A NOTE ON AN INDEX OF UTILITY OF MIXED CROPPING AND ALLOCATION OF SUCH AREAS UNDER SEPARATE CROPS

BY

D.N. LAL

Patna University, Patna-1

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The problem of estimating areas under different crops as also their yield rates when mixed cropping occurs is interesting. Notwithstanding the directives from the Department of Economics and Statistics, Ministry of Agriculture, Government of India, in this connection the states follow different methods and thus their results lack comparability.

In this short note a simple method for calculating an index to determine the utility of mixed cropping and of allocation of such areas under separate crops is indicated. It is assumed that the usual standardised methods of crop cutting experiments are used to estimate yields of crops under various methods of sowing.

2. The area under mixed crops can be allocated to area under the constituent crops in a smple objective way. This can be achieved by introducing the concept of Effective Area under a crop. This area can be easily calculated from the field records normally collected for determining yield rates and areas. The calculations are not to be done at the field level by the field staff but at the headquarters where data for the region or the whole state are compiled and analysed. The method indicated below is simple and straightforward and can be made a routine one.

The Effective Area under a crop may be defined as the area which when multiplied by the average yield rate of the crop will give the total yield of that particular crop taking into account yields from both the pure sown area and mixed sown area under that crop in a region.

3. Let A_1, A_2 and A_m be the areas in a certain region recorded as under crop (1), under crop (2) and under mixed cropping consisting of a mixture of crop (1) and crop (2) respectively. Let the total yields from these areas be Y_1, Y_2, Y_m respectively and let $Y_m = Y_{m1} + Y_{m2}$ where Y_{m_1} and Y_{m_2} are the yields of crop (1) and crop (2) respectively under mixed cropping. These can be determined from the data collected on the basis of crop cutting experiments. The yield rates for crop (1), crop (2) and the mixture will be $y_1 = Y_1/A_1$, $y_2 = Y_2/A_2$ and

$$y_m = \frac{Y_m}{A_m} = \frac{Y_{m_1} + Y_{m_2}}{A_m} = y_{m_1} + y_{m_2}$$

Thus the yield rate of crop (1) from mixed area where it is sown as a mixture with crop (2) is y_{m_1} whereas if sown as pure it is y_1.

Thus we can say that

$$\frac{\text{Unit area under mixed crop (1)}}{\text{Unit area under pure crop (1)}} = y_{m_1}/y_1$$

i.e. Unit area under mixed cropping for

crop (1) $= (y_{m_1}/y_1)$ unit area under pure crop (1)

Thus area A_m under mixed cropping with crop (1) in it $= y_{m_1}/y_1$. A_m area under pure crop (1)

Hence we conclude that the Effective Area under crop (1) is

$$A_1 + \frac{y_{m_1}}{y_1} A_m$$

Similarly the Effective Area under crop (2) is

$$A_2 + \frac{y_{m_2}}{y_2} A_m$$

Thus the total effective area under crop (1) and crop (2)

$$A_1 + A_2 + \left(\frac{y_{m1}}{y_1} + \frac{y_{m2}}{y_2} \right) A_m = A_1 + A_2 + IA_m$$

and it may be noted that if

$$I = \frac{y_{m_1}}{y_1} + \frac{y_{m_2}}{y_2} > 1 \qquad \ldots(A)$$

then it means mixed cropping is beneficial as it is equivalent to extending the cultivable area under the crops since the total area cultivated is $A_1 + A_2 + A_m$.

Thus if $I>1$ mixed cropping need be recommended and encouraged if quantity of food grain is the chief criterion. On the other had if $I=1$ then also it is recommended as it serves as an insurance against total failure of crops under adverse climatic conditions.

$$\bar{y}_1=\frac{Y_1+Y_{m_1}}{A_1+\frac{y_{m_1}}{y_1}A_m}=y_1$$

and for crop (2) will be

$$\bar{y}_2=\frac{Y_2+Y_{m_2}}{A_2+\frac{y_{m_2}}{y_2}A_m}=y_2$$

The average yield rate of both the crops taken together is

$$\bar{y}=\frac{Y_1+Y_2+Y_m}{A_1+A_2+A_m}$$

Thus the value of the index I will determine whether or not mixed cropping be recommended. If its value exceeds unity or is equal to unity it can be recommended and not otherwise. The criterion (A) can be easily extended to cover the case of multiple mixed cropping consisting of k crops.

In this case if y_{m_i} is the yield rate of i^{th} crop from mixed cropping and y_i its yield rate under pure sowing then mixed cropping will be beneficial if

$$\sum_{i=1}^{k}\frac{y_{m_i}}{y_i}\geqslant 1$$

for the same reason.

4. In the above discussion we have not taken into account the inputs of seeds sown in the fields. We may assume that for crop (1) and crop (2) it has been the standard agricultural practice in a particular area or region to sow quantities q_1, q_2 respectively per unit area of the cultivable land and that q_m is the quantity of the mixture per unit area under mixed cropping the mixture containing the seeds of crop (1) and crop (2) in the ratio of $\lambda_1:\lambda_2$

where $\lambda_1, \lambda_2>0$ and $\lambda_1+\lambda_2=1$

i.e. quantity q_m of the mixture contains $\lambda_1 q_m$ of crop (1) and $\lambda_2 q_m$ of the crop (2). It is obvious that $\lambda_1 q_m<q_1$ and $\lambda_2 q_m<q_2$.

Suppose on analysing the yield Y_m from the mixed cropping we obtain Y_{m_1} and Y_{m_2} as the total yields of crop (1) and of crop (2) respectively from area A_m when quantity $\lambda_1 q_m$ and $\lambda_2 q_m$ of crop (1) and crop (2) respectively are sown on that area. Assuming proportionality of yield to input to hold for yield within the limits of standard sowing rates we note that $\lambda_1 q_m$ of crop (1) on the Unit area of A_m gives a yield rate of y_{m_1} of crop (1) while when q_1 of crop (1) is sown on the unit area of the field under single crop (1) above it is y_1. Thus if we had sown q_1 under the mixed sowing method the yield would have been

$$\frac{q_1}{\lambda_1 q_m} y_{m_1}$$

i.e. unit area under mixed cropping yields crop (1)

$$= \frac{q_1}{\lambda_1 q_m} y_{m_1}$$

Hence it follows that unit area under mixed cropping with crop (1)

$$= \left(\frac{q_1}{\lambda_1 q_m} \frac{y_{m_1}}{y_1} \right) \text{ unit area under crop (1) alone.}$$

Thus the area A_m under mixed cropping containing crop (1)

$$= \frac{q_1}{\lambda_1 q_m} \frac{y_{m_1}}{y_1} A_m \text{ area under crop (1) alone}$$

$$= A_1 + \frac{q_1}{\lambda_1 q_m} - \frac{y_{m1}}{y_1} A_m$$

Similarly the effective area under crop (2) alone

$$= A_2 + \frac{q_2 y_{m_1}}{\lambda_2 q_m y_3} Am$$

Thus when the rates of showing of seeds of the two crops as also the proportions of these crops in the mixture used are taken into account the total effective area under crop (1) and crop (2) together

$$= A_1 + A_2 + \left(\frac{q_1 y_{m1}}{\lambda_1 q_m y_1} + \frac{q_2 y_{m_1}}{\lambda_2 q_m y_2} \right) Am$$

$$= A_1 + A_2 - I\, Am$$

where

$$I = \frac{q_1 y_{m1}}{\lambda_1 q_m y_1} + \frac{q_2 y_{m2}}{\lambda_2 q_m y_2} \qquad \ldots(13)$$

Under this situation mixed cropping can be recommended if $I \geqslant 1$ and not otherwise for the reasons stated before. The average yield rate of crop (1) is

$$\bar{y}_1 = \frac{Y_1 + Y_{m_1}}{A_1 + \frac{q_1 y_{m_2}}{\lambda_1 q_m y_1} A_m}$$

and of crop (2)

$$\bar{y}_2=\frac{Y_2+Y_{m_2}}{A_2+\frac{q_2\, y_{m_2}}{\lambda_2\, q_m\, y_2}\, A_m}$$

Each of these in general are less than y_1 and y_2 respectively for it is well known that if

$$\frac{P_1}{a_1}>\frac{X_2}{a_2} \quad \text{then} \quad \frac{X_1}{a_1}>\frac{X_1+X_2}{a_1+a_2}$$

where all the quantites are positive.

5. This approach can be readily extended to cover multiple mixed cropping methohs *i.e.*, when more than two crops are mixed in certain proportion and are sown as a mixture. This practice is prevalent in some areas. Suppose we have k crops sown individually on fields of areas $A_1, A_2, \ldots, A_k$ with quantities $q_1, q_2, \ldots\ldots q_k$ per unit area respectively and let q_m be the quantity of mixture of these crops sown per unit area on the fieid with multiple fixed cropping with area A_m.

Let the mixture used contain the crop (1), crop (2) ..... crop (k) in the ratio of $\lambda_1 : \lambda_2, \ldots : \lambda_k$

where $$\sum_{i=1}^{k}\lambda_i=1 \quad \text{and} \quad 0<\lambda_i<1. \ (i=1, 2, \ldots\ldots k)$$

Following the some argument as above our index to determine the usefulness or otherwise of multiple mixed cropping method will be determined by the value of I

where $$I=\sum_{i=1}^{k}\frac{q_i\, y_{m_i}}{\lambda_i\, q_m\, y_i}$$

y_i being the yield rate of crop (i) under pure sowing ($i=1, 2, \ldots\ldots k$) and y_{mi} is the yield rate of crop (i) from mixed sowing.

The practice of mixed cropping can be recommended when $I \geqslant 1$ and not otherwise.

It may be noted that the average yield of crop (i) will be given by

$$\bar{Y}_i=\frac{Y_i+Y_{mi}}{Ai+\frac{q_i y_{mi}}{\lambda_i q_m y_i}\, A_m}$$

y_i being the total yield of corp (i) when sown in pure from *i. e.* independent of other crops on the field of area A_i and Y_{mi} is the

total yield of crop (i) when sown in the mixture form on field of area A_m.

The effective area under crop (i) will be given by

$$A_i + \frac{q_i\, y_{m_i}}{\lambda_i\, q_m\, p_i}\, A_m \qquad (i=1, 2, \ldots\ldots k)$$

As before $\bar{y}_i < y_i \qquad (i=1, 2, \ldots\ldots k)$

6. Incidently it may be noted that if criterion (A) holds good then criterion (B) automatically holds good but not vice-versa.

In (B) the proportions of the components of the mixture are taken into account but not so in (A) and hence if (B) holds but not (A) then it indicates that mixed cropping will be beneficial only if an efficient mixture of the crops is made by mixing them in proper proportion.

7. From the available records one could be determine whether or not some of the practices of mixed sowing of crops in vogue are useful. It is assumed that λ_i and q_i are all already known from past field practices and optimum proportions have been sturck for each of these $q's$ and $\lambda's$.

If not, then it calls for methodological studies under field conditions to determine these. The type of mixture and the proportions of its constituents as well as the quantity needed per unit area sown will obviously depend on the region and the climatic condition and will vary from place to place. If and when $I \geqslant 1$ the practice of mixed sowing can be encouraged.