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Productivity of Intercropped Maize (*Zea mays*) and Varieties of Yard-long Bean (*Vigna unguiculata*) as affected by Planting Time

R.A.D.T.K. Ranasinghe, W.A.J.M. De Costa[1] and U.R. Sangakkara[1]

Postgraduate Institute of Agriculture
University of Peradeniya
Peradeniya

ABSTRACT. *Intercropping maize (Zea mays) with yard-long bean (Vigna unguiculata sub spp. sesquipedalis) is a common practice in the dry zone of Sri Lanka during the Maha wet season. Due to lack of systematic research data, a study was conducted to determine the productivity of maize x yard-long bean (YLB) intercropping when compared with sole cropping. Effects of different YLB varieties (Havari ma and Polon ma) and planting times (simultaneous with maize and 3 weeks after maize) on intercrop productivity were determined. Land equivalent ratio (LER) was significantly greater than one in all intercrops except in the treatment having late-planted Polon ma where LER was not significantly different from one. Simultaneous planting of YLB with maize produced a greater LER than late-planting. However, LER was not affected by the YLB variety. Intercrop yields of both crops were lower than when grown as sole crops indicating mutual competition for resources. In Havari ma, competition from maize was greater when late-planted. This effect was not observed in Polon ma. When maize was harvested at fresh cob stage, competition from simultaneously-planted YLB on maize was greater. However, the opposite was observed when maize was harvested as dry cobs. Therefore, it is concluded that greater productivity can be achieved by intercropping maize and YLB.*

INTRODUCTION

Intercropping is defined as growing two or more crops simultaneously in the same piece of land (Ruthenberg, 1971). It is a predominant practice among farmers in resource-limited environments, particularly in the developing countries (Francis, 1986). The diversity of crop species and end-products given by an intercropping system not only allows greater and more efficient

[1] Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya.

utilization of available land resources but also provides an insurance against possible crop failure. Intercropping species having different durations of maturity ensures a more uniform income distribution to the farmer as compared to monocropping (Lynam *et al.*, 1986).

In Sri Lanka, farmers have traditionally practised intercropping, particularly in the uplands. Upland cropping systems in the wet zone have a significant perennial component, while those in the intermediate and dry zones predominantly consist of mixtures of annual crops. Maize and yard-long bean (*Vigna unguiculata* sub spp. *sesquipedalis*) intercropping system is one such example which is being practised in rainfed uplands in the *Maha* season. An interesting feature of this system is that maize acts as a support for the vines of yard-long bean (YLB).

Although maize x YLB intercropping has been practiced for many years, no systematic research has been conducted (S.J.B.A. Jayasekara, pers. comm.) to determine optimum management practices that would achieve maximum productivity. Therefore, the present study was carried out with the objective of determining the effects of different planting times and different YLB varieties on the productivity of a maize x YLB intercropping system.

MATERIALS AND METHODS

The experiment was carried out from October, 1995 to February, 1996 at the University Experimental Station, Dodangolla, Kundasale (IM3, 367 m above sea level) on a reddish brown latosolic (Rhodudults) soil.

Treatments and experimental design

The treatment structure was a 2-factor factorial, with planting time and YLB varieties as main effects. The two planting times tested were 'simultaneous' and 'late' planting. In 'simultaneous' planting, both maize (var. '*Badra I*') and YLB were sown at the same time whereas in 'late' planting YLB was sown 2 weeks after maize. In all treatments, maize was planted on 12, October, 1995. The YLB varieties used were '*Polon ma*' (PM) and '*Havari ma*' (HM). In addition to the 4 intercropping treatments, there were 5 sole crop treatments, *i.e.* maize, simultaneous- and late-planted PM and HM. The 9 treatment combinations were laid out in a randomized complete block design with 3 replicates. The plot size was 6 m x 3 m with a 1 m distance between plots.

Crop establishment and management

The crops were established by seed. The spacing of both species were 60 cm x 30 cm giving a plant population of 5.5 per m^2. In intercrops, YLB was sown alongside maize, thereby giving a 100% : 100% additive intercrop. Crops were managed as rainfed with recommended applications of fertilizer for maize and YLB. Pest, disease and weed control was carried out as recommended by the Department of Agriculture.

Measurements

Crop productivity was quantified by measuring cob and pod yields of maize and YLB respectively. Yields were measured by harvesting at different stages of maturity. Maize was harvested as fresh and dry cobs at 95 days after planting (DAP) and 122 DAP respectively. YLB was harvested as both green and dry pods. When YLB was planted simultaneously with maize, harvesting of green pods started at 62 DAP and continued at weekly intervals for 10 weeks. In the same treatment, harvesting for dry pods started at 82 DAP and continued for 8 weeks. In late planted YLB, harvesting started at 59 DAP (green pods) and 82 DAP (dry pods) and continued for 10 and 8 weeks respectively. Each harvest was taken from 5, randomly-chosen and pre-designated plants. When harvested as either fresh cobs or green pods, yields were expressed as both fresh and dry weights. The fresh weights were needed to represent the form of yield which would be sold by the farmer whereas the dry weights indicated the actual biomass present in the yield.

Data analysis

Land equivalent ratio, LER, (Willey, 1979) was used as a comparative measurement of intercrop productivity. The mean sole crop yields of maize and YLB from the present plots were used as single divisors (Thattil, 1985; Mead, 1986) in computing LER. The t-test was used to test whether LER of each intercropping system was significantly greater/smaller than 1. Analysis of variance (ANOVA) was used to compare productivities of different intercropping systems. This method was also used to separate comparisons of raw yields of maize and YLB under sole and intercropping.

RESULTS AND DISCUSSION

Land equivalent ratio (LER)

LER values of all intercropping systems were either significantly greater than 1 (Table 1) or similar to 1, irrespective of the stage of harvesting. All intercrop treatments except that with late-planted *Polon ma* had LER values significantly greater than 1 in at least one stage of harvesting. This indicates that when maize and YLB is intercropped, efficiency of land resource utilization is either greater than or similar to growing sole crops. Separate estimation of LER for different stages of harvesting becomes relevant because both maize and YLB can be harvested either at the fresh, green stage to be consumed as vegetables or at the dry seed stage to be used in animal feed formulations. Information on productivity at these different stages would allow the farmer to decide on the best stage of harvesting to obtain maximum profit. Simultaneously-planted intercropping of maize and *Havari ma* was advantageous over sole cropping at all stages of maturity. On the other hand, intercropping late-planted *Polon ma* with maize did not show a significant advantage over sole cropping at any stage of maturity. It is significant to note that the highest probability of success was at stage 3 (*i.e.* by harvesting as fresh cobs and green pods and processing as dry seeds) where 3 of the 4 tested intercropping systems showed significant advantage over sole cropping.

The variation of LER (Table 2) showed that the YLB variety had no effect on intercrop productivity. On the other hand, simultaneous planting produced a significantly higher LER than late planting, irrespective of the stage of harvesting. This was probably because of the higher utilization, by the early-planted YLB, of above- and below-ground resources which were likely to be present in excess during the early stage of the intercrop. On the other hand, during the initial 3-week period of the late-planted intercrop, there was probably incomplete capture of resources resulting in lower LER as compared to simultaneous planting.

Component crop yields - YLB

YLB yields in all intercrops were significantly lower than the corresponding sole crops (Table 3) at both green and dry stages. This indicated competition for above- and/or below-ground resources by maize in the intercrops involving both YLB varieties at both planting times.

Table 1. Land equivalent ratio (LER) of different maize x YLB intercropping systems estimated at different stages of maturity.

Inter-cropping system	Mean LER at different stages of maturity				
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Mz x HM (S)	1.24 *	1.41 *	1.61 *	1.47 *	1.43 *
Mz x PM (S)	1.23	1.40	1.46 *	1.40 *	1.33
Mz x HM (L)	1.04	1.18	1.13 *	1.14	1.04
Mz x PM (L)	0.85	1.38	1.25	1.04	1.21

Mz- Maize HM- *Havari ma* PM- *Polon ma*
S- Simultaneous planting L- Late planting

* indicates significant difference from 1.0 at p=0.05 from t-test

Stage 1: Fresh weights of fresh cobs and green pods
Stage 2: Dry weights of fresh cobs and green pods
Stage 3: Seed dry weights of fresh cobs and green pods
Stage 4: No. of fresh maize cobs and fresh weight of green pods
Stage 5: Seed dry weights of dry cobs and dry pods

In intercrops, late-planted HM yields were significantly lower than those of simultaneously-planted HM (Table 3), at all stages of harvesting. The exception was seed dry weight of dry pods. Except for the pod fresh weights at the immature stage, yields of late-planted sole crops of HM did not differ significantly from the simultaneously-planted (*i.e.* early-planted) sole crops of HM. This suggests that the competition for resources from maize on HM was greater in intercrops when HM was late-planted.

In contrast to HM, the late-planted sole crops of PM produced significantly lower yields than the simultaneously-planted (*i.e.* early-planted) sole crops of PM (Table 3). Although, intercropped PM yields were always lower in late-plantings, significance was shown only at 2 out of 4 stages of harvesting. Therefore, unlike in HM, in PM it cannot be concluded that

Table 2. Effects of YLB variety and time of planting of YLB on LER.

Sources of Variation	Mean LER at different stages of harvesting				
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
<u>YLB Variety:</u>					
Havari ma	1.14 a	1.30 a	1.45 a	1.30 a	1.27 a
Polon ma	1.04 a	1.27 a	1.35 a	1.22 a	1.24 a
<u>Pl. time:</u>					
Simultaneous	1.24 c	1.41 c	1.54 c	1.44 c	1.39 c
Late	0.95 d	1.16 d	1.27 d	1.09 d	1.13 d
CV (%)	15.68	14.27	14.21	13.89	14.14

Note: The YLB variety x planting time interaction was not significant. Stages of harvesting are as given in Table 1. Mean comparisons are done between YLB varieties and planting times separately for each stage of harvesting. Means in a column following the same letter are not significantly different at p=0.10.

competition from maize was definitely greater in late-plantings than in simultaneous-plantings.

Component crop yields - Maize

Maize yields in intercrops were always lower than those of sole crops, at all stages of harvesting (Table 4). There were no significant differences between maize yields of different intercrops. Therefore, while maize exerted a significant competition for resources on YLB, competition by YLB also had an adverse effect on maize yields in intercrops. In all maize crops, both cob dry weights and seed dry weights were greater at the dry cob stage than at the fresh cob stage. Thus, if maize is grown to be used as an animal feed, it is more profitable to harvest it at the dry cob stage. When harvested at the fresh cob stage, yields of maize intercropped with HM were slightly higher than those intercropped with PM.

Table 3. Mean YLB yields as varied by different cropping systems, YLB varieties and time of planting.

Treatment			Green stage		Dry stage	
			Pod fr. wt. (kg/ha)	Seed dry wt. (kg/ha)	Pod dry wt. (kg/ha)	Seed dry wt. (kg/ha)
HM	S	I	6410	520	960	560
HM	S	M	11040	840	1430	1030
HM	L	I	3240	260	560	330
HM	L	M	7540	710	1340	1100
PM	S	I	6250	530	1080	630
PM	S	M	12380	1020	2050	1410
PM	L	I	2370	410	640	430
PM	L	M	6980	540	1050	990
$LSD_{(p=0.05)}$			1220	140	240	250
CV (%)			19.76	26.88	23.80	35.78

HM- *Havari ma* PM- *Polon ma* S- Simultaneous planting;
L- Late planting I- Intercrop M- Monocrop

This indicates a slightly lower competition by HM on maize. A similar trend was shown at the dry cob stage, but only with simultaneously-planted HM. Interestingly, at the fresh cob stage, a majority of the maize yields in intercrops with late-planted YLB were higher than in those with simultaneously-planted YLB (Table 4), indicating lower competition from YLB in late-plantings. However, at the dry cob stage, a majority of intercrop maize yields with late-planted YLB were lower than those with simultaneously-planted YLB (Table 4), indicating lower competition from YLB in late-plantings. However, at the dry cob stage, a majority of intercrop maize yields with late planted YLB were lower than those with simultaneously-planted YLB (Table 4). This means that late-planted YLB exerts a higher degree of competition on maize during the latter stages of maize yield development. This is probably because the yield formation stage of YLB during which the demand

Table 4. Mean YLB yields as varied by different cropping systems, YLB varieties and time of planting.

Treatment	Fresh cob stage				Dry cob stage	
	No. of cobs ($x10^4$/ha)	Cob fr. wt. (kg/ha)	Cob dry wt. (kg/ha)	Seed dry wt. (kg/ha)	Cob dry wt. (kg/ha)	Seed dry wt. (kg/ha)
Sole Maize	7.41	15090	6590	3750	8420	5830
M-HM-S	5.88	8060	5220	3200	6970	5330
M-PM-S	5.56	8050	4620	2700	6370	4410
M-HM-L	5.89	9980	5400	3250	6040	4210
M-PM-L	5.70	8480	4790	2480	6210	4700
$LSD_{(p=0.05)}$	1.57	3590	1540	800	1880	1070
CV (%)	13.67	19.19	15.20	13.86	14.65	11.59

on resources would be greatest will coincide with cob-maturing stage of maize. Therefore, it is advisable to plant YLB simultaneously, if maize is grown to be used as an animal feed. On the other hand, YLB should be planted late, if maize is expected to be used as fresh cobs. Here, the maize yield, *i.e.* fresh cobs will have formed before the onset of yield formation of YLB thereby minimizing the competition for resources from YLB.

CONCLUSION

Results of the present study showed that intercropping maize and YLB is more advantageous than growing the two crops separately. In addition to the greater or similar efficiency of land resource utilization, the economic advantages would support the above conclusion. As maize is used as a support for the YLB vine, the additional cost of stakes and the associated labour cost of staking incurred in sole cropping of YLB would be saved by intercropping. If the farmer's objective is to maximize the combined intercrop yield, then simultaneous planting is recommended in preference to late planting of YLB. As the intercrop productivity was not significantly affected by the YLB variety, either *Polon ma* or *Havari ma* could be used for intercropping with the farmer being free to make the decision on the basis of other factors such as market preference.

Comparison of component yields of intercrops and their respective sole crop yields showed that both species exerted significant competition for resources on each other. The intercrops should be managed in a way which would minimize the above competition by avoiding the overlapping of the yield formation periods of the two component crops. Here, the best option, in terms of manipulating the planting time, would differ depending on the farmer's objective. If maize is grown to be harvested as fresh cobs, late planting of YLB would minimize its competition on maize. On the other hand, simultaneous planting of YLB is recommended if maize is grown to be harvested as dry cobs. If the farmer's objective is to maximize YLB yields in the intercrops, simultaneous planting would always be advantageous over late planting. As no clear difference was shown in the performance of the two YLB varieties in intercrops, the choice of variety could be left to the farmer.

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