maintained higher germination, and vigour over the untreated seeds in both tomato and brinjal (Tables 1,2). Among the treatments, disodium phosphate (10^{-4}m) recorded higher germination in tomato (52%) and in brinjal (58%) at the end of eight months of storage. It could be attributed that the anti-oxidant property of the disodium phosphate would have controlled the free radical damage and maintained the membrane integrity. Similar study with disodium phosphate was reported in tomato earlier (Sree Ramamurthy, 1984). Treatment with disodium phosphate showed significant improvement in DMP, but the response to treatment was comparatively higher in tomato (19%), than in brinjal (13%) and this might be due to the repair of damage in bioorganelles (Villiers, 1975). Seeds treated with disodium phosphate recorded lower EC and free sugars of seed leachate. The membrane damage due to destructive changes during seed ageing could be repaired and protected by the hydration-dehydration treatment (Basu *et al.*, 1975). In this study, the enzymatic activity was more in the seeds treated with disodium phosphate, confirming the finding of Dey and Mukherjee (1986) in mustard. In may be concluded that mid-storage treatment given to eight month old seeds, particularly with disodium phosphate @ 10^{-4}m significantly reduced the deterioration of seeds under storage.

REFERENCES

BASU, R.N.,BOSE, T.K. CHATTOPADHYAY, K. and PATHAK, G. (1975). Seed treatment for the maintenance of vigour and viability. **Indian Agric., 19**: 91-96.

DEY, G. and MUKHERJEE, R.K. (1986). Deteriorative change in seeds during storage and its control by hydration dehydration pretreatments. **Seeds Res., 14**: 49-59.

ISTA (1985). International Rules for Seed Testing. **Seed Sci. & Technol., 13**: 299-313.

KITTOCK, D.A. and LAW, A.G (1968). Relationship of seedling vigour to respiration and tetrazolium chloride reduction by germinating wheat seeds. **Agron.J., 60**: 286-288.

PRESLEY, J.T. (1958). Relation of protoplast permeability to cotton seed viability and pre-disposition to seedling diseases. **Pl.Dis.Rept., 42**: 852.

SOMOGYI, M. (1952). Note on sugar determination. **J.Biol., Chem., 195**: 19-23.

SREERAMAMURTHY, P.V. (1984). **Seed Invigoration and Maintenance of Seed Quality in Tomato.** M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore CBE.

VILLIERS. (1975). **Genetic Maintenance of Seeds in Imbibed Storage in Crop Genetic Resources for Today and Tomorrow. IBP Programme Vol. 2.**, Cambridge Universtiy Press, Great Britain.

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BIOLOGICAL AND ECONOMIC INDICES FOR MEASURING RESOURCE UTILISATION IN MAIZE-SOYBEAN INTERCROPPING SYSTEM*

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ABSTRACT

Experiments were conducted at the Tamil Nadu Agricultural University, Coimbatore to assess the biological and economic advantages of maize-soybean intercropping system under varying levels of irrigation and nitrogen during summer and *kharif* seasons of 1990. Though, land equivalent ratio (LER) recorded a positive value under varying levels of intercrops, irrigation and nitrogen, the land equivalent coefficient (LEC) showed its superiority in measuring the competition aspects in intercropping. The monetary equivalent ratio (MER) was modified with a new concept called net monetary equivalent ratio (NMER) by accounting the net returns for computing the economic efficiency in intercropping studies. Both biological and economic indices revealed that two rows of intercrop soybean was essential for effective utilisation of resources and for better economic output.

KEY WORDS : Maize, Soybean, Intercropping, LER, LEC, MER, NMER

In terms of land use, growing crops in mixed stand is regarded as more productive than growing them separately. Intercropping is practiced widely throughout the tropics and is an advantageous

Table 1. Effect of irrigation, systems of cropping and nitrogen on yield of maize and soybean and LER, LEC, MER and NMER

Treatment	Yield of maize kg ha^{-1}		Yield of soybean kg ha^{-1}		LER		LEC		MER		NMER	
Irrigation levels	Summer 1990	*Kharif* 1990	Summer 1990	*Kharif* 1990	Summer 1990	*Kharif* 1990	Summer 1990	*Kharif* 1990	Summer 1990	*Kharif* 1990	Summer 1990	*Kharif* 1990
I_1	3291.0	3833.3	223.9	232.9	1.23	1.25	0.23	0.20	1.10	1.07	1.24	1.07
I_2	3765.0	4505.2	244.7	260.0	1.25	1.25	0.25	0.25	1.18	1.10	1.28	1.17
SE_D	21.4	11.2	0.7	0.7	0.004	0.052	0.001	0.002	0.002	1.104	0.002	0.004
CD (0.05)	47.9	25.5	1.5	1.5	0.009	NS	0.002	0.004	0.008	NS	0.005	0.009
System of cropping												
S_1	3505.2	4177.1	-	-	-	-	-	-	1.14	1.08	1.26	1.11
S_2	3546.8	171.9	166.6	197.9	1.17	1.19	1.17	1.18	1.08	1.07	1.20	1.09
S_3	3536.5	4161.5	320.0	276.0	1.31	1.30	0.31	0.25	1.20	1.10	1.32	1.16
SE_D	26.2	14.0	0.7	0.7	0.004	0.052	0.001	0.002	0.002	0.004	0.002	0.003
CD (0.05)	NS	NS	1.6	1.5	0.009	0.100	0.003	0.004	0.008	0.008	0.006	0.006
Nitrogen levels												
N_1	2755.2	3104.2	243.3	243.3	1.23	1.20	0.24	0.21	1.13	1.07	1.25	1.11
N_2	3489.6	4140.6	229.5	247.7	1.24	1.32	0.24	0.22	1.13	1.09	1.25	1.12
N_3	3932.3	4729.2	234.3	239.5	1.24	1.23	0.24	0.22	1.15	1.09	1.26	1.13
N_4	3942.7	4708.3	229.1	234.3	1.24	1.21	0.23	0.22	1.15	1.08	1.28	1.12
SE_D	18.3	15.9	1.0	1.0	0.006	0.073	0.001	0.003	0.006	0.006	0.007	0.006
CD (0.05)	36.9	32.3	2.1	2.1	NS	NS	NS	NS	NS	NS	NS	NS

NS : Not-significant; LER : Land equivalent ratio; LEC : Land equivalent coefficient; MER : Monetary equivalent ratio; NEMR : Net monetary equivalent ratio

system due to better utilisation of environmental resources. Willey (1979) reviewed the various methods for assessing yield advantage of intercropping over sole cropping and among the various concepts land equivalent ratio (LER) was considered as the suitable index for any intercropping situation. However, Adetiloye *et al.* (1983) developed the concept, land equivalent coefficient (LEC) claiming its superiority over LER in terms of its ability to measure intercrop interactions. Measurement of production efficiency has always presented conceptual problems. In a situation where a farmer can grow any of several intercrops on the same piece of land, the economic and dietary considerations will influence the selection of the intercrop(s). Hildebrand (1976) suggested that unit of measuring intercrop advantage must be meaningful to the farmer in such a way that it will help him to allocate his limited resources among competing uses. For measuring the economic advantage of intercropping situation, Adetiloye and Adekunle (1989) put forward the concept of monetary equivalent ratio (MER). In this paper net monetary equivalent ratio (NMER), a modification of MER is suggested to measure the economic advantages in intercropped situations.

MATERIALS AND METHODS

The LER and LEC was computed according to the formula given by willey (1979) and Adetiloye *et al.* (1983) respectively.

MER is defined as the sum of ratios of intercrop monetary returns to the highest sole crop monetary return from the entire land area occupied by all intercrops per unit time. Mathematically MER is expressed as follows (Adetiloye and Adekunle, 1989).

$$MER = (r_a + r_b + r_c) R_a$$

Where R_a is the highest sole crop return obtained from crop 'a' compared with sole crop monetary return of crop 'b' (R_b) or crop c (R_c) and r_a, r_b and r_c are the monetary returns from crop a, b and c respectively under intercropping.

Since only gross returns are accounted in MER, it will be more informative if net returns are used in calculation. Hence, a new concept, viz. net monetary equivalent ratio (NMER) is proposed, taking into account of the added cost of the inputs and added returns from intercropping. Mathematically NMER can be expressed as

$$MER = (r_a + r_b + r_c) / R_a$$
$$= \sum_{i=1}^{n} Y_i P_{yi} / R_a$$

$$NMER = \left(\sum_{i=1}^{n} Y_i P_{yi} - \sum_{i=1}^{m} X_j P_{xj}\right) / (R_a - C_a)$$

$$= \left[\left\{\sum_{i=1}^{n} Y_i P_{yi} - \sum_{i=1}^{n} \sum_{i=1}^{n} X_{ij} P_{xj}\right\} / \max_{1 \le i \le n} \left\{Y_i P_{yi} - \sum_{i=1}^{n} X_{ij} P_{xj}\right\}\right]$$

$$= \left[\sum_{i=1}^{n} \left\{Y_i P_{yi} - \sum_{i=1}^{n} X_{ij} P_{xj}\right\} / \max_{1 \le i \le n} \left\{Y_i P_{yi} - \sum_{j=1}^{n} X_{ij} P_{xj}\right\}\right]$$

where

R_a = the highest return of sole crop a. Rs ha^{-1}

C_a = cost of cultivation of sole crop a. Rs ha^{-1}

Y_i = yield of the i^{th} sole crop in kg ha^{-1}

Y_i = yield of the i^{th} intercrop in kg ha^{-1}

P_{yi} = price of the produce (output) in the i^{th} sole crop Rs ha^{-1}

X_{ij} = Quantity of j^{th} input used in i^{th} sole crop in kg ha^{-1}

X_{ij} = quantity of j^{th} input used in the i^{th} intercrop in kg ha^{-1}

P_{xj} = Price of j^{th} input in Rs.kg^{-1}.

$i = 1,2$ ....n

$j = 1,2$ ....m

n = number of crops.

m = number of inputs

Field experiments were conducted at the Tamil Nadu Agricultural University, Coimbatore situated at 11° N latitude and 77° E longitude at an altitude of 426.70 m above mean sea level, during the summer and *kharif* seasons of 1990. The soil of the experimental field falling under the taxonomic group chromusterts are deep, well drained and sandy clay loam, with a bulk density of 1.26 g cm^{-1}. The field capacity and permanent wilting point of the soil are 25 and 12 percent respectively while the pH and EC remained at 7.90 and 0.62 dSm^{-1}.

The experiment which was laid out in a split plot design and with three replication comprised combination of two levels of irrigation (IW/CPE ratio of 0.5 (I_1) and 0.75 (I_2) and three systems of cropping (maize in paired rows of 45 x 80 cm between rows (S_1), paired row of maize + one row of soybean in between the maize (S_2) and paired row of maize + two rows of soybean in between the maize (S_3) in the main plot and four levels of N *viz.*, 62.5 (N_1), 125 (N_2), 187.5 (N_3) and 250 (N_4) kg ha^{-1} were tested in sub plots. The maize variety CO 1 (duration of 105-110 days) and CO 1 variety of soybean (photoinsensitive in nature with a duration of 85-90 days) were used in the experiment.

RESULTS AND DISCUSSION

The data related to LER, LEC, MER and NMER are summarised in Table 1. Since LER values were greater than one in systems of cropping, irrigation and N levels in both the season it could be interpreted that taking an intercrop of soybean with maize was more productive than sole cropping. Similar increase in LER values by intercropping maize with soybean was reported by Mohta and De (1980). Irrigation at IW/CPE ratio of 0.75 increased the LER value over the ratio of IW/CPE of 0.5. In maize-cowpea system, Fisher (1977) and sorghum- cowpea inter cropping 9.1 observed an increase in

LER with availability of water. Double rows of intercrop soybean showed an increase in LER than single row in both the seasons. This increase in LER was mainly due to an increase in yield of soybean than maize. Similar results were noticed by Ofori and Stern (1987). N levels did not influence the LER values indicating that higher and lower levels were equally effective on LER. At higher and lower levels of N, grain yield did not vary considerably under sole and intercropped maize which resulted in the uniformity of LER values.

The number of rows of intercrop soybean registered an appreciable differences in LEC and double rows of intercrop invariably recorded higher value than single row in both the experiments. Irrigation and N levels did not produce any pronounced changes in LEC and showed a value less than or equal to the minimum required value of 0.25. Though LER values were higher than one in single row of soybean in both the experiments, its ability to compete with principal crop of maize was not seen in both the experiments as evident with an LEC value lower than 0.25. Usually yield advantages have been reported from intercropping studies where LER values were slightly greater than one even though the performance of dominant crop was visibly poor in the field. The result of the present study clearly indicated that two rows of intercrop soybean was essential for effective utilisation of resources with maize and a minimum level of yield might also be obtained from the intercrop component for getting an LEC value higher than 0.25. By comparing the two indices, it could be inferred that LEC is better index suited in interpreting the competition aspects of intercropping than LER. Unlike the biological indices like LER and LEC, both MER and NMER measured the economic feasibility of intercropping studies. Both MER and NMER recorded a value higher than unity for irrigation and systems of cropping indicated its economic viability. The differences in MER and NMER due to N levels in sole and intercropped maize was not seen in both the seasons. But double rows of intercrop soybean explicitly increased the MER and NMER than single row in both the seasons. The biological indices also recorded higher efficiency in double rows of intercrops. Hence, it could be concluded that a minimum of double rows of soybean is required for maize-soybean intercropping system for effective utilisation of resources and better economic output.

The new index NMER invariably registered a higher value than MER for levels of irrigation, systems of cropping and N doses. Since, only the gross returns are accounted in MER, it will be more realistic if net returns are accounted in the computations. It is a shift from yield concept to profitability concept of crops or cropping systems, since cost and benefit are more important for the cultivator. A substantial agronomic advantage does not necessarily guarantee an economic advantage in intercropping and the economic advantage can appropriately be quantified through the new index NMER than MER.

REFERENCES

ADETILOYE, P.O. and ADEKUNLE, A.A. (1989). Concept of monetary equivalent ratio and its usefulness in the evaluation of intercropping advantages. **Trop.Agric., (Trinidad) 66**: 337-341.

ADETILOYE, P.O., EZEDINMA, F.O.C. and OKIGBO, B.N. (1983). A land equivalent coefficient (LEC) concept for the evaluation of competitive and productive interactions in simple and complex crop mixtures. **Ecol.Modelling 19**: 27-33.

FISHER, N.M. (1977). Studies on mixed cropping. II Population pressures in maize bean mixtures. **Exp.Agric.,13**: 185-191.

HILDEBRAND, P.E.(1976). Multiple cropping systems are dollars and "sense" agronomy. In:**Multiple Cropping** (PAPENDICK, R.I., SANCHEZ, P.A. and TRIPLETT, G.S., eds.) spl. pub. No.27. SA, Madison Wsconsion USA pp. 347-372.

MAFRA, R.C., DE., M. LIRA, A. ARCOVERE, A.S.S. ROBEIRO, G., and PARIS, M.A. (1981). **Proc.Int.Workshop in Inter-Cropping (ICRISAT) Jan. 1981. Hyderabad.** pp. 46-51.

MOHTA, N.K. and DE.R. (1980). Intercropping maize and sorghum with soybean **J.Agric.Sci.Camb., 95**: 117-122.

OFORI, F. and STERN, W.R. (1987). The combined effects of nitrogen fertilizer and density of the legume component on production efficiency in a maize cowpea intercrop system. **Field Crop Res., 16**: 43-52.

WILLEY, R.W. (1979). Intercropping - its importance and research needs. Part II. Agronomic relationship. **Field Crops Abst., 32**: 73-85.

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