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Nitrogen Use and Economics of Intercropping in Sri Lanka

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Abstract Field studies to compare N utilization and economics of some intercropped and mono cropped systems were conducted in Sri Lanka using maize / cowpea maize / soybean and maize / mungbean crop combinations. N levels used were 0%, 50% and 100% of the locally recommended rates for the non-legume crop. At all locations, the non legume crop showed a positive response to N under both cropping systems Yield of the intercropped legume was depressed at higher N levels possibly due to shading effect of the non-legume crop. Total output and gross returns increased with intercropping. The net protein utilization value of the inter cropped system was also higher highlighting the importance of such systems for the subsistence level farmers of developing countries.

1. Introduction

In many Asian and Pacific countries, farmers with limited resources have traditionally multiple cropped their lands to minimize risks associated with growing a single crop, and to assure a more stable subsistence in terms of food, nutrition, and possible income. Using the available family labour and limited capital resources, they have attempted to maximize returns from these cropping systems, generally under low levels of technology. In the developed countries, however, multiple cropping has been viewed as a practice not well suited to modern agriculture, and for this reason, research in this field has been largely inadequate. One of the main reasons for this neglect seems to be that most agricultural research reported in literature has been carried out in countries where monocultures prevail. Since agriculture in these countries is mechanized, research has focused on agricultural systems that have mechanization as one of their major components[2] Due to recent increases in population densities and in prices of agricultural resources, an interest is now developing to seek technological alternatives for increasing food production. Intercropping as a means of optimizing the use of land and other inputs, is starting to receive increased attention.

One of the areas requiring an enhanced understanding in multiple cropping systems is the use of fertilizer nitrogen, a resource which is expensive and not easily available to farmers in developing countries. The present study was therefore designed to evaluate N utilization of intercropped systems, and to compare its economics with corresponding monocropped systems.

2. Materials and Methods

A non-leguminous monocrop system at three N levels was compared with an intercropped system consisting of the same crop inter-planted with a grain legume, at the same levels of N. The study was conducted at Peradeniya and

Kundasale in Sri Lanka with two experiments at each location. The levels of N selected were 0%, 50% and 100% of 80 kg N/ha, the recommended N for the row crop[1] maize *Zea mays* L. All plots received 100% of the recommended rates of P (*50 kg P/ha*) and K (*65 kg K/ha*) for the row crop only and other cultural practices for both crops uniformly as per local recommendation. In Peradeniya experiment (B) where soybean was used as the legume, it was inoculated with a commercial inoculum, 'Nitrogin S' at the rate of 5 g/kg of seed. Grain legumes used were soybean *Glycine max* (L) Merr. (1 site), cowpea *Vigna unguiculata* L. (1 site) and mungbean *Vigna radiata* L. (2 sites.) Both row and legume crops were planted at the same time. The legume was planted centrally between row crop rows. Treatments were arranged in randomized blocks replicated four itmes. Locations, soil characteristics and other experimental details are indicated in Table 1.

Table 1 – Locations, soil characteristics and other experimental details

Location		PERADENIYA		KUNDASALE	
		(A)	(B)	(C)	(D)
Altitude	..	450 M	450 M	420 M	420 M
Texture	..	clay loam	clay	loamy sand	loamy sand
pH	..	5·3	6·1	6·4	6·4
Organic carbon (%)	..	1·55	1·98	1·04	1·6
Total N (%)	..	0·27	0·1	0·09	0·28
CEC (me/100g)	..	40·8	43·8	4·60	3·96
Available P (me/100g)	..	52·7	15	23·0	52·7
Available K (me/100g)	..	0·54	2·11	0·35	0·64
Available Ca (me/100g)	..	21·94	25·81	3·35	4·00
Available Mg (me/100g)	..	13·60	12·90	0·83	0·76
Available Na (me/100g)	..	0·92	0·93	0·06	0·04
Row crop variety (maize)	..	Thai Composite	Thai Composite	T 48	T 48
Legume	..	cowpea	soybean	mungbean	mungbean
Legume variety	..	Bushitavo	PB. 1	MI. 1	MI. 1
Date of Planting (1976)	..	May 16	July 16	May 20	July 2
Date of harvesting (1976)					
row crop	..	Sep. 20	Nov. 20	Sep. 23	Nov. 8
legume	..	Aug. 30	Oct. 24	Aug. 16	Oct. 10
Spacing, cm					
row crop	..	75 x 25	75 x 25	75 x 75	75 x 25
legume	..	75 x 20	75 x 5	75 x 20	75 x 20
Rainfall during experimental period, mm+	..	712	721	413	200

+ Supplemental irrigation provided in all cases, as needed

Table 2 – Mean yields of row and legume crops under various levels of nitrogen, kg/ha

	Rate of recommended	PERADENIYA						KUNDASALE					
		(A)			(B)			(C)			(D)		
	N as %	maize	cowpea	total	maize	soybean	total	maize	mungbean	total	maize	mungbean	total
Intercrop System	100	9·85a	0·48	10·33	6·08ab	1·05	7·14	4·88a	0·08	4·96	1·27b	0·13	1·40
	50	9·53a	0·33	9·86	5·10bcd	1·08	6·18	3·86b	0·29	4·15	1·00b	0·15	1·15
	0	7·88b	0·50	8·38	4·25d	1·44	5·69	2·33a	0·43	2·76	0·60c	0·24	0·84
Monocrop System	100	10·16a	—	10·16	6·70a	—	6·70	4·84a	—	4·84	1·67a	—	1·67
	50	10·06a	—	10·06	6·13ab	—	6·13	4·35ab	—	4·35	1·11b	—	1·11
	0	7·88b	—	7·88	5·52ab	—	5·52	3·06c	—	3·06	0·60c	—	0·60

Means in the same column followed by the same letter (s) are not significant at the 5% level (Bayes LSD)

3. Results and Discussion

The mean yield of row and legume crops for various locations is given in Table 2.

Yield of row crop: (i) *Effect of N* – Whether intercropped or not, maize showed a positive response to N application, The yield difference between the 50% N and 100% N levels however, was significant in two cases: intercrop in Kundasale (C) and monocrop in Kundasale (D). These results would perhaps suggest a re-examination of what constitutes a "recommended" fertilizer application by farmers.

An interesting feature is that the magnitude of yield response and its trend varied with variety and location. Thus a considerable variation in the yield of maize was recorded among the four sites. The yield ranged from 0·60 – 1·27 t/ha in Kundasale (D) to 7·88 – 9·85 t/ha in Peradeniya, (A). Maize yields in Kundasale trials are too low to make valid comparisons between locations.

ii. *Effect of Cropping System* — As a general trend, maize yields were somewhat depressed by intercropping, particularly at lower N levels. The differences however, were statistically significant only in a few instances: the 0% N level in Kundasale (C) and Peradeniya (B), and the 100% N in Kundasale (D). The yield gap between monocropped and intercropped maize tended to decrease with increasing N levels, except in Kundasale (D). This would indicate that at lower N levels, there is competition between maize and interplanted legumes for N, and that the competitive effect decreases as the N level increases. Agboola and Fayemi[1] studied the effect of intercropping maize with cowpea and mungbean at varying N levels and found that maize yield was not decreased by intercropping at higher N levels. Similar results have been reported by Haizel[6] when maize was intercropped with cowpea in two cropping seasons. Beets[2] concludes that maize could withstand intercropping with compatible crops. These arguments do not help to explain the yield differences in the Kundasale (D) however, possibility of some, as yet unexplained, interaction between maize and mungbean cannot be ruled out. The significant maize yield reduction due to intercropping at 0% N level in Kundasale (C) and Peradeniya (B) may be a reflection of the inability of maize to compete with either mungbean or soybean for the available soil N. Similar conclusions are also reported by Harwood and Banta.[8]

Yield of Legume: Table 2 indicates that, in all cases, the yield of intercropped legume decreased with increasing levels of N application, except in Peradeniya (A). Thus, at all four sites, the 0% N level gave the highest legume yield, regardless of whether it was mungbean, cowpea or soybean, and this tended to decrease with increasing N levels. Shading and competition effects of the row

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The term "row crop" wherever used will denote the non-leguminous crop being tested; "legume" will designate the inter-planted grain legume.

crop at higher N levels would probably account for this. Syariffuddin *et al*[14] reported an increase in shading effect and a corresponding reduction in legume yield at higher densities of maize. This suggests that wider spacings of the row crop would be required if higher yields of inter-planted legume is desired.

Yield of total system : The total yield of the intercropped system was higher than that of its monocrop counterpart at all N levels, except in a few cases (Table 2). This suggests that there was better utilization of land, N, and other inputs under intercropping. The magnitude of the difference, however, varied with crop combinations and location. Results of these and some other studies so far reported indicate that a new potential for total production systems thus exists if plant types are selected to exploit soil and climates while maintaining optimum plant populations and other cultural practices (Jeganathan *et al.*,[10], and Pinchinat and Oelsligle,[12], for maize – soybean combinations; Requib and Kundu[13], for maize – groundnut and rice-mungbean combinations; and Beets[12], for rice - soybean and maize - soybean combinations). On the other hand, Koli[11] and IRRI[9] report a reduction in yield of both crops in intercropped systems. One of the deficiencies of results so far obtained is that most research concerned with inter- cropping has been conducted with crop varieties selected for performance in pure culture. As Harper[7] points out, varieties that are expected to perform better in mixtures should be specifically bred for this purpose. Data reported by Digkstra and De Vos[4] who tested clover selections in both pure and mixed stands with pasture grass support this view.

Human nutritional value. The effect of cropping systems and N level on the crude protein content of maize and cowpea in Peradeniya (A), although not subject to statistical analysis, shows that, while crude protein of cowpea was not affected by N levels, that of maize increased in both monocrop and intercrop systems (Table 3). At rates below the 100% N level, crude protein content of maize under monocrop was slightly higher than under intercrop; at the 100% N level, on the other hand, crude protein content was higher under the intercrop system the combined maize-cowpea crude protein content of the intercrop system was much higher than that of the maize monocrop system at all N levels. From a practical human nutrition standpoint, the significant points to note are:

Table 3 – Effect of cropping systems and N level on crude protein content of maize and cowpea, Peradeniya (A)

Level of N, kg/ha	Crude Protein Content, %		
	Monocrop System	Intercrop System	
	maize	maize	cowpea
80	10·94	11·70	24·90
40	9·93	8·96	24·90
0	8·88	8·35	25·00

1. The maize- cowpea intercrop yielded approximately 10% more crude protein/ ha, compared to maize monocrop, at the same N levels.
2. Since cowpea has a higher lysine content (427 mg/g vs 167 mg/g N in maize), the concurrent use of cowpea and maize as food should have much better net protein utilization than maize alone.[5]

The data is inadequate to make further explanations, and indicates that there is a need for much further research on the human nutrition aspects of intercropping.

Economics. The total economic value of the produce obtained (t/ha) was based on international wholesale crop prices in some cases and the local market prices prevailing at the time of study in other cases (Table 4). The differentially higher cost incurred in the intercrop for family labour has not been taken into account, since family labour is readily available in most developing countries.

Table 4 – Economics of mono and intercrop systems+

	Gross returns at various N levels, Rs/ha					
	ZeroN/		40 kg N/ha		80 kg N/ha	
	monocrop	intercrop	monocrop	intercrop	monocrop	intercrop
Peradeniya (A)						
maize	3,325·0	3,350·2	4,275·6	4,050·2	4,316·2	4,191·6
cowpea	—	432·0	—	274·4	—	417·2
TOTAL	3,325·0	3,782·2	4,275·6	4,324·6	4,316·2	4,608·8
Peradeniya (B)						
maize	3,175·2	1,806·0	2,608·2	2,167·2	2,850·4	2,583·0
soybean	—	1,741·6	—	1,300·6	—	1,267·7
TOTAL	3,175·2	3,547·6	2,608·2	3,467·8	2,850·4	3,850·0
Kundasale (C)						
maize	1,299·2	991 2	1,841·0	1,642·2	2,063·6	2.074·8
mungbean	—	242·2	—	366·8	—	50·4
TOTAL	1,299·2	1,233·4	1,841·0	2,009·0	2,063·6	2,125·2
Kundasale (D)						
maize	266·0	266·0	466·2	425·6	708·4	541·8
mungbean	—	1,275·4	—	733·6	—	609·0
TOTAL	266·0	1,541·4	466·2	1,159·2	708·4	1,150·8

+ Average wholesale international price used for maize, cowpea and soybean for mungbean the wholesale price prevailing in Sri Lanka at the time of study has been used due to non-availability of data on international prices.

In all four experiments, regardless of crop combinations used, the intercrop system provided higher returns than the monocrop system at corresponding N levels, the increase varying from a non-significant 1% in Peradeniya (A) (50% N level) to a highly significant 416% in Kundasale (B) (0% N level). The only exception where the monocrop yielded more returns was the 0% N level in Kundasale (C). The difference amounts to 5%. Intercropping with a higher value crop such as mungbean provides for a higher differential return than if a lower value crop such as cowpea is used. Roquib *et al*[13] also found combinations of maize and soybean, rice and soybean, and maize and groundnut to give better monetary returns per unit area; Jeganathan *et al*[10] reported more net profit in intercropped maize and soybean. Beets[2], in a comprehensive study on mono - and intercropping economics in Thailand reported that soybean - maize intercrop could yield 30% more income compared to monocrop maize.

Apart from increased returns, intercrop systems could also provide for a greater protection against risks due to pests and adverse climatic conditions, as these tend to affect various crops differently. A farmer would therefore be able to harvest one crop even if the other crop was completely destroyed.

4. Conclusion

Intercropping with compatible crop combinations increases total output per unit area and therefore provides for more efficient utilization of N, land and other inputs. Depending upon market prices of crops used, total returns to farmers are also increased. Intercropping with legumes appears to enhance the net protein utilization value of the system, highlighting the importance of such management practices for subsistence level farmers of developing countries.

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