J. Agronomy & Crop Science 177, 161—164 (1996)

ISSN 0931-2250

Agricultural Science Unit, Indian Statistical Institute, Calcutta 700 035, India

A Proposed Index for Assessment of Row-replacement Intercropping System

P. Banik and D. K. Bagchi

Author's address: P. Banik, Senior Research Fellow, D. K. Bagchi, Professor and Head, Agricultural Science Unit, Indian Statistical Institute, 203, Barrackpore Trunk Road, Calcutta 700 035, India

With 2 tables

Received January 15, 1996; accepted June 17, 1996

Abstract

A new index has been proposed for assessing an intercropping system where the component crops are in row-replacement series. It determines the Actual Yield Loss or gain (AYL) in respect to a component crop in an intercropping situation. Here the sown proportion of the component crops with regard to its sole one is to be considered. This index appears to be more appropriate than other established indices like land equivalent ratio (LER), relative yield loss, etc., particularly when per plant yield is considered. Partial AYLs (which are the two components of this index) can be considered as indicators regarding the competition existing between the component intercrops.

Key words: Actual yield loss, row-replacement series, intercropping.

Introduction

It is always perceived that different intercropping situations may have to satisfy rather different requirements if yield advantages are to be achieved. De Wit (1960), Willey (1979), Mead and Willey (1980), Mead and Riley (1981) and Reddy and Chetty (1984) have reviewed the difficulties of assessing any yield advantage due to intercropping practices and have discussed some of the methods available for the purpose. Willey (1979) considered the Land Equivalent Ratio (LER: the total land area of sole crops required to achieve the same yield as the intercrops) as the most satisfactory index since it is based on a sound agronomic principle. However, LER cannot address the problem of assessment of yield advantage/disadvantage if the objective is to assess the yield advantage on the basis of the criterion, namely yield per plant.

In this article an index has been proposed which takes into account the above mentioned criterion of yield per plant in course of the assessment of an intercropping system particularly where row-replacement (number of row(s) of main crop is(are) replaced by intercrop) series technique (Willey and Osiru 1972) has been followed.

Materials and Methods

The ranking/assessment of crops in an intercropping treatment may be done by several methods like LER where:

$$LER = (Y_{ij}/Y_{ii}) + (Y_{ji}/Y_{jj})$$

$$= L_i + L_j$$

LER is the sum of two partial land equivalent ratio (L_i and L_j).

Table 1. Effect of plant population on the performance of maize/bean intercropping system (after SANCHEZ 1976)

Population (1000 ha^{-1})			Grain yield (t ha^{-1})		RYL (%)		AYL	AYL	
Maize	Bean	Bean type	Maize	Bean	Maize	Bean	Maize	Bean	AYL
40	0	–	2.45	–	–	–	–	–	–
0	100	climbing	–	1.46	–	–	–	–	–
20	30	"	1.67	0.95	−31.83	−34.93	+0.363	+1.386	+1.749
20	60	"	1.47	1.20	−40.00	−17.80	+0.200	+0.506	+0.706
20	90	"	1.40	1.30	−42.85	−10.95	+0.143	+0.088	+0.231
30	90	"	1.86	1.27	−24.08	−13.01	+0.012	+0.063	+0.075
0	110	Bush	–	1.17	–	–	–	–	–
20	30	"	1.69	0.35	−31.02	−70.08	+0.379	+0.069	+0.448
20	60	"	1.86	0.55	−24.08	−52.99	+0.518	−0.138	+0.380
20	90	"	1.85	0.71	−24.48	−39.31	+0.510	−0.258	+0.252
30	90	"	2.41	0.71	− 1.63	−39.31	+0.311	−0.258	+0.053
CD (P = 0.05)			0.41	0.61					

Relative Yield Loss [RYL(%)] can also be used as an index to assess the intercropping system where:

$$\text{RYL}(\%) = [(Y_{ij}/Y_{ii}) - 1] \times 100.$$

In both equations Y is the yield per hectare (unit area), subscripts ii and jj refer to pure stands of species I and J, while ij and ji refer to intercrops.

In a replacement series experiment, the sown proportion of a component crop in the sole and intercrop treatments is not constant and thus land equivalent ratio or relative yield loss cannot assess the magnitude of advantage/disadvantage of component crops effectively.

Here we proposed an index which takes into account the sown proportion of component crops with their sole ones. It can be termed Actual Yield Loss or gain (AYL). It is the proportionate yield loss or gain with comparison to the respective sole ones, where:

$$\text{AYL} = [(Y_{ab}/Z_{ab})/(Y_{aa}/Z_{aa}) - 1]$$

$$+[(Y_{ba}/Z_{ba})/(Y_{bb}/Z_{bb}) - 1]$$

$$= \text{AYL}_a + \text{AYL}_b$$

Here also Y is the yield per hectare (unit area) and Z is the sown proportion, subscripts aa and bb refer to pure stands of species A and B, while ab and ba refer to intercrops. Partial actual yield loss AYL_a and AYL_b represent the proportionate yield loss or gain of species A and B when grown as intercrops, relative to their yield in pure stand. So AYL is the sum of two partials, AYL_a and AYL_b.

The sign (positive or negative) of the value of AYL score gives a quantitative assessment of advantage/disadvantage accrued under any intercrop situation when the main objective is to compare yields on a per plant basis. The magnitudes of partial AYLs of the component crops in an intercrop situation reflect the nature of competition existing between and within component crops.

Results

To establish the relevance of our proposed index (AYL) we have analysed the data set obtained from SANCHEZ (1976) in maize-bean trials, whereas in wheat-legume experiments the data used are obtained from our intercropping trial of wheat with gram, pea and lentil in sole, 1:1 (sown proportion of wheat and legumes are 50:50) and 2:1 (sown proportion of wheat and legumes are 66.5:33.5) row-replacement series (BANIK 1976).

Results (Table 1) indicate that on the basis of RYL(%) values in the intercrop situations it is difficult to assess the component crops as the RYL(%) values of the component crops under all the treatments are negative. Obviously, this implies that the yield has suffered due to intercropping. However, when we consider the actual population in maize/climbing type bean intercropping, component crops of maize and

Table 2. Wheat-legume intercropping in 1:1 and 2:1 row-replacement series

Treatments	Seed yield ($t\ ha^{-1}$) Wheat	Legume	LER Wheat	LER Legume	AYL Wheat	AYL Legume	AYL
Wheat	2.75	–	–	–	–	–	–
Gram	–	0.87	–	–	–	–	–
Pea	–	1.05	–	–	–	–	–
Lentil	–	0.76	–	–	–	–	–
Wheat + gram (1:1)	1.82	0.36	0.662	0.414	+0.324	−0.172	+0.152
Wheat + pea (1:1)	1.87	0.57	0.680	0.547	+0.360	+0.086	+0.446
Wheat + lentil (1:1)	1.89	0.47	0.687	0.618	+0.374	+0.236	+0.610
Wheat + gram (2:1)	2.01	0.26	0.731	0.298	+0.096	−0.103	−0.007
Wheat + pea (2:1)	1.98	0.23	0.720	0.219	+0.080	−0.342	−0.262
Wheat + lentil (2:1)	2.13	0.21	0.774	0.276	+0.161	−0.171	−0.010

bean show the yield again. Through the intercropping of the population of 20 000 maize and 30 000 bean (climbing type) per hectare 36.32% (AYL_a = +0.3632) and 138.58% (AYL_b = +1.3858) yield gain could be noted in maize and bean respectively as compared to their sole treatments, whereas the RYL(%) values of the component crops indicate that in intercropping maize and bean yield losses are 31.83% and 34.93% respectively to sole treatment.

Table 2 indicates that the partial AYL_a of wheat in all the treatments have shown yield gain where legumes have a positive effect on wheat when growth in association (Banik and Bagchi 1994). It also reveals that in all the treatments wheat is the dominant species whereas the legumes are the dominated one because partial AYL_a of wheat is greater than that of legumes (AYL_b), particularly when sown in 2:1 row-replacement series. The AYL index gives more precise information about the nature of competition and the behaviour of each species in the intercropping system, since it takes into account both the sign as well as magnitude.

The results (Table 2) also indicate that the LER of wheat + legume is always more than one except for that of wheat + pea in 2:1 row-replacement treatment. From partial LER, quantitative assessment of yield loss or gain due to association of other species cannot be visualized, whereas partial AYL indicates the yield loss or gain on the basis of its sign as well as values. Now in 1:1 row-replacement treatment, partial AYL of gram is −0.172, i.e. 17.2% yield loss has occurred when grown in association with wheat. Although the AYL of intercropping system is positive the yield gain of wheat (AYL_a = +0.324) compensate the loss of yield of gram when grown in association of wheat making AYL to be positive (+0.152).

Conclusions

It is thus noted that AYL indicates the actual yield advantage/disadvantage taking into account the actual sown proportion of the component crops with regards to its sole treatment. It may be argued to be more logical than the LER because in LER the comparison of sole crop with the intercrop is based on land area only. Indeed, in AYL the idea of relating the yield to the area of land given over to the crop appears as a sensible approach and can be used to see whether the intercropping has an overall positive or negative effect on the yield per plant. So it may be regarded as a good indicator of competition between and within the component crops in an intercropping situation. Thus, in an intercropping situation, where both the component crops are important, AYL might be more relevant.

Zusammenfassung

Ein Vorschlag für einen Index zur Beurteilung eines Reihenersatzes in Mischanbausystemen

Ein neuer Index wird vorgeschlagen, um in Mischanbausystemen, in denen die beteiligten Kulturpflanzenarten in Reihenersatzserien angebaut werden, zu bewerten. In dem Index wird der

aktuelle Ertragsverlust oder -gewinn (AYL) im Hinblick zu den beteiligten Kulturpflanzenarten in der Mischanbausituation bestimmt. Hierbei wird die ausgebrachte Menge der beteiligten Kulturpflanzenarten auf den Reinanbau beurteilt. Dieser Index erscheint geeigneter als andere vorhandene Indizes wie z. B. 'land equivalent ratio' (LER), relativer Ertragsverlust etc., insbesondere wenn der Einzelpflanzenertrag berücksichtigt wird. Teil-AYL's die sich aus den beiden Komponenten des Index' zusammensetzen, können als Indikatoren im Hinblick auf die Konkurrenz zwischen den Komponenten des Mischanbaus betrachtet werden.

References

BANIK, P., 1996: Evaluation of wheat (*Triticum aestivum*) and legume intercropping under 1:1 and 2:1 row-replacement series system. J. Agron. and Crop Sci. (In press).

— —, and D. K. BAGCHI, 1994: Evaluation of rice (*Oryza sativa*) and legume intercropping in upland situation of Bihar plateau. Indian J. Agric. Scis. **64,** 364—368.

DE WIT, C. T., 1960: On Competition. Verslag Landbouw-Kundige Onderzoek **66,** 1—28.

MEAD, R., and R. D. STERN, 1979: Statistical considerations in experiments to investigate intercropping. In: Proc. International Intercropping Workshop, ICRISAT: Hyderabad, India, pp. 263—276.

— —, and R. W. WILLEY, 1980: The concept of a 'Land Equivalent Ratio' and advantages in yields from Intercropping. Expl. Agric. **16,** 217—228.

— —, and J. RILEY, 1981: A review of statistical ideas relevant to intercropping research. J. Royal Stat. Soc. Series A. **144,** 462—506.

REDDY, M. N., and C. K. RAMANATHA CHETTY, 1984: Staple land equivalent ratio for assessing yield advantage from intercropping. Expl. Agric. **20,** 171—177.

SANCHEZ, P. A., 1976: Multiple cropping: An appraisal of present knowledge and future needs. In: R. I. PAPENDICK, P. A. SANCHEZ and G. B. TRIPLETT (Eds.): Multiple Cropping. Spl. Pub. No. 27, pp. 373—338. American Society of Agronomy, Madison, Wisconsin, USA.

WILLEY, R. W., 1979: Intercropping — its importance and research needs Part I. Competition and yield advantages. Field Crop Abstract **32,** 1—10.

— —, and D. S. O. OSIRU, 1972: Studies on mixtures of dwarf sorghum and beans (*Phaseolus vulgaris*) with particular reference to plant population. J. Agric. Sc. (Camb.). **79,** 531—550.