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Full Length Research Paper

Growth habit, plant density and weed control on weed and root yield of sweet potato (*Ipomoea batatas* L.) Areka, Southern Ethiopia

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Sweet potato is mostly left unweeded or weeded lately. Effect of variety, plant density and weeding frequency on weed and tuber yield was studied from 1992 to 1994. Three varieties (Tis 1499: erect and early; Tis 2498: long vine, spreading and early, and Koka 6 intermediate), two weeding frequencies (30 to 40 (W1) and 70 days after sprout (DAS) (W2), and four plant densities (5, 7, 10, and 12.5 plants m^{-2}) were laid out in factorial arrangement in randomized complete block design with three replications. The major weed was broad leaf covering 95% of the total weeds, *Capsella rubella*, *Guizotia scabra* and *Plantago lanceolata* being the dominant weeds. In 1992 and 1993, mean weed density in Tis 2498 was 17 and 18% less compared with Tis 1499 and Koka 6, respectively. Weeds at higher plant densities were 11.8% less compared with the lowest density. All the cultivars produced more yield in 1994, but Tis 2498 and Koka 6 yielded 35.4 and 8.3% less than Tis 1499, respectively. Weeding twice in the first two years significantly increased the mean yield by 46.2%. Weeding of Tis 1499 and Koka 6 twice significantly increased the yield by 23.2% each but Tis 2498 did not respond to weeding. The cultivars Tis 1499 and Koka 6 yielded 22.7 and 18.8 t ha^{-1}, more at 7 and 10 plants m^{-2}, respectively, but Tis 2498 did not respond. Weeding once and twice within the range of 7 to 12.5 plants m^{-2} had no significant yield variation indicating weeding once would suffice at higher plant density. Varieties with high population having erect and intermediate growth habits can be weeded twice. Growth with spreading canopy structure and plant density could be used as means to reduce weed infestation. This will save farmers time and labor and thus, breeders should focus in developing cultivars with spreading canopy structure with high yield.

Key words: Areka, Ethiopia, canopy structure, plant density, sweet potato, weed density, weed infestation.

INTRODUCTION

Sweet potato (*Ipomoea batatas L.*) is one of the major horticultural crops widely grown in the Eastern and Southern regions of Ethiopia. At the national level, the total area coverage of sweet potato was 53,311.65 ha (CACC, 2006). It grows in the lowland and mid altitude areas of the Southern region and occupies more than 29,523.93 ha of land (CACC, 2003). It is grown both in *belg* and *meher* seasons covering large hectares in *meher* (320,823 and 766,495 ha, respectively). The report shows that sweet potato shares 34.1% of the total area and 36.8% of the total regional volume of root crop production. It is indicated that 11.5% of the regional root crop area was grown with sweet potato resulting in 5.12% of the regional root crop production in *belg*.

It is used as a source of food and income to the poor and needy farmers in sweet potato growing areas. In addition, the different parts are used for various purposes: the root for home consumption and sale, the aboveground part for planting material, sale and feed for livestock, and as a soil conservation mechanism. Thus, about 81.5% of the total production of sweet potato is used for home consumption, 9.6% for sale, 6.1% for animal feed, 0.64% for planting material, 0.42% for wages in kind and 1.83% for other uses (CACC, 2003).

The potential yield of sweet potato in research goes up to 50 t ha^{-1}; but on station and on-farm research with

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improved management practices, it indicated a yield ranging from 17.5 to 35.0 t ha^{-1}. However, because of poor management practices, the yield under farmers' condition is low, on average, 7.6 to 7.9 t ha^{-1} (CACC, 2003), while others reported the root yield as low as 5 t ha^{-1} (Degu and Workayehu, 1990; Degu et al., 1991). The report of Bureau of Agriculture (BoA) of Sidama zone indicated that the yield under farmers' management ranges between 6.5 and 9.0 t ha^{-1} which is far below the potential yield. CACC (2007) report also shows that the yield at the national level varies between 7.3 and 8.1 t ha^{-1}. A plant density of 8 plants m^{-2} is under practice while the optimum plant density recommended was between 3.3 and 5.6 plant m^{-2}. The low productivity is attributed to low yielding cultivar, weed competition, low or high plant density, little fertilizer application, and insect pests (CACC, 2003). According to CACC (2003), weeds account for 11.64% of the total damages of sweet potato production. A yield loss of 87 to 98.9% was recorded if sweet potato is left unweeded; even early or late weeding reduced the yield (Awassa progress report, 1991).

Tillage, hand weeding, and multiple cropping systems are of the many alternatives available for weed control. Hand weeding and chemicals are effective to control weeds (ICARDA, 1984). Availability, costliness, efficacy, and its effect on human health are problems to consider when using herbicides. In sweet potato producing areas of the region, land preparation is carried out using traditional ox-drawn implement with few plowings due to shortage of oxen (>50% of the farmers in the region have no ox, CSA, 2003). Weed control measures such as increased plant density and cultivar selection can be exploited. Weeds could be suppressed either by increasing plant density or using cultivars with better competitive ability and provide an optimum yield per unit area. Cultivars differ in their ability to suppress weeds and some studies indicate varieties differing in canopy structure showed no significant effect on weed infestation (Tenaw et al., 1997). On the contrary, Taye and Tanner (1997) reported some varieties to better compete and suppress weeds due to their canopy structure. Olofsdotter et al. (1999) reported varietal differences in suppressing the infestation of *Echinochloa crus-galli* weed and pointed a 15 to 50% of the variation in weed suppression among cultivars due to plant height. Weed interference in a given cultivar is determined by the allelopathic effect combined with competitive ability of the cultivar. Olofsdotter et al. (1999) also noted that shoot and root parameters could account for the differences among cultivars in reducing weed infestation. Other researchers (ICARDA, 1984; Salonen, 1992; Seavers and Wright, 1999) indicated leaf area, plant height, and number of tillers, canopy structure and development as factors that contribute to better crop competitiveness with weed.

Increased seed rate reduces weed growth and weed infestation tends to increase with decreased seed rate (ICARDA, 1984). Various research reports show increased grain yield because of reduced weed competition that resulted from increased plant density (ICARDA, 1984; Elmore, 1998). Higher plant density can reduce tillering that increases the ability of cultivar competitiveness (Kim et al., 1999) while it has a variable effect on leaf area (Kim et al., 1999; Lisson et al., 2000). High plant density can slow down crop growth rate and reduce leaf area index that has a relation in enhancing the competitiveness of the cultivar (Lisson et al., 2000). So far, there is no research information on the relative competitiveness of sweet potato cultivar and plant density on weed population/infestation. This study was initiated to evaluate the effect of cultivar with different canopy structure, plant density and seasonal variation on weed infestation and root yield of sweet potato.

MATERIALS AND METHODS

Site description

The study was conducted at Areka Agricultural Research Center for three consecutive seasons, 1992 to 1994. The soil is reddish brown with clay loam texture, which is classified as Nitosol. The soil has a pH of 5.45 (acidic), TN 0.204 g kg^{-1} (low), P_2O_5 3 mg kg^{-1} (low) and CEC 24.61 cmol kg^{-1} soil (medium) (Landon, 1984). The location has two crop growing seasons, mainly *belg and mehir* that begin from February to May and June to September, respectively.

Treatments

Three cultivars of sweet potato, Tis 1499 erect/vertical growth and, short vine with low vegetative growth and early maturing; Tis 2498 spreading/, long vine with high vegetative growth, and early maturing; and Koka 6 an intermediate with medium vegetative growth and medium maturing, four plant densities (5, 7, 10, and 12.5 plants m^{-2}), and two weeding frequencies [W1-one time weeding 30 to 40 days after sprout (DAS), and W2-weeding twice 30 to 40 and 70 DAS] were used. Plant density was arranged by varying row spacing (1.0, 0.7, 0.5, 0.4 m) and maintaining plant spacing constant (0.20 m). Factorial arrangement in randomized complete block design replicated three times was laid out and the plot size was 4 m wide and 4 m long.

Crop management

Planting dates were June 13 and 4 of 1992 and 1993, respectively, and May 26, 1994. The land was plowed with tractor. Fertilizer was applied at the rate of 18 N and 46 kg P_2O_5 ha^{-1}, respectively, DAP was used as source of the nutrients.

Data collection

Weed types and density were identified using four quadrat counts per plot using iron square of 25 × 25 cm. Data on weed type, weed m^{-2}, leaf area (1994 only), branching, plant population at harvest, and root yield were collected. Leaf area, using destructive sampling, was measured by taking 10 fully expanded leaves per plot.

Table 1. Amount of precipitation in the growing season and long-term rainfall (1988 to 1991) in Areka, Ethiopia.

Month	Season			
	1992	1993	1994	Long-term
May	191.6	310.3	279.8	141.2
June	68.2	94.1	173.0	136.4
July	174.3	269.7	221.7	236.4
August	331.3	185.7	273.9	189.9
September	224.5	117.6	117.9	199.8
October	188.7	94.2	6.7	119.2
Total	1178.6	1071.6	1073.0	1022.9

Statistical analysis

Economic analysis of sweet potato was conducted using yield and the current mean market price of sweet potato (US$ 0.53 kg^{-1}). Variable costs were determined for each treatment with: labor required for W1 and W2 of 20 and 25 person-day ha^{-1}, respectively, at US$ 1.16 perosn^{-1} day^{-1}; labor for cultivation of 20, 25, 30, and 35 person-day for a density of 50×10^3, 70×10^3, 100×0^3 and 125×10^3 plants ha^{-1}, respectively, at US$ 1.16 person^{-1} day^{-1}; and labor for harvesting of 20, 25, 30 and 35 person/day for the aforementioned plant densities, respectively, at US$ 1.13 person^{-1} day^{-1}. Other costs were considered constant across treatments. Net income (NI) was determined as the difference of gross income and variable costs (Babatunde, 2003). Because of the interaction effect of year with variety and plant density, combined analysis over years was conducted after test of homogeneity (Gomez and Gomez, 1994). Log transformation was made for weed infestation and tuber yield of sweet potato to stabilize the variances. Analysis of variance was conducted using SAS statistical package (SAS, 2000) and Tukey test of significance to differentiate treatment means. Correlation and stepwise multiple regression analysis were carried.

RESULTS

Rainfall

Total rainfall in 1992 was above the long-term average (15% more); however, amount of rain in some decades of June, July and September was low with poor distribution. In addition, the heavy rainfall in August and September caused water logging. The rainfall pattern was thus below normal in June (50%) and July (26.3%) and above normal in August (174.5%) and September (112.4%). The precipitation in June, July, August, and September of 1993 was low, which negatively affected the sprout (germination) and physiological maturity. The distribution was poor in June and July and was below normal in June (31%) and September (41%), and normal in July and August. In the year 1994, amount of precipitation was low in June, July, and September but the distribution was good (Table 1). Overall, weather variations in the years affected the effect of cultivar, plant density and weed control on weed infestation, crop growth and yield.

Weed types

The dominant weed species were broadleaf covering 90, 100 and 95% of the total weed populations in 1992, 1993 and 1994 seasons, respectively. More weed population was observed in 1993 followed by 1994. The major weed species during the growing seasons were *Plantago lanceolata, Capsella rubella,* and *Guizotia scabra,* which accounted for 16 to 27% of all weeds present in all years (Table 2).

Weeds m^{-2}

Effect of variety on weed was dependent on seasonal variation (Table 3). Weed population in Tis 1499 was 53.7 and 48.1% less in 1992 and 1994, respectively, compared with that in 1993 (Table 4). In 1992, weed infestation in Tis 2498 was 16.4 and 23.5% less than those of Tis 1499 and Koka 6, respectively, while weeds in Tis 2498 during 1993 were 17.7 and 15.8% less than Tis 1499 and Koka 6, respectively; however, all varieties showed no significant variation in weed population in 1992 and 1994. Weed infestation in 100×10^3 plants ha^{-1} was 11.3 and 12.3% less compared with the density of 50 and 70×10^3 plants ha^{-1}, respectively, though not significantly different from the highest plant density indicating significantly less weed as plant density increased (Table 5). Plant density was negatively associated with weed infestation indicating a negatively linear relationship (r = -0.328**, n=72).

Branch number

Plant density, cultivar and weeding practice had a significant effect on branches per plant. The first three plant densities had more branches and yet no significant variation while significantly fewer branches were observed at the highest plant density (12.5 plants m^{-2}) (Table 6). On the other hand, Tis 1499 and weeding once had significantly more branches. Branching was positively associated with root yield (r = 0.332, n=72).

Leaf area

Leaf area was significantly affected by variety and its

Table 2. Weed types and density m^{-2} (number) observed during the experimental seasons, 1992 to 1994, Areka.

Weed type		
Broad leaf	**Other weeds**	**Grass spp.**
Capsella rubella	*Galinsoga parviflora*	*Cyperus* spp.
Guizotia scabra	*Leuscas* spp	*Setaria* spp.
Plantago lanceolata	*Commelina benghalensis*	
Tagates minuta	*Anagalis* spp	
Ageratum conizoides	*Crinum* spp.	
	Isolepsis spp.	
	Bidens pilosa	
	Portulacea spp.	

Table 3. ANOVA showing the effect of source of variation on weed and measured parameters of sweet potato.

Source of variation	Weed density (no.)	Branch no.	Plant density (no.ha^{-1})	Leaf area (cm^{2})	Root yield (kg ha^{-1})
Year (Y)	**	-	*	-	**
Weeding frequency (W)	ns	ns	ns	ns	**
Y*W	ns	ns	**	ns	**
Variety (V)	ns	*	ns	**	**
Plant density (Pd)	*	**	**	ns	**
Y*Pd	ns	-	*	-	**
W*Pd	ns	ns	ns	ns	ns
Y*V	**	-	ns	-	**
V*Pd	ns	ns	ns	**	**
V*W	ns	ns	ns	ns	**

ns, *, and ** shows not significant, and significant at 5 and 1% probability level, respectively.

Table 4. Interaction effect of year and variety on total weed population, weeds m^{-2}.

Season	Variety		
	Tis 1499	Koka 6	Tis 2498
1992	183^{cd}	200^{cd}	153^{d}
1993	395^{a}	386^{a}	325^{b}
1994	205^{cd}	188^{cd}	232^{c}

Same letter in a column and row shows no significant difference at 5% probability level.

Table 5. Effect of plant density on weed population m^{-2}.

Plant density/plants ha^{-1}	Weed density m^{-2}
50×10^3	265^{ab}
70×10^3	268^{a}
100×10^3	235^{b}
125×10^3	238^{ab}

Same letter in a column shows no significant difference at 5% probability level.

interaction with plant density. Varieties responded differently to the different plant densities. Koka 6 and Tis 2498 had high leaf area at 7 and 5 plants m^{-2}, respectively, but no significant variable among plant densities

Table 6. Effect of plant density, variety and weeding frequency on number of branches plant^{-1}, Areka (1993 to 1994).

Plant density no. (ha^{-1})	Branching (no.)	Variety	Branching (no.)	Weeding frequency	Branching (no.)
50×10^3	5.8^a	Tis 1499	6.2^a	W1	5.8^a
70×10^3	5.5^a	Tis 2498	5.1^b	W2	5.2^b
100×10^3	6.1^a	Koka 6	5.3^b		
125×10^3	4.7^b				

W1-one weeding at 30-40 DAS, W2-two weedings at 30 to 40 and 70 DAS. Same letter in each column shows no significant difference at 5% probability level.

Table 7. Interaction effect of variety and plant density on leaf area (cm^2) 1994, Areka.

Plant density (plant ha-1) (×103)	Variety		
	Tis 1499	Koka 6	Tis 2498
50	48.6^{de}	$51.8^{c\text{-}e}$	81.40^{a}
70	49.3^{de}	$66.4^{a\text{-}c}$	$60.9^{b\text{-}d}$
100	42.5^{e}	$63.8^{b\text{-}d}$	71.2^{ab}
125	49.2^{de}	$61.3^{b\text{-}d}$	$59.9^{b\text{-}d}$

Same letter across a column and row shows no significant difference at 5% probability level.

in Tis 1499 (Table 7). On average, leaf area of Tis 2498 was significantly 44.3 and 12.5% higher than Tis 1499 and Koka 6, respectively. Leaf area had a negative relationship with total weeds m^{-2} showing the higher the leaf area the lower was the weed density.

Root yield

Effects of weeding and variety on tuber yield were dependent on seasonal variation (Table 3). In 1992 and 1993, weeding twice produced 44 and 48% more yield than weeding once, respectively, while in 1994 there was no significant yield variation between weeding frequencies (Table 8). About 6.2% of the total variation in tuber yield was attributed to weeding practice as indicated by the regression equation: tuber yield (q ha^{-1}) = 41.43+26.70W (R^2 = 0.062**), where 'W' is weeding frequency. All varieties produced high tuber yield in 1994 in particular Tis 1499 and Koka 6 while in 1992 significant yield variation was not observed among cultivars. On the other hand, the yield of Koka 6 did not significantly vary in the first two years. Tuber yield of Tis 1499 was 46.1 and 29.5% more than Koka 6 in 1992 and 1993, respectively, but the yield of Tis 2498 was 26.4, 19.7, and 46% less compared with Tis 1499 in 1992, 1993, and 1994, respectively.

Varieties responded differently to the different weeding practices and plant densities. There was an increase in yield as density increased from 5 to 10 plants m^{-2} although significant variation between 7 and 10, and 7 to 12.5 plants m^{-2} was not observed in Tis 1499 and Koka 6, respectively (Table 9). The yield of Tis 2498 did not show significant variation among plant densities despite the high yield from 10 plants m^{-2}. The result showed that a population of 10 plants m^{-2} produced significantly high tuber yield although it was not significantly different from 7 plant m^{-2}. Effect of weeding on tuber yield was dictated by variation in variety and plant density (Table 10). Weeding of Tis 1499 and Koka 6 twice increased the yield by 22.5 and 23.9%, respectively, while weeding practice did not have a significant effect on tuber yield of Tis 2498. Although weeding once and twice produced more as plant density increased (up to 10 plants m^{-2}), further increase reduced the yield. Although weeding twice increased tuber yield by 23.6, 18.2, 15.4, and 5.1% for the 5, 7, 10 and 12.5 plants m^{-2}, respectively, compared with weeding once, the variation within the range of 7 to 12.5 plants m^{-2} was not statistically significant in both weeding practices.

Economic benefit

There was an increase in net benefit as plant density increased from 50 × 10^3 to 100 × 10^3 plants ha^{-1} for Tis1499 and Koka 6 while the optimum economic return for Tis 2498 was between 70 ×10^3 and 100 ×10^3 plants ha^{-1} (Table 11). There was 5.5 and 4.8% more net benefit from 100 × 10^3 plants ha^{-1} than the 70×10^3 plants ha^{-1} for Tis 1499 and Koka 6, respectively. Weeding Tis 1499 and Koka 6 twice, significantly increased the economic benefit by 22.5 and 23.9% more, compared with one weeding, respectively, but the income from Tis 2498 was not significant between weeding practices.

DISCUSSION

Weed infestation was dictated by variation in year,

Table 8. Interaction effect of season with weeding frequency and variety on tuber yield of sweet potato (Mg ha^{-1}), Areka.

Variable	Year		
	1992	**1993**	**1994**
Weeding frequency			
W1	7.00^{d}	10.20^{c}	27.74^{a}
W2	10.08^{c}	15.13^{b}	26.53^{a}
Variety			
Tis 1499	10.58^{de}	14.76^{bc}	31.27^{a}
Koka 6	7.24^{ef}	11.40^{de}	33.25^{a}
Tis 2498	7.79^{ef}	11.85^{cd}	16.89^{b}

W1-weeding once at 30-40 DAS, W2-weeding twice at 30 to 40 and 70 DAS. Same letter in each column and row of each factor shows no significant difference at 5% probability level.

Table 9. Interaction of variety and plant density on tuber yield of sweet potato (Mg ha^{-1}), Areka.

Plant density (no.ha^{-1})	Variety		
	Tis 1499	**Koka 6**	**Tis 2498**
50×10^{3}	14.89^{b-d}	12.65^{d}	11.37^{d}
70×10^{3}	22.08^{a}	18.36^{a-c}	12.56^{d}
100×10^{3}	23.31^{a}	19.24^{ab}	12.90^{cd}
125×10^{3}	15.19^{b-d}	18.95^{ab}	11.87^{d}

Same letter across a column and row shows no significant difference at 5% probability level.

Table 10. Interaction effect of weeding frequency with variety, and plant density on tuber yield of sweet potato (Mg ha^{-1}) Areka.

Variable	Weeding frequency	
	One time:30-40 DAS	**Two times: 30-40 and 70DAS**
Variety		
Tis 1499	16.96^{bc}	20.78^{a}
Koka 6	15.45^{cd}	19.15^{ab}
Tis 2498	12.53^{de}	11.82^{e}
Plant density (no.ha^{-1})		
50×10^{3}	11.60^{c}	14.34^{bc}
70×10^{3}	16.19^{ab}	19.14^{a}
100×10^{3}	17.16^{ab}	19.81^{a}
125×10^{3}	14.96^{bc}	15.72^{ab}

W1-weeding once at 30-40 DAS (days after sprout), W2-weeding twice at 30 to 40 and 70 DAS. Same letter across a column and row for each factor shows no significant difference at 5% probability level.

variety, and plant density which positively or negatively affected the performance of crops and weeds. The high weed infestation in 1993 was due to unfavorable weather in some months during the growing season that reduced the competitive ability of the crop. There was better light interception for weed growth to compete more for soil nutrients and moisture because of poor crop growth. More weeds were observed on varieties having erect (Tis 1499) and intermediate (Koka 6) growth habits, which had 10 and 8.9% more weeds than spreading type (Tis 2498), respectively. The low weed infestation in Tis 2498 could be attributed to its canopy structure and leaf area, which might contribute to better competition for light, moisture, and nutrient (Olofsdotter et al., 1999). The finding showed that varieties with erect and intermediate types need weeding twice while the spreading type can

Table 11. Effect of plant density, variety and weeding frequency on net economic benefit of sweet potato, Eb ha^{-1} (Ethiopian birr).

Variable	Variety		
	Tis 1499	Koka 6	Tis 2498
Plant density			
50 × 10^3	89340	75900	68220
70 × 10^3	132480	110160	75360
100 × 10^3	139860	115440	77400
125 × 10^3	91140	113700	71220
Weeding frequency			
Weeding once: 30-40 DAS	101500	92440	74920
Weeding twice: 30-40 and 70 DAS	124355	1145750	70595

Cost: Weeding: 20 and 25 man-days ha^{-1} and 13 Eb (Ethiopian birr) $man\text{-}day^{-1}$: Harvesting: 20, 25, 30, and 35 man-days ha^{-1} and 15 Eb $man\text{-}day^{-1}$: Cultivation: 20, 25, 30, and 35 man-days and 13 Eb $man\text{-}day^{-1}$. Current sweet potato market price: 6 birr kg^{-1}: Planting material cost: 0.15 Eb $cutting^{-1}$. 1USD=11.25 Eb (Ethiopian birr).

be weeded once. Thus, suppression of early weed growth resulted in less weed infestation (Johri et al., 1992; Mt Pleasant et al., 1992). Faster growth and better ground cover was achieved by Tis 2498 with leaf area ranging from 60 to 81 cm^{-2} compared with Tis 1499 (42-49 cm^{-2}) and Koka 6 (52-66 cm^{-2}).

The root and aboveground biomass could account for differences among cultivars in suppressing weeds, probably reducing the competitiveness of weeds for moisture, nutrients and light (Olofsdotter et al., 1999). The low weed population (11.8% less) at higher plant densities (10 and 12.5 plants m^{-2}) indicated weed suppression as plant density increased probably due to less light interception due to less space for weed growth, and this is in agreement with the finding of (Mt Pleasant et al. 1992 and ICARDA 1984).

Where there was high plant density, there prevailed intra and inter row competition for light, moisture and nutrients, and this resulted in less number of branches, which is in line with the findings of Kim et al. (1999). There was a positive association of branching with tuber yield (r = 0.332**) indicating more branches associated with more tuber yield.

A decrease in leaf area observed as plant density increased was in line with the findings of Kim et al. (1999) and Lisson et al. (2000). The non-significance of weeding frequency on leaf area could be due to at earlier crop growth stage weeding reduced weed competition, which gave an advantage to better growth and use the resources available. It may be concluded that the spreading type may produce more leaf area in the lowest density that may favor growth.

Weather condition affected plant population at harvest. Where there was better amount and distribution, there was better plant sprout (emergence), which finally resulted in higher plant population at harvest. Weeding twice coupled with better season increased harvestable plant population.

Weed infestation in varieties with erect and intermediate growth habits was more but when weeded, produced significantly higher tuber yield. On the other hand, the spreading cultivar, which suppressed weed infestation, had fewer yields than Tis 1499. The smaller yield loss observed in Tis 2498 compared with other varieties might be attributed to its competitiveness with weed.

The high yield was also attributed to increased plant density and weeding frequency coupled with varietal differences in canopy structure. The high yield in Tis 1499 and Koka 6 was their response to weeding frequency, plant density, and season. At each weeding practice, there was an increase in yield as the season progressed due to better amount and distribution of rainfall. The finding showed that weeding the spreading cultivar once at earlier growth stage would suffice due to the crop becoming more competitive and coupled with good distribution of rainfall. Favorable weather provided better crop growth and development, and less weed infestation thus leading to better crop yield.

Overall, a cultivar with spreading canopy structure better competes with weed and showed no significant difference between weeding frequencies. Increased plant density also reduced weed infestation. A population density of 100 × 10^3 plants ha^{-1} for the three varieties and weeding of Tis 1499 and Koka 6 twice was economical. Cultivars with spreading structure and increased plant density could be exploited as means for weed suppression, which saves time and labor of the farmer. Thus, breeders should focus in developing cultivars with spreading growth habit and high yielding, and this tempts breeders to look into this opportunity to help farmers use their time and labor effectively.

REFERENCE

Awassa Progress Report (1991). Research Progress reports

1988-1990.
Babatunde FE (2003). Intercrop productivity of Roselle in Nigeria. Afr. Crop Sci. J., 11(1): 43-47.
Central Agricultural Census Commission (CACC) (2006). Ethiopian Agricultural Sample Enumeration, 2001/02 (1994 EC): Report on the preliminary results of area, production and yield of temporary crops (Meher season, private peasant holdings).
Central Agricultural Census Commission (CACC) (2003). Ethiopian Agricultural Sample Enumeration, 2001/02 (1994 EC): Report on the preliminary results of area, production and yield of temporary crops. (Meher season, private peasant holdings). Part I.
Central Agricultural Census Commission (CACC) (2003). Ethiopian Agricultural Sample Enumeration, 2001/02 (1994 EC): Results for Southern Nations, Nationalities and Peoples' region (SNNPR), Statistical Report on Farm Management Practices, Part III B. Addis Ababa, Ethiopia.
Central Agricultural Census Commission (CACC) (2003). Ethiopian Agricultural Sample Enumeration, 2001/02 (1994 EC): Results for Southern Nations, Nationalities and Peoples' region (SNNPR), Statistical Report on area and production of crops. Part II B.
Elmore RW (1998). Soybean cultivar response to row spacing and seeding rates in rainfed and irrigated environments. J.Prod. Agric., 11(3): 326-331.
Getahun D, Mwangi W, Tenaw W, Grisley B (1991). Areka area mixed farming zone, North Omo region: Diagnostic survey. Research report no. 15. Institute of Agricultural Research, Addis Ababa, Ethiopia.
Getahun D, Tenaw W (1990). Initial results of informal survey. Areka mixed farming zone, Wolayita district, Sidamo region. Working paper no. 11. Institute of Agricultural Research, Addis Ababa, Ethiopia.
Gomez K, Gomez AA (1976). Statistical Procedures for Agricultural Research Second Edition. IRRI book. John Wiley Sons. New York, Brisbane.
ICARDA (1984). Annual report 1983.Allepo, Syria, pp. 5-12.
Johri AK, Singh G, Sharma D (1992). Nutrient uptake by wheat and associated weeds as influenced by management practices. Tropical Agriculture (Trinidad), 69 (4): 391-393.
Kim BOK, Kim HHo, Ko JK, Shin HT (1999). Effect of plant density and nitrogen level on growth and yield in heavy panicle weight type of Japonica rice. Korean J.Crop Sci., 44(2): 106-111.
Landon JR (1984). Booker Tropical Soil Manual: handbook for soil survey and agricultural land evaluation in the tropics and subtropics. Booker Agriculture International Limited, USA.
Lisson SN, Mendham NJ, Carberry PS (2000). Development of a Hemp simulation model 3.The effect of plant density on leaf appearance, expansion and senescence. Australian J. Exp. Agric., 40(3): 419-423.
Mt Pleasant J, McCollum RE, Coble HD (1992). Weed management in a low input cropping system in the Peruvian Amazon region. Trop. Agric. (Trinidad), 69 (3): 250-259.
Olofsdotter M, Navarez D, Rebulanan M, Streibig JC (1999). Weed-suppressing rice cultivars–does allellopathy play a role? Weed Res., 39(6): 441-454.
SAS Institute (2000). SAS User's guide, Statistics version 8.2 ed. SAS Inst., Cary, NC, USA.
Salonen J (1992). Efficiency of reduced herbicide doses in spring cereals of different competitive ability. Weed Res., 32(6): 483-491.
Seavers GP, Wright KJ (1999). Crop canopy development and structure influence on weed suppression. Weed Res., 39(4): 319-328.
Taye T, Tanner DG (1997). Grass weed competition and calculated economic threshold densities in bread wheat in Ethiopia. Afr. Crop Sci. J., 5(4): 371-384.
Tenaw W, Beyenesh Z, Waga M (1997). Effect of variety, seed rate and weeding frequency on weed infestation and grain yield of haricot bean. In: Fassil Reda and Tanner, D.G. (eds.). Proceedings of the second and third annual Conference of the Ethiopian Weed Science Society. Addis Ababa, Ethiopia, pp. 61-69.