CV (%)	5.49	20.68	7.15	13.83	15.83	

Source: Etissa *et al*. (1995)

(2) Two types of planting material (corm and cormels) using the variety Boloso-1. The experiment was laid out as a split-plot design with factorial experimentation with three replications. Two type of planting materials and sixteen possible spacing combinations were randomly arranged in the main plot and sub-plot, respectively. The sixteen spacing arrangements (treatments) used were presented in Table 4.

The type of planting material had a significant ($p \le 0.05$) effect on total and marketable (>250 g) yields. The marketable (>250 g) and total yields obtained from corm were significantly higher than cormel (Table 5). The magnitude of yield difference between corm and cormel was highest for total yield (8.8 t ha^{-1}) than marketable (7.22) yield per hectare. Type of planting material had no effect on unmarketable (<250 g) yield. However, corm gave relatively higher (5.88 t ha^{-1}) unmarketable yield than cormels (4.29 t ha^{-1}). Plant population density also had a highly significant effect on total yield per hectare. The highest total yield (49.85 t ha^{-1}) was recorded at 25,973 plants ha^{-1} (Table 5). Total yield decreased both at higher and lower plant densities. Plant population density had a highly significant ($p \le 0.001$) effect on marketable (>250 g) yield per hectare. Similar to total yield marketable yield also decreased at both higher and lower densities. The highest (36.96 t ha^{-1}) was recorded at 25,973 plants ha^{-1}. Density had a highly significant ($p \le 0.001$) effect on unmarketable (<250 g) yield per hectare. The highest unmarketable yield (13.68 t ha^{-1}) was recorded at 31,745 plants ha^{-1}.

Yields of the two categories (total and marketable yield) were very high at higher densities, reached a maximum at 25,973 plants ha^{-1} and start to decline. Whereas the unmarketable yield were maximum at 31,745 plants ha^{-1} (Table 5). There was a highly significant ($p \le 0.001$) effect of type of planting material by plant population density interaction on marketable and total yield.

RECOMMENDATIONS

In this study corm yield per unit area were maximized at higher densities. However, average shoot number, number of corm and weight of corm per plant were maximized at lower densities. The result of this study revealed that for both marketable and unmarketable yield plant population density of 25,973 plants ha^{-1} is most convenient.

Soil fertility management on taro roots in Ethiopia: The results of experiment on the effect of fertilizers at Areka indicated that application of FYM alone did not influence taro yield (Table 6). Higher yield was obtained with combined application of FYM and inorganic fertilizers as compared to application of only inorganic fertilizers. Within combined fertilizers application, yield of taro was increased with increasing rate of FYM. The highest taro yield (56.54 t ha^{-1}) was obtained when the highest rate of inorganic fertilizers (110-40-100 kg ha^{-1} NPK) were combined with 20 t ha^{-1} farm yard manure and the lowest yield (30.458 t ha^{-1} yield) was obtained from the plot with no inorganic fertilizers (Table 6). Yield advantage of 20 t ha^{-1} was obtained by combining 110-40-100 kg ha^{-1} NPK with 20 t ha^{-1} FYM over the control; however, comparable yield was obtained by application of half dose of NP (55:20 kg ha^{-1}) with 20 t FYM ha^{-1}. Thus, from standpoint of economic and environmental benefits 20 t FYM plus 55 kg N and 20 kg P ha^{-1} is feasible and recommended for taro growers around Areka.

Plant spacing: To determine the spacing requirement of taro (*Colocasia esculenta*) crop, trials were conducted at jimma research center for five consecutive years (1989-1994) using an improved variety, Denu. Corms and cormels were used as planting materials. A combination of five row spacing (50, 60, 70, 80 and 90 cm) and five plants or intra row spacing (30, 40, 50, 60 and 70 cm) were used.

Both plant and row spacing highly affected total tuber yield, even though, there was no interaction effect between them (Table 7). The highest yield of 75.1 and 75.7 t ha^{-1} were obtained from the narrowest inter-row spacing (50 cm) and intra-row distances (30 cm), respectively. The best combination for the highest yield (78.9 t ha^{-1}) was obtained from the plant spacing of 30 cm and row spacing of 70 cm (Etissa, 1996). This spacing combination was adopted in jimma and other areas with similar agro-ecologies.

Table 4: Spacing and plant population density of taro used in the experiment

Spacing (cm)	Plant population density (Plants ha^{-1})	Spacing (cm)	Plant population density (plants ha^{-1})
80×110	13,636	80×50	25,000
80×90	13,888	35×110	25,973
65×110	13,985	50×70	28,570
65×90	17,093	65×50	30,769
80×70	17,857	35×90	31,745
50×110	18,181	50×50	40,000
65×70	21,977	35×70	40,816
50×90	22,222	35×50	57,143

Table 5: Mean squares for total, marketable, unmarketable yield t ha^{-1} and dry matter percentage as affected by type of planting material and population density at Areka 2006

		Mean squares			
Sources	DF	Total yield	Marketable yield	Unmarketable yield	Dry matter (%)
Replication (R)	2	334.61	165.02	32.64	3.04
Planting material (Pm)	1	1858.75*	1250.10*	60.15ns	14.26**
R×Pm (Error a)	2	81.68	41.01	9.01	0.04
Spacing (Sp)	15	897.44***	378.74***	127.97***	13.32ns
Pm×SP	15	192.31***	144.85***	5.99ns	15.21ns
E (Error b)	60	48.69	33.44s	4.72	10.51

***Significant at p<0.001, **p<0.01, *p<0.05 probability level, ns: Non significant at p<0.05 probability level

Table 6: Mean yield of taro in as influenced by application of FYM+NPK at kokate Area, Wolaita

Treatments	Season 2007	2008
0 kg ha^{-1} N-P-K +0 t ha^{-1} FYM	37.75^{bcd}	18.950^{d}
0 kg ha^{-1} N-P-K+10 t ha^{-1} FYM	30.46^{d}	22.63^{cd}
0 kg ha^{-1} N-P-K+20 t ha^{-1} FYM	41.79^{abcd}	19.288^{d}
55-20 kg ha^{-1} N-P+0 t ha^{-1} FYM	45.17^{abcd}	22.20^{cd}
55-20 kg ha^{-1} N-P+10 t ha^{-1} FYM	36.50^{cd}	23.38^{ab}
55-20 kg ha^{-1} N-P+20 t ha^{-1} FYM	54.33^{a}	22.66^{cd}
110-40 kg ha^{-1} N-P+0 t ha^{-1} FYM	53.08^{ab}	25.66^{bc}
110-40 kg ha^{-1} N-P+10 t ha^{-1} FYM	51.67^{abc}	24.45^{abcd}
110-40 kg ha^{-1} N-P+20 t ha^{-1} FYM	55.83^{a}	30.38^{a}
55-20-50 kg ha^{-1} N-P-K+0 t ha^{-1} FYM	49.88^{abc}	22.66^{cd}
55-20-50 kg ha^{-1} N-P-K+10 t ha^{-1} FYM	54.92^{a}	24.29^{bcd}
55-20-50 kg ha^{-1} N-P-K+20 t ha^{-1} FYM	54.29^{a}	22.63^{bc}
110-40-100 kg ha^{-1} N-P-K+0 t ha^{-1} FYM	52.0^{abc}	22.83^{cd}
110-40-100 kg ha^{-1} N-P-K+10 t ha^{-1} FYM	52.63^{ab}	24.00^{bcd}
110-40-100 kg ha^{-1} N-P-K+20 t ha^{-1} FYM	56.54^{a}	23.79^{bcd}
LSD	15.8	4.8
CV	19.4	15.21

Value with different alphabets in the same column showing significant difference among them

Table 7: Tuber yield of taro (t ha^{-1}) as affected by intra-and inter-row spacing at jimma

Intra-row spacing (cm)	Inter-row spacing (cm) 50	60	70	80	90	Means
30	75.6	76.4	78.9	72.3	75.1	75.7
40	77.4	76.7	75.8	70.9	74.0	74.9
50	76.4	76.1	76.4	72.3	72.7	74.8
60	74.0	69.5	69.6	62.6	67.2	68.6
70	72.0	72.9	68.3	62.4	63.5	67.8
Mean	75.1	74.7	73.8	68.2	70.7	72.4

CV (%): 16.22 Source: Etissa (1996)

Types of planting material: Taro is a vegetative propagated crop making use of tubers which is the consumable part; farmers are always experiencing shortage of planting material. To avert this problem, farmers' usually use cut corms, cormels (suckers) or intact (mother) corms which ever they get at their disposal, as a source of planting material, regardless of their yielding potential. Therefore, to select best planting material that can give better yield, a trial was conducted at jimma between 1987 and 1992. Three types of planting materials were evaluated: Whole corms, cut corms and suckers. (Table 8).

Result showed that mother corms (whole corms) gave the highest mean tuber yield (66.3 t ha^{-1}) while sucker gave the lowest yield (49.9 t ha^{-1}). Cut corms or setts gave the second highest yield (61.9 t ha^{-1}) (Etissa *et al*., 1995).

CASSAVA

Determination of appropriate planting time for cassava production at wolaita area, Southern Ethiopia: Cassava (*Manihot esculenta* Crantz) is one of the most important food securing root and tuber crop grown in southern Ethiopia. It is mostly grown for subsistence in low land areas of Amaro, Gamogofa, Wolaita and South Omo and serves as a famine reserve food. It can produce high carbohydrate per hectare than any other food crops can be harvested as needed. The planting time for cassava in the tropical countries primarily depend on soil moisture. This experiment was conducted at Areka research centre for three years (2001-2004) with the objective of determining optimum planting time for cassava production. Thirteen planting dates were randomly allocated in Completely Randomized Block Design (RCBD) with four replication.

Table 8: Mean tuber yield of taro using different types of propagules at Jimma

Type of propagule	Mean tuber yield (t ha^{-1}) 1988	1989	1990	1991	1992	Means
Cormlets (suckers)	72.9	35.6	58.6	49.1	33.3	49.9
Intact (mother) corms	83.4	65.1	57.6	58.9	48.1	66.3
Cut corms	72.4	58.6	70.2	53.6	55.0	62.0
LSD 0.05	7.3	21.2	9.1	12.9	12.5	
CV (%)	5.49	20.68	7.15	13.83	15.83	

Source: Etissa *et al*. (1995)

Table 9: Total fresh root yield of cassava as affected by date of planting

Treatment (Date of planting)	Years overall 2001/02	2002/03	2003/04	Mean
Mid March	24.06	34.22	42.79	33.75^{A}
Early April	20.34	43.54	43.23	35.70^{A}
End of April	15.45	45.43	45.54	35.48^{A}
Early May	21.75	27.76	47.41	32.30^{A}
End of May	25.26	38.17	46.12	36.52^{A}
Early June	23.94	43.51	36.64	34.70^{A}
End of June	25.91	41.67	32.22	33.26^{A}
Early July	20.29	38.47	37.03	31.93^{A}
End of July	18.52	39.52	40.70	32.91^{A}
Early August	18.77	24.19	33.25	25.40^{B}
End of August	14.66	31.54	25.47	23.89^{B}
Early September	16.15	30.83	24.38	23.79^{B}
End of September	20.29	30.88	19.33	23.50^{B}
CV (%)				24.89
LSD				6.247

Means followed by the same letters are not significantly different from each other (p = 5%)

According to the result of the analysis, different planting dates were highly affected total tuber yield (Table 9). The highest mean yield of 36.52 t ha^{-1} were obtained from the treatment five (planting date at the end of May). Separate analysis for each year indicated that fresh root yield was significantly affected by time of planting (Table 9). It was observed that delayed planting might reduce root yield but early planting would increase root yield.

The result of the experiment indicated that the optimum planting time for better yield of cassava at Areka is between mid March to late July which confirmed that farmers experience of cassava planting is the right time for better yield. The result of this investigation supports cassava planting dates experience of the farmer in the area.

CONCLUSION

Research on root and tuber crops in southern and south western Ethiopia was started nearly three decades ago as part of the national coffee and crop diversification program. A contemporary review of research findings could reveal the huge agro-ecologic potentials of the region for the production of these crops which can play a significant role in strengthening the national food security efforts. There is a great promise from these crops that could provide a potential diversification options to coffee other crop farmers at times of bad harvest and/or price drop through ensuring food provision and income generation. However, the prevailing lack of knowledge on improved production and post harvest technologies of the crops under this category calls for immediate attention with either technology generation or popularization of the available technology elsewhere in the world. In general, the research activities that had been carried out so far on these crops were inefficient to resolve all such multi-dimensional production problems and agronomic practices which hampering their effective exploitation.

Since Ethiopia has a considerable diversity of different root and tuber crops, production and processing technologies like fertilizer rate, time of planting and population density of all other potential root crops should be studied. All associated problems that retarded production and development of root and tuber crops call for peculiar attention and concerted efforts of all stakeholders involved in research and/or development activities. To benefit from the untapped immense potentials of these crop species towards ensuring the food security program of the country, the National Agricultural Research System (NARS) and higher institutes (Universities) in these areas should be geared towards taking all the necessary actions to curb all the above stated research gaps and challenges.

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