Intercropping Summer Crops Into Winter Oilseeds and Legumes: Possibilities and Challenges.

Dr. G.J. Lewis
Crop Production Technology Group, School of Land and Food, The University of Queensland, Gatton

Introduction.

Intercropping is a form of agriculture which is widely practiced in the developing world. It involves growing a mixture of crops together in the same field. The combined yield of mixtures of two crops is frequently higher than either of the crops grown as sole crops (Natarajan and Willey, 1980a; Nadar, 1983b). If the intercropping takes the form of establishing a second crop into an existing crop stand it is known as relay cropping. Relay cropping is a specialised form of intercropping where a second crop is sown into an established crop stand (Nadar, 1983a). Unlike ordinary intercropping the field only supports two crops for the period of time between planting of the second crop and harvesting of the first crop.

Many areas practising relay cropping have similar climate and soils to those of eastern Australia so this approach has the potential to increase both the efficiency of resource use and the profitability of mechanised cropping enterprises in this area (Natarajan and Willey, 1980b). However, in order to realise this potential the agronomic and engineering technology associated with this system must be adapted to mechanised agricultural systems. Controlled traffic will be an important part of this technological package because it is necessary to have precise placement of the seed of the second crop between rows of the first crop in order to avoid crop damage. This paper will discuss the reasons why a farmer may choose to adopt relay cropping and the problems which may arise with reference to establishing summer crops (sorghum and sunflower) into two winter broadleaf crops (faba bean and mustard).

Reasons for Adopting Relay Cropping.

There are a number of reasons why a producer may choose to use relay cropping to grow a winter and a summer crops rather than double cropping. These revolve around the availability of resources (water, light and nutrients) and the length of the growing season. These reasons include:

1) the duration of the summer growing season may be insufficient for summer crops such as sunflower and sorghum to complete their life cycle unless the crop can be established before the winter crop is harvested.

2) planting the summer crop (sunflower and sorghum) into the standing broadleaf crops enables them to be established as close as possible to their optimal time of sowing (Nadar, 1983a).

3) a grower, who has already established a crop of faba bean or mustard, may wish to take advantage of favourable spring conditions to establish the sorghum or sorghum on an opportunistic basis. This flexibility would be particularly advantageous if the winter faba bean or mustard are relatively low yielding (but still too profitable to plough them in) yet the spring rains have refilled the soil water profile.

4) the grower may wish to take advantage of the rotational benefits associated with nitrogen fixation by faba beans and bio-fumigation by mustard. Protein content of wheat grown as an intercrop with beans has been shown to be higher than when grown as a sole crop (Bulson et al., 1997). It is possible that nitrogen fixation by the faba beans will increase the proten content of the sorghum.

5) maintaining ground cover to control erosion (Nadar, 1983a)

Risks

The underlying assumption on which relay cropping is based is that there are resources available to the initial crop (faba beans or mustard) which are not being fully utilised (Snaydon and Satorre, 1989) and are

therefore available to the developing sorghum or sunflower seedling. Once established subsequent rainfall must be sufficient for the sorghum or sunflower to produce commercially acceptable yields. Therefore, the first risk associated with a relay cropping strategy is that there are insufficient resources available to establish the second crop. In dry years the winter broad leaf crops will have exhausted the water supply in the surface layers of the soil, prohibiting seed germination and seedling establishment. Conversely, in wet years vegetative growth of the winter crop may be such that insufficient light is reaching the soil surface for growth of the spring crop. If relay cropping is to be practiced as a regular part of the cropping system it may be necessary to reduce plant population to ensure sufficient resources are available for establishment of the second crop. In Mediterranean environments leaf area of mustard is drastically reduced by the coincidence of water stress in spring and flowering (Lewis and Thurling, 1994). If this pattern is repeated in sub-tropical and uniform temperate climates this may provide a window of opportunity for planting the spring crop

Nutrients will not be as limiting as light or water because the seedling nutrient requirements are relatively small and fertiliser can be applied to the sorghum or sunflower either at planting or once the faba bean or mustard has been harvested.

Soil temperature beneath the canopy of winter crop may also inhibit establishment of the spring crop. Massaso (1997, unpublished) found that sorghum planted into a wheat crop at Gatton in mid-September failed to emerge, although there was good emergence in the absence of the crop, because temperature of the soil beneath the canopy was several degrees cooler than exposed soil. If planting is to take place in early spring then japanese millet or sunflower should be grown because they will germinate at lower soil temperatures.

Planting Difficulties.

The canopy of the winter crops is a substantial impediment to passage of the tines and undercarriage of the planting implement through the crop. This is easily overcome in cereals by increasing the row spacing and increasing the clearance of the tractor and planter. The branching habit of faba bean and mustard will impede the planter substantially more than the culms of a cereal. It may be possible to reduce this restriction by planting the crop at high density within the rows in order to restrict branching. The resulting increase in crop height will be a disadvantage during the planting of the summer crop, but will provide a wider window of opportunity for harvesting the winter crop.

Increasing the row spacing may have the unintended consequence of reducing the yield of the winter crop. Experiments with wheat show that widening row spacing from 18 cm to 27 cm decreased yield by 6.1 % while increasing row spacing to 36 cm reduced yield by 7.3% (Doyle,1988)

Sowing winter crops into summer crops, particularly if the summer crop is a species such as mungbean which is relatively short, provides fewer technical difficulties because of the wider row spacings commonly employed. However, the depletion of the soil water by the summer crop makes it unlikely that the winter crop will be profitable. In those areas of south-eastern Australia which have a winter rainfall pattern and produce irrigated summer crops this may be feasible.

Passage of the planter through the faba bean or mustard stand may cause substantial damage to the winter crop because of removal of plants by the tines as it attempts to place seeds of the sunflower or sorghum between the rows of winter crop. The number of plants removed will be reduced if row spacing is increased and precision of tine placement is increased. This impact can be reduced by planting the spring crop while the faba bean and mustard are relatively short, have immature flowers and pods and still retain

flexibility within their stems. My current research will involve measurement of crop damage caused by the planting implement.

Weed Control

Weed biomass was reduced by intercropping of beans and wheat, due to the increased level of competition between the crops and the weeds (Bulson *et al.*, 1997). Likewise, presence of a well established, actively growing winter crop together with the seedlings of the summer crop should reduce the biomass of spring weeds in the current experiment. These weeds have the potential to greatly reduce the yield of the sunflower and sorghum. Mustard will be much more effective in suppressing the growth of weeds within the crop, because it has a higher plant population than faba beans.

On the other hand relay cropping greatly complicates selection of herbicides, because any herbicide residues applied to the winter crop must have broken down sufficiently by spring that they do not interfere with establishment of the summer crop. The presence of sorghum (a cereal) within the stand of faba beans and mustard will greatly restrict the use of selective herbicides.

Harvesting the Winter Crop.

When a summer crop is planted into a winter crop , the winter crop will mature much earlier than the spring/ summer crop and will therefore need to be harvested earlier. This raises two issues a) ability to harvest the winter crop.and damage to the summer crop.

In a cereal, such as wheat, the grain is borne on the top of the plant, so a conventional harvester will be able to remove the grain from the crop with little impact on the developing seedlings, provided the seedling of the summer crop is beneath the level of the heads. Both faba beans and mustard bear pods on a number of levels within the canopy, in the case of faba beans pods may be set to the base of the plant whereas the podding zone of mustard may begin 50 to 90 cm above the ground depending on the variety. In the current experiment the faba bean is 20 cm shorter than the mustard in early August (flowering of the mustard). Given this it is likely that a greater proportion of the mustard will be able to be harvested than the faba beans. The exact proportion will depend on the height of the summer crop when the winter crop is ready for harvest.

The final consideration is the impact on seed yield of the sorghum or sunflower on harvesting the winter crop. In third world countries such as Kenya, where harvesting is done with hand tools, harvesting a bean crop from a tall crop such as maize does not pose any difficulties (Nadar, 1983a). However, when the crop is to be mechanically harvested their is a risk that the process of harvesting the winter crop will severely damage the summer crop. In this respect sorghum may be a better choice as the summer tag crop than sunflower because it grows more slowly, has a shorter mature height and responds to removal of the main stem by tillering. Sunflower on the other hand as a rapidly growing, tall crop will restrict the window for harvesting the winter crop and will be severely affected by removal of the growing point, because the grain is borne on a single large capitulum.

Taking into account these harvesting considerations it is likely that the mustard/ sorghum system will be more successful than the faba bean/ sunflower or faba bean/ sunflower systems.

Conclusions

Relay cropping has the scope to increase the productivity of cropping enterprises in eastern Australia by enabling them to use resources more efficiently and to increase their cropping frequency. However, there are a number of significant obstacles to widespread adoption of this system relating to both the agronomic and machinery aspects. Research is underway to identify the impact of the possible constraints discussed

in this article and to develop strategies to overcome them. Controlled traffic will play an important role in this system because of the necessity for precise placement of seed of the summer crop between the rows of the winter crop.

References

Bulson, H.A.J.; Snaydon, R.W. and Stopes, C.E. (1997) Effects of plant density on intercropped wheat and field beans in an organic farming system. Journal of Agricultural Science (Cambridge) 128:59 -71.

Doyle, R. (1988) Closer spacred crop rows and type of farm machinery. Western Australian Journal of Agriculture 29(1):17-19.

Lewis, G.J. and Thurling, N. (1994) Growth, development and yield of three oilseed *Brassica* species in a water-limited environment. Australian Journal of Experimental Agriculture 34(1): 93-104.

Nadar, H.M. (1983a) Effect of relay cropping on maize yields as influenced by cropping systems, row spacing and populations. East African Journal of Agriculture and Forestry 43:122 -123.

Nadar, H.M. (1983b) Intercropping and intercrop component interactionunder varying rainfall conditions in EasernKenya. 1.: Maize/ Bean intercrop. East African Journal of Agriculture and Forestry.43:166 -175.

Natarajan, M. and Willey, R.W. (1980a) Sorghum/ pigeon pea intercropping and effects of plant population density. 1. Growth and Yield. Journal of Agricultural Science (Cambridge) 95:51-58.

Natarajan, M. and Willey, R.W. (1980b) Sorghum/ pigeon pea intercropping and effects of plant population density.2. Resource use. Journal of agricultural Science (Cambridge) 95: 59 -65

Snaydon, R.W. and Satorre, E.H. (1989)Bivariate diagrams for plant competition data: modifications and interpretation. Journal of Applied Ecology 28: 930-946.