INTERCROPPING in semi-arid areas

Report of a symposium held at the Faculty of Agriculture, Forestry and Veterinary Science, University of Dar es Salaam, Morogoro, Tanzania, 10-12 May 1976

Editors: J. H. Monyo, A. D. R. Ker, and Marilyn Campbell

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Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa

Monyo, J. H.
Ker, A. D. R.
Campbell, M.
IDRC

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The views expressed in this publication are those of the individual author(s) and do not necessarily represent the views of IDRC.
Farmer's field near Ibadan, Nigeria, showing intercrop of cowpea under maize.
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A Limited Objective Approach to the Design of Agronomic Experiments with Mixed Crops

N. M. Fisher

Department of Crop Science, University of Nairobi, Nairobi, Kenya

Most authorities agree that mixed cropping of annual crops in tropical regions is a more efficient means of using available land area than are pure stands. However, agronomists will need to ascertain what the optimum management is for a given crop association in a given environment, i.e., they will need to study the agronomy of mixed crops.

The scientific method of isolating a number of subsystems of a complex system for study when applied to mixed cropping would involve studying a mixture of two crops, arranged in a more clearly defined geometric pattern than is common in traditional agriculture. This approach is valuable (a) because as the interactions of two crops are understood, it becomes possible to extrapolate this understanding to the more diverse systems; (b) although the small farmer will not easily be persuaded to abandon his practice of mixed cropping, he is capable of improving his system to make use of technological innovations such as improved varieties and fertilizers.

In Kenya, the small farmer is moving toward planting associations of only two crops, with at least one of these crops in rows. Food cropping is now dominated by a single crop association, maize–beans, with hybrid maize and fertilizer being used and the maize planted in rows.

This apparently successful compromise has been worked out on the farm, not in the research stations, even though much extension effort has been expended to persuade the farmer to abandon his mixed cropping. It is a hopeful sign that even as research agronomy moves toward accepting for the time being the inevitability of mixed cropping, so the farmer is himself evolving a simpler system that can more easily be studied and further improved by the scientific method.

Even though it may be desirable to optimize the indigenous mixed cropping system rather than to replace it, an association of only two crops is a more difficult system for which to define optima than is a pure stand because the number of agronomic variables is multiplied by mixing the crops. Thus the fairly simple factor of time of planting of a pure stand becomes complicated if one must consider all the possible combinations of time of planting of the two crops relative to each other as well as to the cropping season. The same argument can be applied in different forms to the factors plant density, plant arrangement, fertilizer application, tillage practice, and all aspects of crop protection. In short, we cannot design practicable experiments that accommodate all possible variables.

A frequent response to this dilemma has been to isolate one of the factors, and this has been done for the factor plant density by Evans (14), Willey and Osiru (21), Osiru and Willey (22), and Huxley (58). Evans (59) has studied fertilizer responses in mixed crops, and J. O. Owuor of the University of Nairobi...
plans to examine the effect of relative times of planting in maize-bean mixtures. However, the factor selected for study may not be the most important one for immediate optimization.

An alternative approach is to concentrate attention on one of the crops rather than one of the factors and to attempt to optimize the management of this crop as it is grown within the mixture. This approach, though of limited objective, has advantages where two conditions apply. Firstly, one of the two crops must be known to be competitively aggressive over the other. It is not intended to suggest that aggression is always a feature of one crop in a mixture, only that where aggression does occur, the approach might be useful. Aggression in mixed cropping is identified by the capacity of one crop to maintain yields almost unaltered whether or not the competitively recessive crop is present, with all else, including the density of the aggressive crop, being equal. In good rainfall seasons maize is highly aggressive in maize-bean mixtures at Kabete but is not in poorer seasons (60).

The second condition is that the optimum management of the aggressive crop in pure stand should have been well researched. There is as yet no reason to believe that the optimum management of an aggressive crop is very different in mixture than in pure stand, certainly not sufficiently different to justify the adoption of separate recommendations for the two systems. It becomes counterproductive if the steady progress achieved with one crop is jeopardized at the farm level by a confusion of issues brought about by the mixed cropping controversy. Nobody realizes this more clearly than the better Kenyan small farmer who has frequently adopted recommendations for maize derived from research with pure stands, even though he persists in interplanting beans. He has undoubtedly benefited and it is unhelpful if this fact is ignored, whatever view is held of the relevance of research done in pure stands.

Since all the problems of mixed cropping cannot be solved in a single experiment, it is a valid interim research strategy to accept the recommendations for an aggressive crop provided that these are scientifically determined, even if in pure stand. The research objective then becomes one of optimizing the agronomy of the recessive crop while holding the aggressive one constant. For many crop associations, this is a more urgent requirement than determining, for instance, the optimum plant arrangement for the mixture. When it becomes known which agronomic factors are most important for the recessive crop in the mixture, then is the time to vary the agronomy of the aggressive crop in combination with the important factors of the recessive.

To illustrate this approach, an experiment was carried out at three sites (Kitale, Kakamega, and Kisii) in western Kenya (45). The preconditions for the usefulness of the approach were ideally met. The maize was already known to be aggressive at two of the sites (61) and the agronomy of maize had been studied in some detail (62, 63, and annual reports of the National Agricultural Research Station, Kitale). In contrast, almost no research had been done with beans, even in pure stand. The strategy was therefore to accept the maize recommendations, which meant the use of a hybrid variety, planted as soon as practicable after the beginning of the rains, at a spacing of 75 x 30 cm. A generous but economic application of phosphorus was placed in the planting hole and a similar topdressing of nitrogen applied around the maize plants. The beans were interplanted with one row between each maize row, and pure stands of both maize and beans were included for comparative purposes.

At none of the three sites was there a statistically significant effect of bean
cultural treatment on maize yield, and at two sites where comparison was possible, the mixed crop maize yields were not significantly different from pure stands. Thus the maize was certainly aggressive over the beans whose yields at the different sites varied between 17 and 73% of pure-stand yields for the first time of planting and between 0 and 29% for the second planting. The bean yields clearly indicated the overriding importance of the relative time of planting factor in maize–bean mixtures. The response to fertilizer was not significant at any site and, even at Kitale, the magnitude of the response was not great enough to meet the cost of fertilizer. There was little difference between 10- and 15-cm spacing in the row and certainly, the spacing factor is of little importance relative to time of planting. Thus by the design of an experiment with limited objectives, immediately useful results have been achieved without confusing the maize recommendations that have contributed to some improvement in maize growing over the last decade on the small farms of the area. For future research, it is clear that time of planting is the factor to concentrate on to define the optimum strategy for the small farmer faced with a peak labour requirement at the onset of the rains.

A secondary but rather interesting finding from this experiment emerged rather by accident than by design. Maize yields at Kisii were low because of a combination of late planting, hail damage, and disease. It was nevertheless at this site that the advantages of mixing over pure stands were greatest, though it must be remembered that total production was lowest. In fact, the sites could be arranged as in the table below in decreasing order of land equivalent ratio (LER), a measure of the degree to which the mixed crops gave a higher return to land area than the pure stands. This arose because where maize yields are lowest, the beans were most capable of developing a worthwhile yield in mixtures. On most small farms, maize yields are lower than on the research stations for reasons that are to some extent beyond the control of the farmer. Clearly, if this is so, the advantages of mixed cropping are considerable.

<table>
<thead>
<tr>
<th>Pure maize yield (quintals/ha)</th>
<th>LER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitale</td>
<td>84</td>
</tr>
<tr>
<td>Kakamega</td>
<td>52</td>
</tr>
<tr>
<td>Kisii</td>
<td>27</td>
</tr>
</tbody>
</table>

\[
LER = \frac{\text{maize yield in mixture}}{\text{maize yield in pure stand}} + \frac{\text{bean yield in mixture}}{\text{bean yield in pure stand}}
\]