HELIA, **24**, Nr. 35, p.p. 1-10, (2001) UDC 631.582:633.255:633.854.78

INTERCROPPING SUNFLOWER AND MAIZE IN MOZAMBIQUE

Josè Lopez[1], Mario Baldini[2], Luciana Quagliotti[1], Angelo M. Olivieri[2*]

[1] *Università di Torino, Dipartimento di valorizzazione e protezione delle risorse agroforestali, Via Leonardo Da Vinci, 44 - 10095 Grugliasco (To), Italy*
[2] *Università di Udine, Dipartimento Produzione Vegetale e Tecnologie Agrarie, via delle Scienze 208, 33100, Udine, Italy*

Received: September 05, 2001
Accepted: December 05, 2001

SUMMARY

A trial was carried out in Mozambique in 1998-1999, with the aim to study the effect of three levels of maize-sunflower intercropping ratios (25:75, 50:50, 75:25) in comparison with the pure-stand crop of two sunflower and maize varieties. For both maize varieties yield per plant decreased in relation to density, being lowest in the pure-stand crop. This beaviour was partially true for sunflower. The intercropping 75:25 maize-sunflower ratio showed the highest seed yield per hectare (5195 kg ha^{-1}) and the maize and sunflower LER coefficients suggested that maize is slightly dominant over sunflower in the mixture. The relative advantage of the two species in respect to the single crop stand was about 16 and 19%. However each species and variety reached its maximum yield per hectare when it was grown as pure stand crop (100%). On the other side, when yield is examined in terms of food energy (K-calories), given by maize grain and sunflower protein and oil per hectare, maize-sunflower 75:25 mixture ratio appears to be much more convenient and suitable for food supply even when compared with the maize pure crop stand. The increase in K-calories is 380 ha^{-1} and the better balance in carbohydrates, proteins and lipids can assure sustainability to standard farm families as those living in Mozambique. Using sunflower oil, a quite good amount of unsaturated fatty acids and lyposoluble vitamins are also supplied in the diet of farming people.

Key words: food calories, intercropping, yield advantage, land equivalent ratio, maize, sunflower, sustainability

* Corresponding author, Tel.: +39-0432-558605, Fax: +39-0432-558603, e-mail: angelo.olivieri@dpvta.uniud.it

INTRODUCTION

Because of the economic relevance of its oil, sunflower crop has in recent years greatly enlarged its acreage in sub-Saharian regions where the environmental conditions are suitable for this crop species.

In Mozambique, sunflower was introduced in the '40's and the Russian variety Peredovik had success for many strains obtained after selection in different areas. After the political peace agreement in 1992, sunflower interest has been re-established and now cultivation takes place according to different farming systems. In the family crop system, mixed cropping is standard (Rulkens *et al.*, 1999), thus sunflower is grown intercropped with several local species. In commercial farmers, however, sunflower hybrid varieties are used just as they are typically used all around the world. On the base of the traditional agriculture, open pollinated varieties are grown at small farms usually managed by a family, and sunflower oil is usually extracted after meal decantation of seed crushed in a mortar. Recently, manual oil presses have been introduced, but the extracted oil rate does not exceed 75% weight in relation to the seed hull content and seed texture.

In Mozambique like many other African areas, maize has largely substituted the traditional sorghum varieties and represents the most widely grown food staple crop, being cultivated by 75% of the small family farms (Ministerio do Plano e Finanças de Moçambique, 1998). The need of alimentary oil was pointed out by Vidal *et al.* (1962) after evidence of the scarcity of lyposoluble vitamins in the diet of the largest part of local population. In comparison with the requirement of 3.7 kg of edible oil per capita per year, van Renterghem (1999) reports that in recent years in the Nampula province (Northern Mozambique) the edible oil consumption has been only 1.5 kg. The regional average in Southern Africa countries is 4.6 kg. Sunflower is now being introduced in multiple cropping systems mixed with species like bean, groundnut, cassava, sorghum and maize.

Intercropping sunflower-maize has been studied mostly in tropical areas and Singh (1982), Bakht and Shah (1989), Fagbayide *et al.* (1997), Galal (1998), Robinson (1984) found no advantages in total yield production in respect to maize alone. However, Nyakatawa and Nyati (1998) in Zimbabwe found total yield increasing when maize and sunflower were grown together. Using relay cropping maize- sunflower, Nyakatawa and Nyati (1998), and da Silva *et al.* (1992) achieved best results in terms of combined seed yields land equivalent ratio (LER) and total cash income of both crops.

In this study involving sunflower and maize crops, we report the results coming from a field trial in which three mixture levels given by two maturity-contrasting varieties of each species were tested. The results are expressed in kg per plant and per hectare of sunflower and maize grain as well as in K-calories per hectare related to the maize grain and sunflower protein and oil content. We present information about the convenience in using intercropping in respect to the pure stand crops

studying the yield per plant (de Witt, 1960) and the "land equivalent ratio" (LER) developed by Willey (1979).

MATERIAL AND METHODS

At Umbeluzi in southern province of Maputo (Mozambique) (26° 03' S, 32° 23' E), about 40 km southward from Maputo City, in a sandy-clay soil with table water level of about 1 m, a trial was carried out in 1998-1999, with the aim to study the effect of three levels of maize:sunflower intercropping ratios (25:75, 50:50, 75:25), in comparison among them and with the pure-stand crops. Two sunflower varieties, 20 GN and Black Rekord, were selected by the Italian Governmental Cooperation "Sunflower" Project, operating in Mozambique since 1995. 20 GN is a semi-dwarf variety with a short cycle, contrasting with medium-long cycle of Black Rekord. The latter variety, having been improved for many traits, was registered in Mozambique as UEM2 (Olivieri *et al.*, 1999). Matuba and Manica are two maize varieties obtained from the National Seed Company in Mozambique (SEMOC). Matuba is a small stature plant with a short cycle, whereas Manica is a tall plant with a long cycle.

Maize and sunflower were sown in plots of five rows, 5 m long and 80 cm apart. Plant distance on the row was 25 cm, ensuring the plant density of 5 plants m^{-2}. The experimental design was arranged according to a factorial scheme, where the treatments were: 2 maize varieties x 2 sunflower varieties x 3 intercropping ratios, while the non-factorial part included the pure stand crops inclusive of two sets of two varieties. The experiment was organized in a randomized block design with 4 replications. Sowing, according to the local use, was made on 13th October 1998. After emergence, plants were thinned and weeds were controlled manually.

Two irrigation treatments were applied: the first one immediately after sowing in order to facilitate the emergence and to prevent animal damage. The second one was applied after 20 days when the crop was thinned. No further irrigation was required since the rain season began and problems of overflowing occurred when plants had almost reached the maturity stage. For sunflower, the plots including the pure stand crop of 20 GN are missing because of a flood at the harvesting time.

After pollination, sunflower heads were covered with nylon foil in order to protect them against bird damage. Harvesting was done manually, collecting single cobs and heads from mature plants of three central rows of each plot (about 16 m^2), and eliminating two plants at the beginning and end of each row. Threshing was made by hand and seed weight was recorded after drying in open air conditions for three days (seed moisture close to zero percent). Data, expressed in seed yield (g per plant and kg ha^{-1}) and in energy of food (K-calories ha^{-1}) were analyzed according to statistical methods. Table 1 reports the ANOVA for yield per plant as well a the general organization of the experiment.

In order to study the competitive effects and yield advantages of the intercropping in respect to the pure stand crop, the land equivalent ratio was calculated as LER = Yij/Yii + Yji/Yjj, where Yij and Yji are the yield of the two species when they are grown together and Yii and Yjj are the yield of the two species in pure stand (Willey, 1979).

RESULTS AND DISCUSSION

Table 1 showed the analysis of variance for single plant yield of maize and sunflower. It appears that for both species significant differences are in relation to the varieties under study independently to their competitor, as well as for the three intercropping ratios.

Table 1: Analysis of variance for yield per plant (g) in maize and sunflower

	Maize		Sunflower	
	D.F.	Sum squares	D.F.	Sum squares
Treatment	13	1987**	12	819**
Factorial Part	11	1441**	11	901**
Maize (M)	1	8523**	1	75 n.s.
Sunflower (S)	1	556 n.s.	1	9304**
Intercropping ratio (I)	2	2411**	2	419**
I x M	2	312 n.s.	2	7.8 n.s.
I x S	2	613 n.s.	2	126 n.s.
M x S	1	25 n.s.	1	3.4 n.s.
I x M x S	2	41 n.s.	2	1.2 n.s.
No Factorial Part	1	294 n.s	-	-
Fact. vs. no Fact.	1	9684 **	1	561 **
Blocks	3	557 n.s.	3	569**
T x Bl (Error)	39	327	36	69
Total	55		51	

P<0.05, **P<0.01, n.s. = not significant

For maize, yield per plant increased as maize density ratio in the mixture decreased (Table 2). Maize yield per plant, in pure stand crop, was on average 108.9 g, reaching 154.0 g when it was present at the 25% rate. Differences are evident for the two varieties Manica and Matuba because of their plant growth, but both of them had the same competitive behaviour, thus intercropping x variety interaction was not significant.

For sunflower, scarce evidence of competitive effects emerges in relation to the intercropping ratio. The maximum yield (30.9 g) was reached when sunflower density was 75%, whereas it decreased as sunflower plants in the mixture were far apart. It is evident that the dominant effect of maize over sunflower prevailed over the competition within the species. For this species in pure stand is not possible to

get an averaged yield because of the missing 20 GN. When intercropped, Black Rekord was more productive than 20 GN.

Table 2: Mean yield per plant (g) for maize and sunflower cultivar in the different intercropping ratios examined

Intercropping ratio	Maize			Sunflower		
Maize : Sunflower	Manica	Matuba	Mean ratio	20 GN	Black Rekord	Mean ratio
100 : 0	116.9	100.9	108.9 c	-	-	-
25 : 75	172.1	136.0	154.0 a	17.1	44.7	30.9 b
50 : 50	151.0	132.4	141.7 ab	10.8	39.7	25.2 c
75 : 25	142.1	116.8	129.5 b	9.8	36.7	23.2 c
0 : 100	-	-	-	*	37.9	37.9 a
Mean varieties	145.5 a	121.5 b		12.6 b	39.8 a	

Values followed by the same letter do not differ significantly at the 5% probability level
* = missing value

Table 3 reports for maize and sunflower yield per unit area (kg/ha) in the three intercropping situations and in the pure stands. For each species and variety the highest yield was obtained when they were grown as pure crop (100%) and there was an almost linear decrease in relation to their intercropping ratios. These data confirm the greater importance of plant population than the production per single plant itself in the determination of the yield per unit area (Merrien, 1998). Manica (4359 kg ha^{-1}) and Black Rekord (1206 kg ha^{-1}) confirmed their higher yield potential in comparison with the other varieties of maize and sunflower, respectively.

Table 3: Maize and sunflower varieties yield per area (kg ha^{-1}) for the different intercropping ratios and cultivar examined

Intercropping ratio	Maize			Sunflower		
Maize : Sunflower	Manica	Matuba	Mean ratios	20 GN	Black Rekord	Mean ratios
100 : 0	6183	5183	5682 a	-	-	-
25 : 75	2151	1699	1925 d	640	1377	1009 b
50 : 50	3775	3310	3542 c	269	993	632 c
75 : 25	5328	4381	4854 b	123	559	341 d
0 : 100	-	-	-	*	1893	1893 a
Mean varieties	4359 a	3643 b		344.1 b	1205.7 a	

Values followed by the same letter do not differ significantly at the 5% probability level
* = missing value

Grain yield per hectare of the mixture is reported in Table 4. Maize in pure crop and the intercropping 75:25 ratio maize-sunflower, showed the highest yields (5683 and 5195 kg ha^{-1}, respectively), which were significantly different from the other ratios. Conversely for sunflower, relative to the Black Rekord, pure crop furnished the lowest yield (1893 kg ha^{-1}), while the highest yield (5195 kg ha^{-1}) was obtained as reported above for maize, by the 75:25 maize-sunflower ratio. This means that the maize contribution to the total yield is greater than that of sunflower.

Table 4: Combined mixture (sunflower and maize) grain yield (kg ha^{-1}) in relation to the intercropping ratios and cultivar examined

Intercropping ratio	Maize			Sunflower		
Maize : Sunflower	Manica	Matuba	Mean ratios	20 GN	Black Rekord	Mean ratios
100 : 0	6183	5183	5683 a	-	-	
25 : 75	3095	2773	2934 c	2664	3203	2934 c
50 : 50	4367	3981	4174 b	3961	4387	4174 b
75 : 25	5663	4727	5195 a	4840	5550	5195 a
0 : 100	-	-		*	1893	1893d
Mean varieties	4827 a	4166 b		3822 a	3758 a	

Values followed by the same letter do not differ significantly at the 5% probability level
* = missing value

Competitive parameters

Table 5 presents data of Land Equivalent Ratio (LER), that explains the area of each crop required to produce the same yield when grown in intercropping. The relative yield contributions of maize, Manica and Matuba, are always greater than their ratio density in the field. For Black Rekord, the only sunflower variety for which it is possible to do this analysis, this fact is not true when it is mixed with Manica at the higher ratio. In fact, in this case 75% of sunflower produces correspondingly to 68% of the pure stand. It appears that in relation to the intercropping ratio 50%, the maize LER was higher than that of sunflower and this confirms the fact that maize is slightly dominant over sunflower. It is important to note that the total LER values obtained with Manica and Matuba are greater than the unity in all three mixtures, meaning that there is a potential advantage in doing intercropping. However, real convenience appears with the highest total LER value, when maize is present in the ratio of at least 50%. The advantage is great when Black Rekord is sown with Matuba. In this case the advantage reaches up 19%.

Table 5: Land equivalent ratio (LER) of maize - sunflower intercropping trial, as affected by cultivar and intercropping ratio

Intercropping ratio	LER (s)	LER (m)	LER tot	LER (s)	LER (m)	LER tot
maize : sunflower		Man.			Mat.	
25 : 75	0.68	0.33	1.01	0.77	0.31	1.08
50 : 50	0.50	0.59	1.09	0.54	0.61	1.15
75 : 25	0.29	0.87	1.16	0.30	0.89	1.19

(s) = sunflower (cultivar Black Rekord) Man. = cultivar Manica;
(m) = maize; Mat. = cultivar Matuba

Figure 1 shows yield data expressed in K-calories ha^{-1} when sunflower (cv. Black Rekord) is mixed with maize varieties Manica and Matuba. The actual values realized in each variety are shown by dashed lines whereas the corresponding

expected yields are given by dotted lines. The solid line means the actual total yield. It is to observe that maize, when grown in mixture, yielded always more than the expected yield for all intercropping ratios. This does not occur for sunflower where the actual yields are very closed to the expected ones.

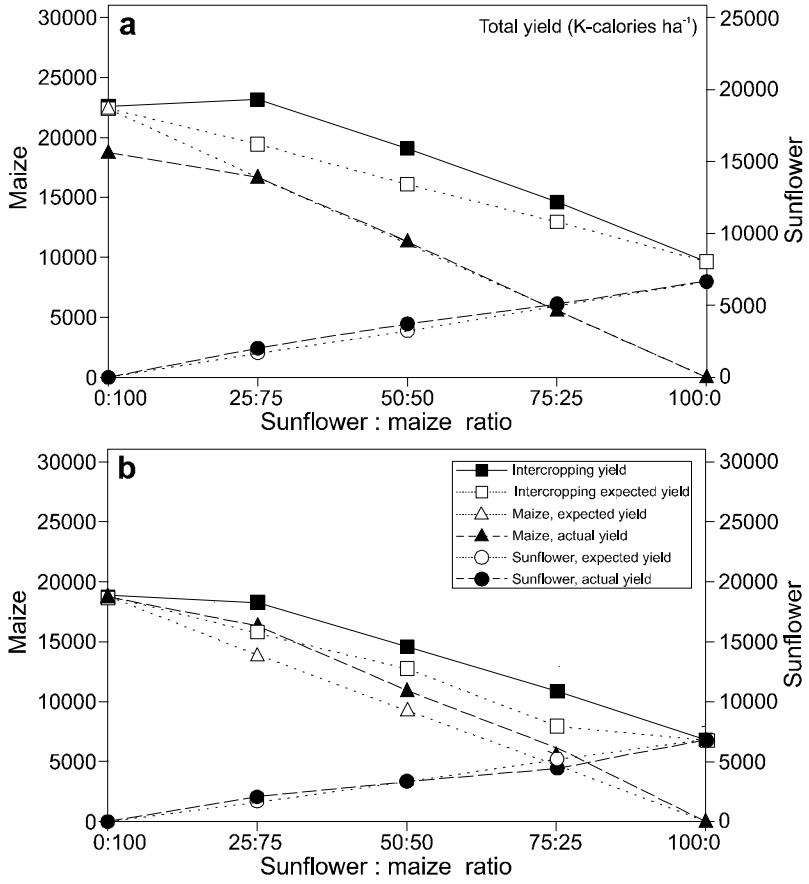

Figure 1: Yield energy advantages, expressed as K-calories ha^{-1}, in sunflower-maize intercropping. Dotted lines represent sunflower, maize and intercropping expected yield; dashed lines represent sunflower and maize actual yield and solid line represents intercropping actual yield. Cultivar Manica ***(a)*** *and cultivar Matuba* ***(b)*** *for maize; cultivar Black Rekord for sunflower.*

The comparison between yields in pure stand crop and intercropped species evidenced advantage for only 75:25 maize-sunflower ratio when Black Rekord was grown with Matuba. In this case K-calories ha^{-1} increased to 380 K-calories ha^{-1}, that is, 3% more in respect to maize pure stand crop.

CONCLUSIONS

From the present study it appears that sunflower-maize intercropping, in the situations studied here, did not give any advantage in terms of grain yield per hectare in respect to the pure crop. This is in agreement with the results reported by Robinson (1984), Fagbayide *et al.* (1997), and Galal (1998).

However, it is to note that when the yield is converted in food energy, *i.e.*, K-calories per hectare, 75:25 maize-sunflower mixture ratio is most suitable from the nutritional point view when compared with the maize pure crop. In terms of food supply, the traditional farm family living in Mozambique can obtain the largest quantity of energy by this intercropping ratio and the food is better balanced among carbohydrate, lipid and protein contents and for the liposoluble vitamins supply. It appears that this intercropping system can give sustainability to the farm family in the largest rural area of Mozambique.

In the area studied so far no constrains exist for temperature conditions, thus provided the same water supply, other mixtures involving different varieties might be studied. The present experiment shows that Manica maize aggressiveness can be partially balanced by sunflower Black Rekord, but this fact did not hold with sunflower 2GN. Considering the strong competition given by the long-cycle maize (Manica), we believe that relay cropping, *i.e.*, sowing two species at different times, would be an advantageous intercropping solution.

ACKNOWLEDGEMENTS

This work was supported by the Italian Government through the Progetto Girasole in Mozambico, headed by Dr. Emma Gori of Ministero Affari Esteri.

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CULTIVO CONJUNTO DEL GIRASOL Y MAIZ EN MOZAMBIQUE

RESUMEN

En el periodo de 1998-1999, en Mozambique fue efectuada la investigacion para estudiar el efecto de la cosecha conjunta del maiz y girasol en tres proporciones (25:75, 50:50, 75:25) en comparacion de cultivos puros de dos variedades del girasol y maiz. En ambas variedades del maiz, el rendimiento por planta se reducia con la densidad, y el valor minimo fue obtenido en el cultivo puro. El girasol se comportaba solo parcialmente de tal manera. La cosecha conjunta con la proporcion de maiz-girasol 75:25 dio el rendimiento mas alto por hectarea (5195 kg ha^{-1}), y LER-coeficientes del maiz y girasol indicaron que el maiz era un poco mas dominante en la miezcla que el girasol. La ventaja relativa de ambas especies al respecto del cultivo era cerca de 16 y 19%. Entrentanto, cada especie y cada variedad alcanzaban el rendimiento maximo por hectarea cuando se cultivaban con el cultivo puro (100%). Por otro lado, cuando el rendimiento se investiga con respecto al valor energetico de nutricion (K-caloria), que hacen el grano de maiz y las proteinas y el oleo de girasol por hectarea, la miezcla de maiz-girasol 75:25 se hace aun mas favorable que el cultivo puro de maiz. El aumento en K-calorias es de 380 ha^{-1}, y mejor proporcion de los componentes de hidrocarbonatos, proteinas y lipidos asegura la subsistencia de economias familiares usuales en Mozamique. Ademas, el oleo de girasol enriquece la alimentacion de la gente en las haciendas con las cantidades importantes de acidos grasos no saturados y vitaminas liposolubles.

CULTURE CONJOINTE DU TOURNESOL ET DU MAÏS AU MOZAMBIQUE

RÉSUMÉ

Au cours des années 1998-1999, une expérience a été faite au Mozambique dans le but d'examiner l'effet que produirait la culture conjointe du maïs et du tournesol dans trois rapports (25:75, 50:50, 75:25) en comparaison avec des cultures exclusives de deux sortes de tournesol et de maïs. Pour les deux sortes de maïs, le rendement par plante a diminué avec la densité, alors que la moindre valeur a été obtenue dans la culture exclusive. Le tournesol ne s'est comporté que partiellement de cette façon. La culture conjointe dans le rapport maïs-tournesol 75:25 a donné le plus grand rendement par hectare (5195 kg ha^{-1}), et les coefficients LER du maïs et du tournesol ont montré que le maïs était un peu plus dominant dans le mélange de tournesol. L'avantage relatif des deux espèces en rapport avec la culture exclusive était d'environ 16 et 19%. Cependant, chaque espèce et chaque sorte a atteint le rendement maximal par hectare quand elle était cultivé dans une culture exclusive (100%). Par ailleurs, quand on examine le rendement en termes de valeur énergétique de nourriture (K-calories), que représentent le grain de maïs et les protéines et l'huile de tournesol par hectare, le mélange maïs-tournesol 75:25 semble plus favorable que la culture exclusive de tournesol. L'augmentation en K-calories est de 380 ha^{-1}, et le meilleur rapport en composantes d'hydrates de carbone, de protéines et de lipides assure la subsistance d'un ménage familial moyen comme ceux que l'on trouve généralement au Mozambique. De plus, l'huile de tournesol enrichit l'alimentation humaine dans les fermes par leur importante quantité d'acides gras non saturés et de vitamines liposolubles.