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MAIZE-*TEF* RELAY INTERCROPPING AS AFFECTED BY MAIZE PLANTING PATTERN AND LEAF REMOVAL IN SOUTHERN ETHIOPIA

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ABSTRACT

Maize-*tef* (*Eragrostis tef* (Zuc.) Trotter) relay intercropping is practiced in parts of southern Ethiopia. However, the impacts of maize (*Zea mays* L.) planting pattern and leaf stripping by farmers are not yet understood. The efficiency of maize-*tef* relay intercropping was assessed under different combinations of maize planting pattern and leaf removal. Planting pattern included broadcasting, 60 cm x 37.5 cm, 75 cm x 30 cm, and 100 cm x 22.5 cm, while leaf removal consisted of no leaf removal, leaf removal below the ear, and leaf removal below the ear plus two leaves removal at ten days interval. *Tef* was sown by broadcasting under the standing maize crop about 35 days from maize silking. Broadcasting and narrow inter-row maize spacing significantly ($P<0.05$) reduced grain yields of both maize and *tef*. Maize leaf removal below the ear improved *tef* grain yield without reducing maize yield significantly. Additional leaf removal above the ear significantly ($P<0.05$) improved *tef* straw yield but not grain yield. Leaf removal was accompanied by shortening of days to maturity of maize and *tef*. Improved performance of *tef* due to wider inter-row spacing and defoliation was associated with increased vigour and density. Land equivalent ratio values ranged up to 1.3, which indicated an acceptable level of efficiency for the cropping system.

Key Words: Eragrostis tef, land equivalent ratio, *Zea mays*

RÉSUMÉ

L'interculture en relais du maïs - *tef* [*Eragrostis tef* [zuc] Trotter] est pratiquée au sud de l'Ethiopie. Cependant, l'impact du modèle de planter le maïs [*Zea mays* L.] et la méthode d'effeuillage par les fermiers ne sont par encore compris. L'efficacité de relais inter-culture du maïs - tef était calculée pour différentes combinaisons de modèle de planter le maïs et d'enlèvement des feuilles. Le modèle plante incluait la diffusion, 60cm x 37.5 cm, 75cm x 30cm, et 100cm x 22.5cm, tandis que la méthode d'effeuillage consistait de feuilles non enlevées, feuilles enlevées au-dessous de l'épi, et les feuilles enlevées au-dessous de l'épi en plus de deux feuilles enlevées à dix jours d'intervalle. *Tef* était ensemencé par la diffusion sous le pied de la culture de maïs à peu près 35 jours à partir des maïs doux. La diffusion et l'étroit espacement des rangés de mais d'une manière significative [$P<0,05$] avaient réduit les rendements du maïs et de *tef*. L'enlèvement des feuilles de maïs en dessous de l'épi avait amélioré le rendement de grain *tef* sans réduire la production de maïs d'une manière significative. L'enlèvement supplémentaire des feuilles au-dessus de l'épi améliora le rendement en matière sèche de la paille et non des graines. L'enlèvement des feuilles était accompagné par une réduction de jours de maturité de maïs et *tef*. La performance améliorée de *tef* due à un grand espacement entre rangés et à la défoliation était associée avec l'accroissement de la vigueur et de la densité. Les valeurs de la proportion équivalente de terre ont atteint jusqu' à 1,3, indiquant un niveau acceptable d'efficacité pour le système de culture.

Mots Clés: *Eragrostis tef*, proportion équivalente de terre, *Zea mays*

INTRODUCTION

Small farmers in many countries are seriously constrained by low crop yields and limited land resources (Cordero and McCollum, 1979). In Ethiopia, the southern region is one of the most densely populated parts, with a high agricultural density. Wolaita and Sidama, the most densely populated provinces, have more than 200 people km^{-2} with an agricultural density of 11 and 6 people ha^{-1}, respectively (RPOSE, 1985). The average land holding per farmer in Awassa Zuria is 0.5-1.0 ha and 0.25-3.0 ha in Wolaita and in Kindo Koysha (FARM Africa, 1992).

Multiple and mixed cropping are common in southern Ethiopia, with associations comprising of maize, *tef*, rapeseed, haricot bean, sweet potato, *enset*, coffee, and banana. *Tef* is commonly relay intercropped with maize in parts of Sidama. Maize is planted at the start of the rainy season by broadcasting. The land under maize is prepared with shallow cultivation when the crop reaches the dough stage. Maize leaves below the ear are removed to improve light penetration. *Tef* is planted by broadcasting under the standing maize crop. This is practiced more when the expected maize yield is reduced by adverse environmental conditions like drought.

The advantage of multiple cropping, especially when land is scarce and labour ample is well established (Cordero and McCollum, 1979; Ruthenberg, 1980; Onume and Sinha, 1991). However, several factors need to be investigated to improve the productivity of crop mixtures. The density of component crops and their spatial arrangement may have an impact on intercropping yield advantage. To obtain high yields from crop mixtures, the crops should be arranged in such a way as to minimise both inter- and intra-specific competition, while allowing easy application of inputs (Yunusa, 1989). Fisher *et al.* (1987) reported reduced cowpea yield when intercropped within maize rows, due to shading. On the other hand Yunusa (1989) observed no significant differences between and within row planting patterns in maize-soybean intercropping. Natarajan and Willey (1986) indicated that single or double groundnut patterns with sorghum or millet show a better yield advantage than triple row patterns, especially when moisture is limiting. So far, there is no data on the impact of maize panting pattern on the performance of intercropped *tef*.

In intercrop combinations, the amount of light reaching to the shorter component is reduced depending on the density of the components, canopy architecture and relative time of sowing. In a maize-bean intercropping, Gardiner and Craker (1981) indicated that at low (18,000 plants ha^{-1}) and high (55,000 plants ha^{-1}) maize densities, the amount of the solar radiation available for the bean was 50 and 20% of the incident light, respectively.

One of the possibilities used to improve light penetration to the under storey component is stripping of leaves from the taller component. In maize-*tef* relay intercropping, farmers practice leaf removal below the ear to improve light penetration and partly to feed cattle. Under maize-millet relay intercropping in Nepal, farmers remove bottom leaves and the top part of the maize stem largely for the same reasons (Subedi, 1996). Subedi (1996) reported that leaf removal below the ear 20 or 30 days after silking has no effect on grain yield of maize or on the millet component. In maize-*tef* relay intercropping, there is a need to examine if the leaf removal practiced by farmers leads to a better light utilisation without seriously affecting the maize yield.

In maize-*tef* association, maize has a deeper root system than *tef*. This allows for the exploitation of soil nutrients and moisture at different soil layers. Also, temporal differences in crop resource use are particularly important in drought periods to minimise competitions between component crops during droughts (Fussel and Serfani, 1986).

Tef serves as a rescue crop in water stress areas like Ziway and Kobbo (Ketema, 1989). Relay intercropping gives the second crop a chance to be planted at a time when soil moisture is readily available (Chan *et al.*, 1980). This permits *tef* to establish well and give a reasonable yield even under sub-optimal moisture conditions.

The objectives of this study were to (i) investigate the effects of maize planting pattern and leaf removal on the performance of the maize-*tef* relay intercropping, over two cropping seasons and (ii) assess the efficiency of this cropping system.

MATERIALS AND METHODS

This experiment was conducted during the cropping seasons of 1996 and 1997, in the Southern Ethiopia at Awassa. Awassa is located at 7°5'N and 38°30'E, 1660 meters a.s.l. Specifically, the site was at the Farm and Research Centre of the Awassa College of Agriculture, Debub University.

A late maturing composite maize, cultivar A511, and an early maturing brown seeded *tef* land race cultivar were used. An additive type of crop mixture was used, where the components were sown at their sole crop densities.

Treatments comprised of two factors; namely maize planting pattern and leaf removal. The planting pattern consisted of broadcasting (P1), 60 cm x 37.5 cm (P2), 75 cm x 30 cm (P3) and 100 cm x 22.5 cm (P4). Maize leaf removal levels were: no leaf removal (L1), leaf removal below the ear (L2), and L2 plus two leaves removed at ten days interval (L3). A randomised complete block design with three replications was used. Each treatment was planted on a 6 m x 3 m plot. Sole plots of maize and *tef* were also planted in two replications adjacent to the experiment.

Blanket fertilisation was done for the intercropped plots at 54 kg nitrogen ha^{-1} and 20 kg phosphorus ha^{-1}. Nitrogen was applied as split, half at planting and the half other two weeks before tasseling. Separate sole plots of maize and *tef* were planted near the intercrops in two replications. For these plots standard agronomic practices of each crop were observed. Maize was planted at a spacing of 75 cm x 30 cm and 54 kg N ha^{-1} and 20 kg P ha^{-1} were applied as in the intercropped plots. A dose of 27 kg N ha^{-1} and 10 kg P ha^{-1} were given for *tef* and all was applied during planting. The maize plots were thinned to 44,000 plants ha^{-1}.

Tef was sown at the rate of 2 kg ha^{-1}. The seedbed for *tef* was prepared by moderate cultivation and it was made firm by human feet. One hand weeding was carried out 23 days after planting. The first defoliation (L2) was carried out at about 35 days after maize silking; 6 leaves were removed on average.

Two more defoliations, each with two leaves removal, were carried out at ten days interval for L3 plots, with 2 - 3 final upper leaves per plant remaining.

Harvesting for *tef* involved the centre 4 x 3 m area, while the entire plot was harvested for maize. After harvesting, both maize and *tef* were left on the field for further drying. Grain yield of maize was adjusted to 13 % moisture content.

Data were analysed using analysis of variance of the General Linear Models of the Statistical Analysis System (SAS, release 6.12). Mean separation for main effects were obtained by Fisher's least significant difference (LSD) test. The efficiency of the cropping system was analysed using the land equivalent ratio (LER) method (Mead and Willey, 1980).

RESULTS

Effect of maize planting pattern and leaf removal on the maize component. There was a significant ($P<0.05$) variation in grain yield due to planting patterns during 1996 and 1997 (Table 1). The lowest yield was obtained from P2 during both years while P3 and P4 gave the highest yields. Among leaf removal schemes, no leaf removal (L1) gave the highest yield followed by L2 and L3 during 1996 and 1997. However, only L3 in 1996 significantly ($P<0.05$) reduced maize yield. Leaf removal affected grain weight significantly ($P<0.05$) only in 1996, even though the trends were similar for both years (Table 2). Maize grain yield was higher in 1996 compared to 1997. This is due to late planting as a result of failure of germination of first sowing and due to poor distribution and amount of rainfall in 1997 The crop received about 33% less rainfall in 1997 compared to 1996 during its growth period (Table 3).

Time to physiological maturity was not significantly affected by planting pattern (144-146 days) but was affected by leaf removal (Table 4). There were no significant interactions between the factors, for all the traits observed.

Effect of maize planting pattern and leaf removal on the *tef* component. Maize planting pattern significantly affected *tef* grain yield in 1996 ($P<0.05$) and 1997 ($P<0.01$). *Tef* yield was highest from P4 in1996 and 1997 (Table 5). Broader inter-row spacing of maize improved *tef* grain yield compared to narrow inter-row spacing and broadcasting. Defoliated plots gave significantly higher yields than non-defoliated plots during both years (P<0.01). However, repeated defoliation (L3) was not significantly effective.

The trend for the straw yield was consistent with that of grain yield (Table 6). Planting pattern significantly influenced straw yield (P<0.05). The lowest straw yield was obtained from P2 in 1996 and P1 in 1997. However, the difference between P1 and P2 was not significant (P>0.05) in 1996. Unlike the grain yield, additional leaf removal (L3) increased straw yield significantly in 1996.

Leaf removal affected both vigour and density significantly (P<0.01). Plots with no leaf removal were the least vigorous and had lower density (Table 7). Density was significantly higher under wider inter-row maize planting.

Defoliated plots flowered three days earlier and matured one to two days earlier than others, on the average (Table 8). There was no significant difference between L2 and L3 in this parameter.

Tef height was significantly (P<0.05) taller with leaf removal as compared to L1, but not significantly affected by planting pattern (Table 9). For all the parameters there were no significant interactions between the factors.

Efficiency of the cropping system. The LER values were greater than one for all treatments, which shows that the cropping system was efficient compared to sole cropping (Table 10). Among planting patterns, P3 and P4 were superior during both years. Leaf removal below the ear and L3

TABLE 1. Grain yield of maize (mg ha^{-1}) for a maize-*tef* relay intercropping with various planting patterns and leaf removal schemes in Awassa, Ethiopia

Planting pattern	1996 Leaf removal L1	L2	L3	Mean	Planting pattern	1997 Leaf removal L1	L2	L3	Mean
P1	7.44	7.38	7.11	7.33ab	P1	4.55	4.16	3.83	4.16b
P2	7.33	7.05	6.83	7.05b	P2	4.44	3.77	3.94	4.05b
P3	7.55	8.00	7.27	7.44a	P3	4.66	4.83	4.61	4.72a
P4	7.50	7.55	7.33	7.44a	P4	4.33	4.77	4.50	4.55ab
Mean	7.44a	7.38a	7.16b		Mean	4.50a	4.38a	4.22a	

Means followed by the same letter are not significantly different at 5% level; sole plot yields were 9.33 t ha^{-1} for 1996 and 5.66 t ha^{-1} for 1997; P1 = Broadcasting; P2 = 60 cm x 37.5 cm; P3 = 75 cm x 30 cm; P4 = 100 cm x 22.5 cm; L1 = no leaf removal; L2 = leaf removal below the ear; L3 = L2 + two leaves removal at 10 days interval

TABLE 2. Thousand grain weight (g) of maize for a maize-*tef* relay intercropping with various planting patterns and leaf removal schemes in Awassa, Ethiopia

Planting pattern	1996 Leaf removal L1	L2	L3	Mean	Planting pattern	1997 Leaf removal L1	L2	L3	Mean
P1	456	416	363	414a	P1	359	383	356	369a
P2	461	397	383	411a	P2	383	353	378	371a
P3	447	419	387	418a	P3	382	390	335	369a
P4	443	376	392	403a	P4	398	375	363	378a
Mean	452a	402a	381b		Mean	380a	375a	360a	

Means followed by the same letter are not significantly diffent at 5% level; P1 = Broadcasting; P2 = 60 cm x 37.5 cm; P3 = 75 cm x 30 cm; P4 = 100 cm x 22.5 cm; L1 = no leaf removal; L2 = leaf removal below the ear; L3 = L2 + two leaves removal at 10 days interval

TABLE 3. Monthly mean weather records of the experimental site at Awassa, in Southern Ethiopia

Monthly	rainfall, mm		Air temperature, °C				Radiation	
			Minimum		Maximum		MJ m^{-2} day^{-1}	
	1996	1997	1996	1997	1996	1997	1996	1997
April	129.2	148.4	14.2	14.3	27.6	27.1	13.7	14.0
May	231.4	48.0	14.4	13.6	26.9	28.2	14.6	16.8
June	294.7	114.3	14.6	14.1	24.5	26.8	12.8	14.7
July	147.1	93.3	14.4	14.5	24.1	25.0	11.7	13.9
August	117.6	84.0	14.4	14.5	24.4	26.4	12.2	15.5
September	161.2	150.0	13.9	13.6	25.2	26.8	13.6	16.8
October	58.5	193.8	11.8	13.9	26.5	26.0	15.5	13.3
November	26.5	142.4	9.9	14.1	27.7	25.9	17.4	15.5
December	1.2	5.7	10.4	11.7	28.4	27.8	18.1	15.7

In 1996, maize was planted on 5 April and harvested on 3 October; *tef* was planted on 27 August and harvested on 20 November. In 1997, maize was planted on 24 May and harvested on 24 October; *tef* was planted on 10 September and harvested on 6 December

TABLE 4. Days to maturity of maize for a maize-*tef* relay intercropping in 1996, with various planting patterns and leaf removal schemes in Awassa, Ethiopia

Planting pattern	Leaf removal			Mean
	L1	L2	L3	
P1	148	143	142	144a
P2	151	142	143	145a
P3	150	144	143	146a
P4	150	143	143	145a
Mean	150a	143b	143b	

Means followed by the same letter are not significantly different at 5% level; P1 = Broadcasting; P2 = 60 cm x 37.5 cm; P3 = 75 cm x 30 cm; P4 = 100 cm x 22.5 cm; L1 = no leaf removal; L2 = leaf removal below the ear; L3 = L2 + two leaves removal at 10 days interval

TABLE 5. Grain yield of *tef* (t ha^{-1}) for a maize-*tef* relay intercropping with various planting patterns and leaf removal schemes in Awassa, Ethiopia

Planting pattern	1996			Mean	Planting pattern	1997			Mean
	Leaf removal					Leaf removal			
	L1	L2	L3			L1	L2	L3	
P1	1.12	1.47	1.55	1.38ab	P1	0.33	0.44	0.56	0.44b
P2	0.72	1.40	1.55	1.22b	P2	0.46	0.53	0.57	0.52ab
P3	0.95	1.62	1.75	1.44a	P3	0.50	0.58	0.64	0.57a
P4	1.16	1.63	1.78	1.52a	P4	0.56	0.61	0.65	0.60a
Mean	0.99b	1.53a	1.65a		Mean	0.46b	0.54a	0.60a	

Means followed by the same letter are not significantly different at 5% level; sole plot yields were 1.80 t ha^{-1} for 1996 and 0.83 t ha^{-1} for 1997; P1 = Broadcasting; P2 = 60 cm x 37.5 cm; P3 = 75 cm x 30 cm; P4 = 100 cm x 22.5 cm; L1 = no leaf removal; L2 = leaf removal below the ear; L3 = L2 + two leaves removal at 10 days interval performed similarly and better than L1. The partial LER calculated for the maize and *tef* components indicated that, both contributed to the efficiency of the system (data not shown). However, it was mainly *tef*, which influenced the significance of treatment differences. This was associated with improved performance due to leaf removal and wider inter-row spacing.

DISCUSSION

Effect of maize planting pattern and leaf removal on the component crops. Maize yield was reduced when row spacing was less than 75 cm and when broadcasted, possibly due to more lateral root damage during cultivation and due to problems of stand establishment with broadcasting. Poor stand establishment could be mainly attributed to the covering of seeds to inadequate depth, which causes poor imbibition, and greater exposure to birds. Inter-row spacing for maize, generally, varies from 70 to 100 cm. The results seem to indicate that for the same seeding rate it is better to use wider inter-row spacing for such late cultivars.

Late leaf removal resulted in yield loss and smaller grain size only in 1996. It is not surprising that the first leaf removal, which was done about 35 days after silking, did not result in significant yield loss since these lower leaves receive

TABLE 6. Straw yield of *tef* (t ha^{-1}) for a maize-*tef* relay intercropping with various maize planting patterns and leaf removal schemes

Planting pattern	1996				Planting pattern	1997			
	Leaf removal			Mean		Leaf removal			Mean
	L1	L2	L3			L1	L2	L3	
P1	2.33	2.75	3.30	2.80ab	P1	0.85	1.37	1.65	1.40b
P2	1.37	2.75	3.25	2.45b	P2	1.50	1.75	2.03	1.75a
P3	1.90	3.20	3.65	2.92a	P3	1.87	1.95	2.03	1.95a
P4	2.49	3.37	3.87	3.22a	P4	1.78	1.95	1.90	1.88a
Mean	1.93c	3.02b	3.52a		Mean	1.58b	1.75ab	1.90a	

Means followed by the same letter are not significantly different at 5% level; sole plot straw yields were 6.87 t ha^{-1} for 1996 and 2.85 t ha^{-1} for 1997; P1 = Broadcasting; P2 = 60 cm x 37.5 cm; P3 = 75 cm x 30 cm; P4 = 100 cm x 22.5 cm; L1 = no leaf removal; L2 = leaf removal below the ear; L3 = L2 + two leaves removal at 10 days interval

TABLE 7. *Tef* vigour and density for a maize-*tef* relay intercropping in 1996 with various maize planting patterns and leaf removal schemes in Awassa, Ethiopia

Planting pattern	Vigour				Planting pattern	Density			
	Leaf removal			Mean		Leaf removal			Mean
	L1	L2	L3			L1	L2	L3	
P1	2.0	3.6	3.6	3.1a	P1	2.0	3.3	2.6	2.6c
P2	1.6	3.3	3.0	2.6a	P2	2.0	3.3	3.0	2.7bc
P3	2.6	3.0	4.0	3.2a	P3	2.6	3.3	4.3	3.5ab
P4	2.3	3.3	4.0	3.2a	P4	2.6	3.6	4.6	3.6a
Mean	2.1b	3.3a	3.6a		Mean	2.3b	3.4a	3.6a	

Means followed by the same letter are not significantly different at 5% level; P1= Broadcasting; P2 = 60 cm x 37.5 cm; P3 = 75 cm x 30 cm; P4 = 100 cm x 22.5 cm; L1 = no leaf removal; L2 = leaf removal below the ear; L3 = L2 + two leaves removal at 10 days interval

TABLE 8. Days to flowering and maturity of *tef* for a maize-*tef* relay intercropping in 1996 with various maize planting patterns and leaf removal schemes in Awassa, Ethiopia

Planting pattern	Days to flowering				Planting pattern	Days to maturity			
	Leaf removal			Mean		Leaf removal			Mean
	L1	L2	L3			L1	L2	L3	
P1	51	48	50	50a	P1	83	82	82	82a
P2	54	49	50	51a	P2	84	82	81	82a
P3	50	50	48	49a	P3	83	82	81	82a
P4	53	49	48	50a	P4	82	81	81	81a
Mean	52a	49b	49b		Mean	83a	82b	81b	

Means followed by the same letter are not significantly different at 5%; P1= Broadcasting; P2 = 60 cm x 37.5 cm; P3 = 75 cm x 30 cm; P4 = 100 cm x 22.5 cm; L1 = no leaf removal; L2 = leaf removal below the ear; L3 = L2 + two leaves removal at 10 days interval

TABLE 9. Height (cm) of *tef* for a maize-*tef* relay intercropping in 1996 with various maize planting patterns and leaf removal schemes in Awassa, Ethiopia

Planting pattern	Leaf removal			Mean
	L1	L2	L3	
P1	56	61	61	60a
P2	58	61	60	60a
P3	58	69	63	63a
P4	58	67	70	65a
Mean	57a	62ab	64b	

Means followed by the same letter are not significantly different at 5%; P1 = Broadcasting; P2 = 60 cm x 37.5 cm; P3 = 75 cm x 30 cm; P4 = 100 cm x 22.5 cm; L1 = no leaf removal; L2 = leaf removal below the ear; L3 = L2 + two leaves removal at 10 days interval

TABLE 10. Total Land Equivalent Ratio (LER) for a maize-*tef* relay intercropping with various maize planting patterns and leaf removal schemes in Awassa, Ethiopia

Planting pattern	1996				Planting pattern	1997			
	Leaf removal			Mean		Leaf removal			Mean
	L1	L2	L3			L1	L2	L3	
P1	1.21	1.33	1.34	1.30b	P1	1.24	1.27	1.32	1.28b
P2	1.05	1.28	1.31	1.21c	P2	1.34	1.31	1.39	1.35b
P3	1.16	1.40	1.43	1.33ab	P3	1.47	1.56	1.59	1.54a
P4	1.23	1.42	1.45	1.37a	P4	1.45	1.58	1.54	1.53a
Mean	1.16b	1.36a	1.38a		Mean	1.35b	1.43ab	1.46a	

Means followed by the same letter are not significantly different at 5%; P1 = Broadcasting; P2 = 60 cm x 37.5 cm; P3 = 75 cm x 30 cm; P4 = 100 cm x 22.5 cm; L1 = no leaf removal; L2 = leaf removal below the ear; L3 = L2 + two leaves removal at 10 days interval relatively less radiation than the upper leaves and were nearing senescence. Also, the crop was already into the reproductive stage with grain number and cob length already determined (Martin *et al.*, 1976). Subedi (1996) found no yield reduction from defoliation below the ear 30 days after silking, while Nigatu (1982) reported a slight influence from defoliation 15 days after silking. The yield component, which could still be affected, is grain size. Grain size may be affected by reduced capacity for photosynthesis due to less leaf area, less translocation of assimilates from leaves to grain and reduced duration of grain fill. The latter may be important since the grain fill period was reduced by seven days in 1996 with leaf removal. The effect of defoliation (L3) on grain size and time to maturity was not significant in 1997, probably due to water stress which constrained grain fill rate and duration. The reason for earlier maturity with leaf removal is not established but may be a response to injury causing plants to hasten maturity. Defoliation below the ear could be valuable for a better penetration of light and earlier maturity leading to earlier harvest of maize, hence, removing competition to the *tef* component. Leaf removal above the ear may depress maize yield but could improve *tef* straw yield, which is valuable itself. It should be noted that *tef* straw is a valuable by product, which fetches a high market price. It is an important feed to cattle and also serves as a component for wall plastering in house construction.

Both *tef* grain and straw yield were improved with wider inter-row maize spacing and leaf removal. This could be mainly due to the amount of light that reached to the under- storey component. *Tef* as a C4 crop could benefit from increased availability of light. The proportion of incident light transmitted to *tef* is inversely related to the leaf area index of the maize canopy. Defoliation reduced leaf area index, while the wider inter-row spacing allowed a better passage of light between rows by minimizing proximity of leaves in adjacent rows. However, from a maize-millet relay intercropping study, Subedi (1996) found no improvement in the performance of intercropped millet from a similar defoliation treatment, 30 days after silking. This may be partly attributed to the fact that well established millet plants (35-days old millet seedlings) were transplanted to establish the relay intercrop component. Additional leaf removal above the ear (L3) gave a significant advantage only for the straw yield, resulting in a lower grain to shoot biomass ratio. The average grain to shoot biomass ratio for the intercrop was 0.30, and 0.20 for the sole plots. An increase in harvest index under intercropping was also observed in other component crops other than *tef* (Harris *et al.*, 1987).

Other agronomic traits of *tef* like vigour, density, days to flowering and days to maturity were also influenced by maize leaf removal. *Tef,* which received more light due to leaf removal was more vigorous and dense. It seems that leaf removal influenced the performance of *tef* mainly through vigour and density. Reduction in *tef* flowering and maturity with leaf removal could be due to differences in microclimates at different layers leading to discrepancies in accumulation of daily thermal time. Shading by the maize canopy may have reduced the temperature at the level of *tef.*

Efficiency of the cropping system. The relay cropping system was more efficient than sole cropping under the given management alternatives. Most LER values were more than 1.3, which is considered practically acceptable for intercropping production (Onume and Sinha, 1991). Thus, the land could be more efficiently utilized by relay intercropping *tef* with maize than growing them separately. This was due to the favourable influence of maize planting pattern and leaf removal on *tef* performance. In this combination, the intercropping advantage may have been derived from the complementary utilisation of space and time by the components. Regarding soil profile utilisation, maize and *tef* having different root depth, could exploit different soil layers for moisture and nutrients.

Intercropping of maize with *tef* could be a profitable practice. Wider maize inter-row spacing and leaf removal should be used for a better efficiency of the cropping system. Wider inter-row spacing is also relatively more convenient for planting and carrying out management practices for *tef.* Since additional leaf removal above the ear may depress maize yield, it may not be wise to do it especially in favourable years.

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