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Original Research Article

PERCENTAGE YIELD DIFFERENCE, AN INDEX FOR EVALUATING INTERCROPPING EFFICIENCY

ABSTRACT.

Aim: To evaluate intercropping efficiency using percentage yield difference (PYD) and to compare the index with other indices

Study design: The design was a 2 X 5 factorial in a randomized complete block and replicated three times.

Location: The study was carried out at the Lower Niger River Basin Development Authority, Ejiba in the Southern Guinea Savannah zone of Nigeria in 2008 and 2009 cropping seasons.

Methodology: Erect and prostrate cowpeas and maize were mixed at five population ratios. Sole crops of each crop at full population were included as control treatments. Land Equivalent Ratio (LER), Area Time Equivalent Ratio (ATER), Monetary Equivalent Ratio (MER), and Percentage Yield Difference (PYD), were estimated and compared.

Results: LER, ATER, and PYD values were similar for the two cultivars in the two years. LER values ranges between 1.18 – 1.27 in 2008 and 1.12 – 1.30 in 2009. MER did not follow the same trend as LER and ATER. Lower values were obtained particularly in 2009. However, the highest MER 1.35 and 1.23 in 2008 and 2009 respectively were obtained in prostrate cowpea / maize mixture at population ratio of 100:50. The PYD advantage varies between 5-33% in the two years.

Conclusion: The comparable values of PYD with other indices suggest that it can be used to evaluate intercropping efficiency in crop mixture.

Key words: Land Equivalent Ratio, Area Time Equivalent Ratio, Monetary Equivalent Ratio, Percentage Yield Difference, Intercropping efficiency.

INTRODUCTION

Intercropping as one of the types of mixed croppingis the practice of growing more than one crop on the same field at the same time. This practice is widely practice among small holder and peasant farmers in the tropics [1,2]. Mutsears *etal.*[3] pointed out the potential advantagesof the system such as better utilizationof natural resources (solar radiation, mineral nutrients and water), higher labour productivity and reduced risk of crop failure as compared with sole cropping. Afe and Olufintoye [4] reported the superiority of the system over sole cropping in early and late maturing cowpea /maize mixture. In another study, [5] also noted that intercropping could be an eco-friendly approach at reducing weed problem through non-chemical methods.

Efficiency of intercropping over sole cropping have been assessed by various indices Willey and Osiru [6] use the concept of land equivalent ratio(LER) defined as the totalland area required under sole cropping to give the yield obtained in the intercrop mixture. Adetiloye and Ezedima [7] use the concept of land equivalent coefficient (LEC) defined as theproduct of land equivalent ratio in the intercrop. It was developed to assess the interaction and productive potential in crop mixtures. Hiebsch and Mc Collum [8] proposed the concept of area time equivalent ratio (ATER), as a modification for LER. This takes in to consideration the crop dimension in the field that is, the time the crop occupies the field from planting to harvesting. Ofori and Stern [9] observed and noted that this index is appropriate in crop mixture where component crops have different maturity dates.

Monetary equivalent ratio (MER) defined as the sum of the ratio of intercrop monetary returns to the highest sole crop monetary return to the entire land area occupy by all intercrops per unit time [10].

While all these indices and others relate with the yield differences that exist between the componentcrops in the mixture,percentage yield difference (PYD) as an index has not

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been documentedand compared to interpret intercropping advantages. This research was therefore designed to interpret/ evaluate intercropping advantages using percentage yield difference between the component intercrop and the sole crop and to compare the advantage with other indices.

MATERIALS AND MEHTODS

The result of field trial involving erect and prostrate/ maize intercropping system in 2008 and 2009 cropping in Ejiba, Southern Guinea Savannah agro ecological zone of Nigeria were evaluated using the Land Equivalent Ratio (LER), Area Time Equivalent Ratio (ATER), Monetary Equivalent Ratio (MER) indices. The percentage yield difference of the treatments were also calculated and compared with the LER, ATER and MER values. The treatment consist of five population ratios of cowpea and maize combined in a 2 x 5 factorial and arranged in a randomized complete block in three replicates. Sole crop of cowpea and maizeat full population were included as control treatments. Yield data collected were statisticallyanalysed using [12] models and treatment means compared at P = .05 using Duncan's Multiple Range Test.

YijYji

LER was estimated as = _____+_____

YiiYjj

Where:

Y = yield per unit area

Yii andYjj = sole crop yield of component crops i and j

Yij andYji = intercrop yield

ATER =(Yi/Tt)/(Ys/Ti)

Where:

Yi= Grain yield of intercrop species i

Tt = Duration in days of the species with the longest growing period.

Ys = Grain yield of the sole cropped species

Ti = Duration of growth cycle of species i.

ra + rb

MER=_____

Ra

Where:

Ra = Highest sole crop monetary return obtain from a; compared with the sole crop monetary return of crop b (Rb)

Ya=pa xya

Yb =pbxyb

Ra =paxYa

Rb=pbxYb

ra and rb = monetary returns of crop a and b under intercropping.

pa, pb = current market price of unit weight of crop a and b

ya, yb= intercrop yield a and b

Ya = sole crop yield of most economic sole crop from the land area equivalent that is occupied by all intercrop for the same given period of time.

Ys_a –$Yi_a$$Ys_b$– Yi_b100

PYD= 100 - [_____ + _____]x ____

$Ys_a$$Ys_b$1

Where:

Ys_a = sole crop yield of crops A

Ys_b= sole crop yield of cropsB

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Yi_a = intercrop yield of crops A

Yi_b= intercrop yield of cropsB

PYD isdefined as the yield difference between sole crop (100) and the intercrop expressed in percentage. It is based on the understanding that yield differences exist in crop mixture between the sole crop and the intercrop and that the sole crop was assumed to be hundred percent. Irrespective of the component population ratio employed, time of planting of component crop, plant geometry etc. the reduction of one crop is usually compensated by increased yield of the other crop. When this yield difference is expressed in percentage, the efficiency of the system in numerical value isshown. The PYD value gave the numerical value of intercropping advantage when the percentage intercrop was deducted from the sole crop. PYD value is inversely proportional to yield advantage that is, the lower the value the higher the efficiency of the system and vice versa.

RESULTS

LER, MER, ATER and PYDvalues for 2008 and 2009 cropping seasons are presented in Tables 1, 2,3and 4. The LER values variedbetween 1.18 and 1.27 for erect cowpea in 2008 and 1.12 to 1.30 in 2009. Similar values of ATER were recorded for the prostrate cowpea/ maize mixture in the two years. In contrast, MER did not follow similar trend with ATER and LER, particularly for intercropping involving erect cowpea / maize intercropping. Indeed, there was no monetary advantage of intercropping of this cultivar over the two years except at 100:75 population ratios in 2009 where appreciable MER was recorded (1.07). However, reasonable MER values were obtained in prostrate cowpea / maize mixture in allthe component population ratios in the two years except 50:50 population ratios in 2009. The value varied between 1.03 – 1.27 in 2008 and .94 – 1.16 in 2009.

The PYD showed similar trend with LERand ATER in all the treatment combinations in the two years. Yield advantage of 19-27% was obtained for erect cowpea in 2008 and 12-30% in 2009,while prostrate cowpea had 8-33% in 2008 and 12-33% in 2009.

DISCUSSION

The compared values of LER and ATER in all the parameter follow similar trend to the obtainedpercentage yield difference. This indicates that the yield reduction of component crop A was compensated by increased yield of component crop B. This yield differencewhen expressed in percentage will give the intercropping efficiency for the intercrop in land and in time dimensions.

The efficiencyof the mixture when evaluated withMER did not follow similar trendswith percentageyield difference values. The obtained values (MER) were lower than the percentage yield difference in all the parameters. This contrastsuggests that the percentage yield difference cannot be used asan index to interpret intercropping efficiency when the objective of theend user is monetaryadvantage. This assumption is also valid for LER and ATER. This corroborated with the earlier findingsof [8,12],who observed that the efficiency of intercropping might be misleadingwhen LER alone is used, particularly when monetary gain is the primary objective of the end user.

These comparablesimilar values of PYD with LER and ATER make it a valid index for interpreting intercropping advantage in crop mixture. This simple and reliable method is adaptable for a wide range of crop mixtures.

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Table 1. PYD, LER, ATER and MER in erect cowpea/ maize intercrop in 2008.

Population Ratio	Yield		PYD**	LER*	MER*	ATER*
C : M	C	M				
100 : 75	.76	2.80	27.19ab	1.27a	.90e	1.27a
100 : 50	.93	2.18	29.78a	1.31a	.80f	1.31a
100 : 25	1.08	1.61	31.58a	1.32a	.71g	1.32a
075 : 25	1.02	1.67	27.38ab	1.16b	.67gh	1.27bc
50 : 50	.78	2.32	16.97c	1.18b	.80e	1.21b
sole	1.10	4.82	100	1.00c	1.00c	1.00c
Mean	38.82	1.21	.81	1.23		

*Values with the same letter(s) in the same column or row are not significantly different at P=.05 level of probability by Duncan's Multiple Range Test.
**Values with the same letter(s) in the same columnare not significantly different at P=.05 level of probability by Duncan's Multiple Range Test
C=Cowpea, M= Maize, PYD= Percentage Yield Difference, LER= Land Equivalent Ratio, MER= Monetary Equivalent Ratio, ATER= Area Time Equivalent Ratio.

Table 2. . PYD, LER, ATER and MER in prostrate cowpea/ maize intercrop in 2008.

Population Ratio	Yield		PYD**	LER *	MER*	ATER*
C : M	C	M				
100 : 75	2.09	2.68	32.78a	1.33a	1.27b	1.33a
100 : 50	2.38	2.01	29.52ab	1.26ab	1.29ab	1.23b
100 : 25	2.65	1.61	21.86c	1.31a	1.35a	1.30a
075 : 25	2.13	1.62	12.21d	1.12c	1.10c	1.11c
50 : 50	1.67	2.23	7.89e	1.07cd	1.03d	.99c
Sole	2.71	4.82	100	1.00c	1.00c	1.00c
Mean			33.94	1.19	1.17	1.6

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C=Cowpea, M= Maize, PYD= Percentage Yield Difference, LER= Land Equivalent Ratio, MER= Monetary Equivalent Ratio, ATER= Area Time Equivalent Ratio.

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Table 3 . PYD, LER, ATER and MER in erect cowpea/ maize intercrop in 2009.

Population Ratio	Yield		PYD**	LER*	MER*	ATER*
C : M	C	M				
100: 75.82	2.72	30.08a	1.30a	1.07c	1.30a	
100: 50 1.09	1.83	29.58a	1.29a	.97e	1.29a	
100: 25 1.15	1.56	27.70ab	1.27ab	.94ef	1.28ab	
075: 25 1.09	1.50	21.57b	1.20c	.89d	1.21b	
50 : 50.85	1.89	12.29c	1.12d	.87g	1.13c	
Sole	1.28	4.12 100	1.00fg	1.00ge	1.00e	
Mean	1.02	36.87	1.2	.95	1.12	

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**Values with the same letter(s) in the same columnare not significantly different at P=.05 level of probability by Duncan's Multiple Range Test
C=Cowpea, M= Maize, PYD= Percentage Yield Difference, LER= Land Equivalent Ratio, MER= Monetary Equivalent Ratio, ATER= Area Time Equivalent Ratio.

Table 4. PYD, LER, ATER and MER in prostrate cowpea/ maize intercrop in 2009.

Population Ratio	Yield		PYD**	LER*	MER*	ATER*
C : M	C	M				
100 : 75	2.08	2.52	33.39a	1.34a	1.16ab	1.33a
100 :50	2.55	1.67	26.66ab	1.27ab	1.17ab	1.19b
100 : 25	2.80	1.43	31.93a	1.33a	1.23a	1.35a
075 : 25	2.25	1.40	12.17c	1.12de	1.13b	1.12c
50 : 50	1.90	1.60	4.82d	1.07df	.94ef	1.04de
Sole	2.88	4.12	100	1.00fg	1.00de	1.00e
Mean		34.83	1.18	1.11	1.17	

*Values with the same letter(s) in the same column or row are not significantly different at P=.05 level of probability by Duncan's Multiple Range Test.
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C=Cowpea, M= Maize, PYD= Percentage Yield Difference, LER= Land Equivalent Ratio, MER= Monetary Equivalent Ratio, ATER= Area Time Equivalent Ratio.

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