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Evaluation on Compatibility of Maize and Orange Fleshed Sweet Potato Relay Cropping Through Spatial and Temporal Arrangement, Tigray, Ethiopia

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Abstract

In Tigray, maize is the principal cereal crop which is grown both under rainfed and irrigation. On other hand, orange fleshed sweet potato (OFSP) is the newly introduced cash and nutrient rich crop. Both crops are grown mainly as a sole; however smallholders have limited landholding and there is therefore a need to encourage farmers to adopt innovative integrated crop intensification approaches to increase productivity of their lands. The objective of this study was to examine the potential of short-season sweet potato variety to reduce hunger gap through application of relay-cropping in maize-based production systems. The experiment was conducted in 2011/2012 rainy season at Mekelle Agricultural Research Center farm using the variety Tula for OFSP and Melkasa II for Maize. Treatments tested were three relay cropping ratios of 1 row OFSP and 3 rows maize, 1 row OFSP and 2 rows maize, 1 row OFSP and 1 row maize relayed at 4 weeks, 6 weeks, 8 weeks interval after maize planting compared against sole crops of maize and sweet potato. Land Equivalent Ratio (LER) was calculated to determine land use efficiency in the relay intercropping systems. Relaying time of sweet potato did not affect maize growth and yield, whereas planting ratios has significantly affected maize performance. Root yield of sweet potato decreased as the proportion of planted maize increased and root yield reduced remarkably as date of transplanting delayed in all treatment combinations. All treatment combinations were more than unity, hence both companion crops are compatible for intercropping. The highest land equivalent value of 45% was recorded from two rows of maize and one row of sweet potato planted when sweet potato cuttings were relayed at four weeks after maize planting. The results revealed that farmers in the dry lands could benefit from relay-cropping of sweet potato with maize, which could reduce hunger gap and increase income of rural households.

Keywords: *Orange fleshed sweet potato; Maize; Intercropping; Hanger gap, and nutrition*

Introduction

Sweet potato is a root crop that performs better than major crops of the world under extreme soil and climatic conditions prevalent in developing world particularly in Africa (Zerihun, 2009). It has particular importance since it is rich in carbohydrate, Vitamin C, fiber and mineral. Orange-fleshed sweet potatoes have emerged as one of the most promising plant sources of ß-carotene and have been recognized to improve the food security (Hagenimana and Low, 2000).

In Ethiopia, sweet potato is one of the most widely grown root crops and becoming a major source of food for the poor. It is the third important root crop next to Enset and Potato (Engida *et al*., 2009). Though, sweet potato is the newly introduced cash and food crop in Tigray, currently, it gained special significance due to the crop is a relatively drought tolerant which playing a more important role to secure the hunger gap and serve also as income generating crop.

The agricultural system in Tigray has been mainly cereal based. Maize is the principal cereal crop grown both under rain fed and irrigation. It is used as bread, local beer, roasted or boiled green maize, and its stover is used for animal feed. Though both crops are important for food, feed and nutritional security smallholder's farmers often used their limited landholding for maize than for sweet potato therefore, there is a need to encourage farmers to adopt innovative integrated crop intensification approaches to increase productivity of their lands. One possible approach to resolve this problem would be to maximize the utilization of limited agriculture land through multiple cropping to increase productivity per unit area of available land (Getachew *et al*., 2006; Seran *et al*., 2010). Intercropping has long been a common practice in developing countries (Wahla *et al*., 2009) as an important multiple cropping system. Intercropping is one of the cropping strategies that have been recognized to improve the food security situation and incomes for the farmers (Sullivan, 2003)

Traditionally, sweet potato has been grown as an intercrop with beans, cassava, maize and pigeon pea (Gibson, 2006). Maize and sweet potato (Ipomoea batatas) are a common intercropping combination in the semi-arid Rift Valley of East Africa Amede *et al*. (2001).

A different intercrop study reported that sweet potato yield was reduced by up to 56%, while maize yields were not affected (Webi, 2007). Thus there is great opportunity for vertical increase in area and production of sweet potato without affecting area and production of other crops. Though, intercropping of sweet potato and maize is common in other part of the country the yield responses of either OFSP or maize under intercropping are lacking therefore, this trial was initiated.

Objectives

- To examine the potential of Inter- and relay-cropping of sweet potato in maize to reduce hunger gap and increase food production and income of rural households.
- To investigate the best production niches and highest land use efficiency for the productivity of maize/sweet potato intercropping

Materials and Methods

Site description and Experimental design and treatments

The experiment was carried out at the agricultural research farm of Mekelle Research Center, Illala. Illala is located at longitude 39° 30' E and latitude 13° 31' N at an altitude 1970 m.a.s.l. Geographically, it is located in the south east of Tigray found at elevation of 1970 m.a.s.l at 25° 5 'N Latitude and 390 6 ' longitudes. The area is agro-ecologically classified in the semiarid region characterized by short rainy period (June to early September). The area receives an average annual rainfall of 666 mm of which 561 mm was received in the 2011 cropping season. The average yearly minimum and maximum temperatures are 11.7°c and 26°c, respectively (Mekelle research Meteorological service (Table 1).

According to the rating of Tekalign Tadese (1991) the soil reaction of the experimental site is categorized as moderately alkaline (7.8) , low organic matter (1.32 %) and low total nitrogen (0.02 %) , P-Olsen 4.7 mg/kg (Cottenie, 1980). Based on the rating of Hazelton and Murphy (2007) CEC of the soil is high (34.2 mol kg-1) and EC is non saline (0.25ds/cm) .Treatments tested were three relay cropping ratios of 1 row OFSP and 3 rows maize, 1 row OFSP and 2 rows maize, 1 row OFSP and 1 row maize, sweet potato relayed at 4 weeks, 6 weeks, 8 weeks interval after maize planting compared against sole crops of maize and sweet potato.

Month	Rainfall	Temp°c	
	Mm	Min	max
Jan	0	9.7	24.8
Feb	0	9.4	26.9
Mar	21.6	11.9	25.5
Apr	25.7	14.3	28.2
May	55.9	14.2	27.6
June	29.2	12.7	28.7
July	236.1	13.5	26.2
Aug	231.3	13.6	24.3
Sep	66.4	11.5	25.5
Oct	0	10.8	25.2
Nov	0	11	25

Dec	0	8	24.6
Total	666.2		
Mean		11.74	26.700

Source; Mekelle Research Meteorological service

Table1: *Monthly total rainfall (mm) and monthly average air temperature ranges (T°), in 2011 cropping season.*

Experimental Procedures and crop management

The experimental field was ploughed two times with tractor followed by manual seed-bed preparation and laid out according to the experimental scheme. The experiment was run by superimposing the treatments of sweet potato on the already planted maize stands in strip plot arrangement with three replications. Plot size of 5 m x 5 m, 25 m^2 was used. Maize was planted on June 29 while, sweet potato cuttings was planted based on the determined ratio and sole maize and sole potato was included for comparism. Spacing between plants was 30cm and between rows was 75 cm. Fertilizer rates of 50 kg urea and 100 kg Dap ha^{-1} was applied for all treatment combinations. The plots were weeded two times using human labor. Following full maturity, maize was harvested at the first week of November and sweet potato from December to January.

Data collection and measurements

Data on grain yield of maize and root yield of sweet potato were determined from 10 randomly sampled plants per plot during physiological maturity and converted to tones ha^{-1}.

Land equivalent ratio (LER) was computed to measure the efficiency of the intercropping as compared with sole crops. LER for maize/sweet potato was calculated as sum of the partial LER values of maize and sweet potato (according to (de wit *et al*., 1965).

Land equivalent ratio (LER) = (YAB/YAA) + (YBA/YBB) Where:
YAB=yield of crop A (maize) when relay cropped with crop B (sweet potato),
YBA=Yield of crop B (sweet potato) when relay cropped with crop A (maize),
YAA=Yield from sole planted crop A (maize),
YBB=Yield from sole planted crop B (sweet potato).

A LER of 1.0 would indicate that the amount of land required for both crops in the different pattern was the same as that for each crop grown individually. It is also an indicator of complementary of the component crops. LER greater than one indicated, the cohesiveness among component crops.

Results and Discussion

Sweet potato Component

The result revealed that sweet potato root yield was reduced remarkably as date of transplanting delayed in all spatial arrangements (Table 2). Better sweet potato root yield was recorded from cuttings planted after 4 weeks, while root development was hindered for the rest treatments. Moreover, root yield has been greatly influenced by spatial ratios of the component crops. Root yield decreased as the proportion of maize increased attributed to the nature of spatial and temporal arrangement. This might be attributed to interference of maize canopy for light interception and the lately planted cuttings were severely affected by shortage of moisture towards the end of the rain season. The result is in close collaboration with the study of (Webi, 2007) who reported that sweet potato yield was reduced by up to 56%, while maize yields were not affected.

Planting ratio in rows	Relay time in weeks		
	4WK	6WK	8WK
1maize/ 1 sweet potato	18.7^{b}	15.50^{b}	12.60^{a}
2maize /1 sweet potato	16.7^{b}	13.44^{a}	12.70^{a}
3 maize /1 sweet potato	12.5a	11.22^{a}	10.78^{a}
Sole Sweet potato	24.80^{C}	20.90^{bc}	18.70^{b}
CV(%)	8.40		

WK= Weeks after maize planting

Table 2: *Effect of intercropping ratio and planting time sequence on root yield of sweet potato (t/ha), Illala, 2011/12.*

Maize component

The highest grain yield of maize was obtained from sole crop followed by three rows maize/one row sweet potato (Table 3). The difference among transplanting date of sweet potato did not affect maize growth and yield, whereas planting ratios has significantly affected maize performance. Naturally vines of sweet potato grow horizontally and these vines could not compete for light, but remarkably compete for nutrients and moisture. Moreover, grain yield has been greatly influenced by spatial ratios of the component crops. Grain yield increased as the proportion of maize increased. This might be attributed to less interference of sweet potato canopy for light interception

planting ratio in rows	Relay time in weeks (WK)		
	4WK	6WK	8WK
1maize/1 sweet potato	3.27[a]	3.26[a]	3.12[a]
2 maize/1 sweet potato	4.95[b]	4.88[b]	4.67[b]
3 maize/1 sweet potato	5.66[c]	5.61[c]	5.83[c]
Sole			6.34[d]
CV (%)	6.7		

WK= weeks after planting

Table 3: *Effect of intercropping ratio and planting time sequence on grain yield of Maize (t/ha), Illala, 2011/12.*

Land equivalent Ratio

The results implicated highest land use efficiency was recorded from two rows of maize and one row of sweet potato and three rows of maize with one row of sweet potato combination ratios relay planted at four weeks (Table 4). Regarding sweet potato, late relayed treatments were significantly low in land use suitability attributed to light competition and shortage of moisture towards the end of the rain season (Table 1). All treatment combinations were more than unity, hence both companion crops are compatible for intercropping. The results revealed that farmers in the dry lands could benefit from Inter- and relay-cropping of sweet potato with maize, which could reduce hunger gap and increase income of rural households.

Relay time in weeks			
Cropping pattern Sweet potato	**4WK**	**6WK**	**8WK**
1maize/1 sweet potato	0.75	0.74	0.66
2maize/1 sweet potato	0.67	0.64	0.67
3 maize/1 sweet potato	0.50	0.53	0.57
Sole sweet potato	1.00	1.00	1.00
Maize partial Land Equivalent Ratio			
1maize/1sweet potato	0.51	0.51	0.49
2maize/1 sweet potato	0.78	0.77	0.73
3 maize/1 sweet potato	0.89	0.88	0.81
Sole maize	1.00	1.00	1.00
TLER			
1maize / 1sweet potato	1.26[b]	1.25[b]	1.15[b]
2maize / 1 sweet potato	1.45[c]	1.41[c]	1.40[c]
3 maize /1 sweet potato	1.39b[c]	1.41[c]	1.38[c]
Sole Crop	1.00[a]	1.00[a]	1.00[a]
CV (%)	6.4		

Table 4: *Partial and total Land Equivalent Ratios of maize relay cropped with sweet potato at different days.*

Conclusion and Recommendation

Intercropping of maize with sweet potato is a potential for reduction of hunger gap and increasing food production and income of rural households. The results implicated that the component crops are compatible and gave land use and biological yield advantage when used as intercropping or relay cropping under farmers condition. Further research should be geared towards allocating the land in proportion consider companion crops are equally importance. This system might help to boost overall farm productivity through managing as sole crop.

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