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Achievements of Cassava Agronomy Research in Southern Ethiopia in the Last two Decades

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Abstract

The paper describes research results of obtained in the process of generation of appropriate cultural practices, cropping systems and other agronomic studies of cassava in Ethiopia. Based on plant population studies carried out for three consecutive years on major cassava growing areas of SNNPR, plant spacing of 100 cm x 80, 120 cm x 80 and 80 cm x 80 was recommended for Awassa, Amaro kele and Amaro Jijola areas, respectively. The moisture content of cassava roots were invariably higher in varieties Qule, Kele and local in 12th and 15th MAP; But, decreases there after markedly in a linear way. Conversely, viscosity and root yield of the cassava increases significantly ($P < 0.05$) starting the 12th MAP. Results of intercropping maize and cassava showed that alternate rows (1C:1M) had LER advantage of 71%. Similarly, growing cassava intercropped with haricot bean, cow pea, soy bean and mung bean resulted in LER of 1.82, 1.49. 1.48 and 1.62 compared to sole beans in Amaro area. In one study that investigated planting positions and planting parts, slant and vertical plantings are suitable in Awassa sandy soils compared to horizontal planting. Similarly, this study revealed that planting materials shall be taken from middle and top part of the main stem of cassava compared to its branches. In another study that investigated land preparation methods, it was found that furrow and ridge planting produced comparable results of 48t/ha and 43t/ha compared to 38t/ha produced by flat plantings. Planting date trial carried out for three consecutive seasons elaborated that rainfed cassava planting could be carried out from mid April to early May based on optimum marketable and total tuber yield obtained. Thus, the crop responded very well to crop management practices like plant density, land preparation methods, planting positions, intercropping, etc.and farmers or investors could optimize production by using these recommendations.

Keywords: Plant density, Intercropping, LER, Planting date, Starch content.

Contents

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1. Introduction

Cassava is a stable food of more than 600 million people all over the world and is grown in as many as 90 countries [1]. It is the most important root crop in Africa. The next is yam. It is a hardy crop that grows reasonably well in poor soils and in areas well with erratic or low or unpredictable rainfall. It has been common among the rural poor mainly because it required fewer fertilizer inputs. “Cassava is a staple food crop cultivated in several developing countries, largely by small farmers. It is a source of subsistence and of cash income to poor farmers as well as a source of rural employment, particularly of women manly because it tolerant to poor soils and harsh climatic conditions producing reasonably yield poor management conditions. It is a perennial crop native to tropical America with its center of origin in north-eastern and central Brazil. It is cultivated mainly for its enlarged starchy root. Globally, it is the sixth most important source of calories in the human diet. In Africa, it has expanded as a food security crop. In SNNPR, the average total area planted to the crop and production of cassava per annum is 4942 ha and 53036.2 tones respectively. During the past 20 years, production of cassava expanded rapidly in Asia, especially in Thailand, in response to expanded demand for imports by the European Community, where it is used as livestock feed. There are concerns, however, about the likely decline in demand for cassava as food as incomes rise in developing countries and also about the stability of the European demand.

Cassava *(Manihot esculenta* Crantz) is sixth most important source of calories in the human diet-world,fourth most important food energy source in the tropics, is food security crop, because of its ability and capacity to yield well in drought prone, marginal wasteland under poor management where other crops would fail, the average total coverage and production of cassava per annum in Southern region is 4942 ha and 53036.2 tones, respectively and in Ethiopia, cassava is grown in Southern and south eastern parts as staple crop.

Fig-1. Cassava in local markets in Ethiopia

Source: Picture taken in Konso market, Southern Ethiopia

Cassava based production systems include small scale rain-fed farming in pathes of plots in backyard eg. Amaro, Bele, Gofa, Yeki and Tepi areas, Medium scale production in wide private farms eg. Amaro, Metu and Gofa areas, Irrigated cassava production particularly in dry periods eg. Amaro and finally cassava is grown intercropped together with taro, sorghum, teff, safflower, maize, enset, common beans , etc

Problems in cassava production include limited availability of additional land for crop production, decreased soil fertility and declining yield for major food crops have been cited as the major concerns for agriculture’s ability to provide nourishment for the increasing population, cassava is a long duration crop that takes more than 18 months for harvest and is planted at intra and inter row spacing of 80-120 X 60-100 and takes 3-4 months to develop enough canopy.

2. Objectives

- to sensitize and document the findings of cassava agronomy research in southern Ethiopia
- to draw conclusions based on major findings of cassava management research and subsequently recommend the necessary technologies for further use

3. Methodologies

Cassava agronomy research has been carried out in the last twenty years in southern agricultural research institute. Summary of research findings was prepared and presented by authors in the national first cassava research review workshop from 17-18 May 2012 at Awassa, SARI southern Ethiopia. Data of different experiments were gathered from various research centers and authors. The gathered data were systematically compiled in logical manner that makes sense where conclusions were drawn accordingly using standard methodologies. Agronomic data like plant height, weight and number of roots/plant and roots/plot, root length and root diameter were measured at harvest where as canopy diameter was estimated at mid flowering in all experiments.

The LER is calculated as

$LER = L_A + L_B + \ldots\ldots + L_N$ = AASY + BBSY + …… + NNSY = Σ=NINNSY1 Where L_A, L_B… L_N is the LER for the individual crops

Y_A, Y_B… Y_N are the individual crop yields in intercropping.

S_A, S_B… S_N is their yields as sole crops

When LER is greater than 1 or more, it signals yield advantage and a ratio of less than 1, is yield disadvantage [2].

4. Results and Discussion

4.1. Plant Population Density at Awassa

An experiment was conducted in 2004 and 2005 cropping seasons in *Fluvisols* of Awassa at 7^0 04’N and 38^0 31’E longitudes at an altitude of 1700 m a.s.l. with the objective of determining appropriate plant and row spacing that maximizes cassava root yield in sub-humid region of Ethiopia. The experiment was laid in randomized complete block design with three replication where each replication contain factorial combination of four levels of plant spacing (60 cm, 80 cm, 100 cm and 120 cm) and three levels of row of spacing (80 cm, 100 cm and 120 cm). Significant positive association was observed between dry root yields (DRY) and root diameter, root size, root number, root length, canopy diameter and dry biomass yield (DBY). Results showed that significantly higher root diameter ($p<0.05$) and significantly wider canopy diameter were observed due to row spacing of 120 cm than that of 80 cm row spacing. However, responses of root and canopy diameter were not significantly different ($P<0.05$) among 100 cm and 120 cm row spacing. Significantly higher ($p<0.01$) root yield/plant was measured due to 120 cm row spacing than other row spacing levels. However, cassava root yield per unit area was significantly higher ($p<0.05$) due 100 cm and 120 cm row spacing than 80 cm row spacing. But, the effects of row spacing were not significant on number of roots/plant and length of roots. When plant spacing was considered, canopy diameter ($p<0.01$) and number of roots/plant ($p<0.05$) were significantly higher due to 120 cm plant spacing than other plant spacing levels. Yield/plant due to plant spacing levels of 100 and 120 cm was not significantly different ($p<0.05$). Also, effects of plant spacing were not significantly different ($p<0.05$) on cassava root diameter, root length and root yield/unit area. However, 60 cm plant spacing produced significantly lower ($p<0.05$) number of roots/plant, canopy diameter and root yield/plant than that of 80 cm. Hence, use of 100 cm row spacing and 80 cm plant spacing is optimum for cassava production in *Fluvisols* of Awassa and similar agro-ecologies [3].

4.2. Plant Population Density at Amaro Kele, Jijola, Bele and Loma

Factorial experiment was laid in RCBD with three replications at Jijola district, Amaro to determine optimum inter and intra row spacing for cassava. The treatments involved 80, 100 and 120 cm row spacing and 60, 80, 100 and 120 cm plant spacing. Aboveground biomass was significantly ($p\leqq0.05$) affected by spacing and the highest biomass was observed at spacing of 100 cm x 120cm. similarly, the root yield of cassava was statistically higher due to 80 cm x 80 cm spacing. In Amaro Kele area 120 cm x 80 cm spacing produced significantly higher yield compared to other interaction levels. Non significant results were obtained in the plant population study trials at Loma and Bele [2, 4, 5].

4.3. Harvesting Stage and Cultivars Effects on Starch Quality and Quantity

The trial was carried out during 2009-2010 at Gofa Woreda, SNNPR. A factorial combination of five level of harvesting stage (9, 12, 15, 18, 20, 24 months after planting) and three cassava varieties (*‘kelo’, ‘qulle ’* and a local variety) were laid out in randomized complete block design with three replications. Data on tuber yield, yield components were recorded and some starch quality parameters from cassava tubers were analyzed in laboratory and all the data were statistically analyzed. Statistically analyzed quality parameters results indicated that moisture of the tuber starch was affected significantly by harvesting stage and variety of cassava. PH and viscosity of the tuber starch were significantly affected by harvesting stage. The highest viscosity of the starch was recorded by harvesting the crop at 18 months after planting. Moisture content was significantly reduced after 15 months after planting. PH of the starch was significantly reduced 15 months after harvesting. Neither the harvesting stage nor the variety did not affect significantly the color and dry appearance of the cassava starch. Tuber yield and yield components of the crop were significantly affected by the interaction of variety and harvesting stage. The highest tuber yield (151q/ha) was obtained when variety ‘*qul'e’* was harvested at 21 months after planting. Generally significantly better tuber yield of all varieties were recorded by harvesting cassava starting 18 months after planting.

Table-1. Moisture content of different cassava varieties as affected by harvesting stage

	Harvesting stage (months after planting)					**mean**
Variety	**9**	**12**	**15**	**18**	**21**	
kelo	63.5	82.4	84.0	67.8	55.1	70.56
qulle	63.3	81.4	77.1	56.2	64.5	68.49
local	65.1	83.9	80.1	50.6	64.9	69.49
Mean	63.99b	82.57a	80.39a	58.18c	60.53bc	
Cv (%)	7.6					

Source: unpublished data

Table-2. Viscosity and PH of cassava as affected by harvesting stage

Harvesting stage (months after planting)	scosity	PH
9	7.7ab	6.7ab
12	4.97c	6.9ab
15	6.52bc	7.4a
18	9.42a	6.7ab
21	8.17ab	6.1b
Cv (%)	32.3	11.2

Source: unpublished data

Table-3. Tuber yield of different cassava varieties as affected by harvesting stage

	Harvesting stage (months after planting)					mean
Variety	**9**	**12**	**15**	**18**	**21**	
Kelo	36.14	49.38	45.25	113.7	105.7	70.03
Qulle	19.9	47.5	72.1	138.5	161.8	86.0
Local	15.9	48.34	71.63	51.17	140	65.5
Mean	23.99	48.41	63.01	101.3	135.8	
LSD(5%)variety= 17.63, harvesting stage=22.76, variety X harvesting stage = 39.43						
Cv (%) = 33.5						

Source: unpublished data

4.4. Cassava / Maize Intercropping

This study was conducted in 2005 and 2006 at Goffa woreda, Gamo Goffa zone, to determine optimum ratios of component crops that will improve land use system of intercropping system. There were four cassava/maize intercrop row arrangements: 1row cassava: 1 row maize, 2rows cassava: 1 row maize, 2rows cassava: 2 rows maize, 1row cassava: 2 rows maize, and two sole crops of maize and cassava were incorporated. Maize hybrid variety *'BH-140'* and '*Quele'* variety of cassava were used in the trial. Other agronomic practices were applied equally for all plots. The experiment was lied out in randomized complete block design with four replications. The combined analysis over years showed that different maize plant densities intercropped with cassava had significant ($p<0.001$) effect on grain yield and yield components of maize. The highest grain yield of maize was obtained when maize and cassava was intercropped in alternate rows (1row cassava: 1 row maize). On the other hand cassava tuber yield was not affected by the intercropped maize. The analysis of land equivalent ratio showed that the advantage of intercropping was 71 % over sole cropping. Among the intercropping pattern the highest yield advantage were also obtained when cassava and maize were intercropped in alternate rows. The economic analysis also indicated that the highest net benefit (13,715.4 birr/ha) were obtained when one maize row was grown between 2 cassava rows.

Table 4. Grain yield of Maize and tuber yield of cassava (q/ha) under different intercropping pattern (mean 2005-*2006)*

Treatments	Maize	Cassava	stand percent of maize at harvest
1C:1M	53.11a	450.5	91.2a
1C:2M	47.32ab	474.5	60.6b
2C:1M	21.40c	464.5	94.7a
2C:2M	30.08bc	470	92.4a
Sole cassava	-	502	
Sole maize	66.28a		65.1b
Pr CV (%)	0.0002	26.1	<.0001 14.6

Means followed by the same letter(s) with in a are not statistical different by DMRT ($P\leq 5\%$)

Source: AwARC [2]

4.5. Cassava-Legumes Inter-Cropping

The trial was carried out for two successive cropping seasons from 2005 to 2008 at Amaro clay loam textured soil with a pH of 6.5 and located in an altitude of 1400 m a.s.l. The site has bimodal rainfall with very short rain season starts from last week of February to end of March and the second season from September to October. The cassava variety used was Kelo while the four legume varieties were haricot bean (Omo-95), mung bean (boroda -1), soybean(Awassa 95), and cow pea (Maze). *T*wo rows of 40cm apart were made between the two cassava rows to plant legumes with the spacing of 40cmX 10cm haricot bean, 40cmX 5cm for soy bean, 40cmX 10 for cow pea and 40cmX 5 cm for mung bean. Both crops were planted at a time during the first shower of rainfall, February –May. Data of each crop were taken from 5 randomly tagged plants per experimental unit (plots). Root yield of cassava were weighed using spring balance during cassava harvest and grain yield of legumes also weighed using ordinary balance. Land equivalent ratio of cassava is calculated as intercrop yield of cassava/pure stand yield of cassava and that of legumes is calculated as intercrop yield of legumes/pure stand yield of legumes; The overall land equivalent ration (LER) is simply the sum of LER of cassava and LER of legumes. The competitive value is simply the ratio of the individual LER's of the two crops. The collected data were subjected to ANOVA using SAS computer software.

Table-5. Effect of intercropped grain legumes with cassava on yield of legumes kg/ha)

Treatments	Sole yield (kg/ha)	Intercrop yield (kg/ha)	LER	Competitive value
Haricot Bean	3510	3222	1.09	1.49
Cow Pea	3302	2844	0.86	1.37
Soybean	2010	2010	1.00	2.08
Mung Bean	1740	1948	1.12	2.24

Source: unpublished data

Intercropping cassava with haricot bean, cowpea, soybean and mung bean, reduces cassava yield by 27%, 37%, 52% and 50% respectively. However, intercropping cassava with haricot bean, cowpea, soybean and mung bean resulted in 82, 49, 48 and 62% greater land use efficiency than for either crops grown alone.

Table-6. Agronomic performance of cassava under intercropped and sole production conditions

Treatments	Roots/ plant	Root length(cm)	Root diameter (cm)	Biomass (ton/ha)	Root yield (ton/ha)	LER_c	LER
Cassava + haricot bean	2.7	32	2.98	49.38b	14.81b	0.73	1.82
Cassava + cow pea	2.7	36	3.13	35.99b	12.88c	0.63	1.49
Cassava+ soybean	2.9	38	2.87	49.29b	9.71de	0.48	1.48
Cassava+ mung bean	2.4	29	2.30	44.25b	10.26d	0.50	1.62
Sole cassava	2.9	37	3.48	72.50a	20.33a		
Cv%	50.8	27.69	36.09	22.24	31.57		
LSD5%	NS	NS	NS	13.69*	7.24*		

Note: NS = not significant, Letters in the same column= Significant at 5% probability.
Source: unpublished data

The highest value of LER was obtained by growing cassava with haricot bean (1.82) followed by cassava with mung bean (1.62) whereas relatively the lowest was cassava grown with soybean (1.48). Overall land equivalent ratio (LER) was greater than one when cassava intercropped with legumes. This suggested that the actual productivity was higher than expected when cassava was intercropped with grain legumes. This is so because early slow growth of cassava was effected by grown additional legume, cassava can maintain its maximum growth after component crop removal and the growth one these crops under cassava has no adverse effect on growth performance of each crops. land use efficiency improved by 82% when cassava intercropping with haricot bean and that of mung bean was by 62% and the lowest was with soybean and is by 48% which indicated that the actual productivity was higher than expected when cassava was intercropped with legumes. The benefit of obtaining additional legume grain would have positive advantage on food security and land use efficiency, especially in weed suppression and soil conservation in the first six months of cassava growth were slow growth of cassava could lead to such problems

5. Planting Dates

Cassava can be planted in any time of the year if moisture is available either in the soil through rainfall or irrigation. However, planting date trial carried out for three consecutive years showed that march to May plating is better than the other planting in the major cassava growing areas of Ethiopia. At planting there should be enough moisture to secure 80 to 90% of germination; however, if soils are waterlogged aeration and root formation were usually hindered. The harvesting date study revealed that the released Qule and Kele varieties could be harvested in 18 months time. However, starch contents are higher if cassava is harvested in dry months.

Table-7. Mean of cassava root yield as affected by planting dates for three consecutive growing seasons at Amaro

Planting dates	Mean Root yield (t/ha)	
	Marketable yield	**Total root yield**
April 7/2000,01,02	14.85	20.52
May 2/2000,01,02	13.42	23.07
May 17/2000,01,02	8.91	17.83
June 1/2000,01,02	9.77	17.41
June 16/2000,01,02	5.25	16.05
July 1/2000,01,02	9.51	21.48
July 16/2000,01,02	5.78	14.7
July 31/2000,01,02	6.53	18.92
Aug. 15/2000,01,02	4.81	15.9
Aug. 30/2000,01,02	2.61	14.55
Sept. 14/2000,01,02	3.79	14.46
Sept. 29/2000,01,02	2.46	13.04
CV	10.85	16.32
LSD (5%)	4.19	5.07

Source: AwARC [1]

6. Planting Position and Planting Materials

The orientation of cuttings during planting depends on plant variety and environmental conditions, and influences numerous growth characteristics and yield.

The study compared different planting methods. Results showed that slant and vertical plantings are suitable in Awassa sandy soils compared to horizontal planting. Similarly, the study revealed that planting materials shall be taken from main stem of cassava compared to its branches. In this study it was confirmed that the middle and top portion of the cassava stem produced quality planting materials that resulted in superior yield.

Table-8. Mean of yield components and yield of cassava at Awassa

Position	Planting materials	Root length cm	Root diameter, cm	Root yield (t/ha)	No. stems/hill
Slant	Main stem top	29	4.5	27.5	3.2
	Main stem middle	25.5	3.8	24.0	3
	Main stem bottom	28.2	3.3	21.7	2.8
	Branch stem top	35	3.8	16.7	1.8
	Branch stem bottom	26.7	3.5	13.3	2.2
Vertical	Main stem top	27	3.7	20.5	2.3
	Main stem middle	25	3.5	18.7	2.8
	Main stem bottom	26	3.7	14.4	3
	Branch stem top	28.7	3.7	15.5	2
	Branch stem bottom	24.8	3	16.7	2
Horizontal	Main stem top	21.5	3.2	9.1	3.8
	Main stem middle	21.5	2.7	11.4	3.5
	Main stem bottom	22.2	2.8	6.9	3
	Branch stem top	26.8	3.8	11.5	2.3
	Branch stem bottom	25.2	3.8	9.9	2.2
	LSD PP X PM (0.05)	NS	NS	6.64	NS
	Planting position (0.05)	2.99	NS	2.97	0.33
	Planting parts (0.05)	3.86	3.4	3.83	0.43
	CV (%)	22.07	25.38	46.18	24.09

Source: Legesse, et al. [6]

7. Land Preparation Methods

Flat, furrow and ridge planting were compared under different plant density scenarios at Amaro. Results showed that furrow and ridge planting produced comparable results of 48t/ha and 43t/ha compared to 38t/ha produced by flat plantings. This might be due to reaped advantage of moisture conservation that subsequently manifested in wider canopy diameter, root length and diameter of cassava. However, manual harvesting required deeper digging, more labor and time in furrow planting compared to others. Therefore, planting cassava in a ridge was recommended in Amaaro Kele area.

Table-9. Mean of root yield of cassava as affected by land preparation methods at Amaro Kele

Land preparation methods	Cassava yield (t/ha)
Ridge	27 a
Furrow	21 ab
Flat	19 b
LSD (5%)	7

Source: Gobeze, et al. [3]

8. Conclusions

Cassava is produced in diverse ecological systems for multiple purposes in Ethiopia. This diversity and multiplicity coupled with site specificity of soils and climate related parameters makes generalization of agronomic recommendations difficult. However, specific recommendations were made on similar edaphic and agro-ecological conditions. Results showed that cassava can be grown easily under variable climatic and edaphic conditions.

When cassava is intercropped with legumes, the cassava root yield generally decreases compared with when cassava is planted alone. This is due to the competition of the component crops for light, water and nutrients. However, cassava-legume intercropping systems usually increase the land use efficiency and economic return over solely grown cassava. These advantages can occur as a result of complementary use of growth resources such as nutrients, water and light by the component crops. The yield advantage may be in terms of higher yield or higher net income. It could further be explained that the yield can be quantified in terms of dry matter production, grain or root yields, nutrient uptake, energy or protein production and market value.

9. Future Research Directions

Strategic cropping system integration should be sought particularly with climbing beans, cow pea and mung beans to allow green manuring, residue cover, residue incorporation, atmospheric nitrogen fixation and enhance cassava and component crop productivity besides breaking disease and insect pest cycles.

Herbicides should be screened for early stage of cassava growth for sedges management as cassava does not tolerate weed effects at early stage of growths.

Further studies on fertilizer requirements, plant density, land preparation, planting positions and harvesting methods shall be carried out under irrigated and mechanized farming conditions.

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