EFFECT OF INTERCROPPING PEA WITH CANOLA OR YELLOW MUSTARD

A Thesis

Submitted to the Faculty

of

Graduate Studies

The University of Manitoba

by

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In Partial Fulfilment of the

Requirement for the Degree

of

Master of Science

Department of Plant Science

April 1992

ISBN 0-315-77778-8

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ACKNOWLEDGEMENTS

The author wishes to acknowledge the following individuals and organizations for their assistance.

Dr. E.H. Stobbe, my advisor, for his continual guidance, support and encouragement through this study.

Dr. R. Sober and Dr. K. Vessey for reviewing this manuscript.

Mr. Alvin Iverson for his technical assistance.

My fellow agronomy graduate students, Harry, Luc, and Yantai for their friendship and assistance.

The summer students who assisted during the field trials.

Kenya Agricultural Research Institute and Canadian International Development Agency for their sponsorship.

And my mother, sister and brothers for their love and encouragement.

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ABSTRACT

Kipkemoi, Peter Langat, M. Sc., The University of Manitoba, April,1992.

Effect of intercropping pea with canola or yellow mustard.

Major professor: Dr. E. H. Stobbe, Department of Plant Science

Intercropping is a farming practice that has recently received attention as a means of improving land productivity in western Canada. The main reason for such advantage would appear to be that when grown together the component crops complement each other and make better use of environmental resources. The objectives of this study were to determine the effect of intercropping pea with yellow mustard or canola on growth and development, and yield of each of the component crops.

The crops were planted in both sole and mixed stands. The sole stands of pea were sown at 120 and 180 kg/ha Canola sole stands were sown at 2 and 6 kg/ha whereas those of yellow mustard were 3 and 9 kg/ha. Mixtures were sown at 120 kg/ha of pea with either 2 kg/ha of canola or 3 kg/ha of yellow mustard. 'Century' pea was used in 1990 and 'Bohatyr' pea was used in 1991. 'Westar' canola was used in 1990 and 'Legend' canola was used in 1991. 'Gisilba' yellow mustard was used in both years. In 1990, dry matter accumulation of pea was not affected in the intercrop, while that of both yellow mustard and canola was reduced (significant at $p<0.05$). In 1991, however, dry matter accumulation of pea was reduced in the intercrop, along with that of yellow mustard and canola (all significant at $P<0.05$). Pea dry matter was reduced more by yellow mustard than by canola. Yield of pea was reduced by 0.5% and 22% when intercropped with canola and yellow mustard, respectively, in 1990. Yields of pea was reduced by 41% when intercropped with canola, and by 38% when intercropped with yellow mustard in 1991. Yields of canola and yellow mustard were significantly reduced when intercropped with peas in both years. The net return analysis suggested that there was no benefit of intercropping in this study, however, the calculation of Land Equivalent Ratio indicated that more land would be required if the crops were to be planted separately. It can be concluded from this study that pea was dominant over yellow mustard and canola and that mustard was a better competitor compared to canola. Intercropping reduced lodging of pea, increased or reduced thousand seed weight of component crops. Nitrogen fertilization had no effect on pea yields in both years.

1.0. INTRODUCTION

There has been a rapidly growing interest in intercropping as a potentially beneficial system of crop production. This system of crop production is common in the tropics but not in temperate climates. Cowell et al., (1989) reported that farmers in western Canada have started intercropping field pea (Pisum sativum L.), here after referred to as pea, with non-legumes in order to facilitate harvest operations and to obtain clean seeds. In 1990, 40.5 thousand hectares of pea were grown in Manitoba and it increased to 72.5 thousand hectares in 1991 (Statistics Canada).

Indeterminate cultivars of pea plants have inherently poor standing ability for a combine harvested crop. The pea crop canopy sags during development and the vines frequently lie flat on the ground at plant maturity. Not only harvest losses can be high but the quality of pea may also be reduced due to soiling and the weathering effects associated with lodging.

Canola (Brassica napus L.) and yellow mustard (Sinapis alba L.), here after referred to as mustard, are major crops grown in western Canada which have strong stems. Intercropping pea with these crops reduces lodging. There are several other possible benefits of intercropping legumes with non-legumes.

In terms of land use efficiency intercropping is regarded as more productive than sole cropping (Andrew and Kassam, 1976; Willey, 1979). Higher nutrient uptake (Dalal, 1974;) and better water use efficiency (Baker and Norman, 1975; Hulugulle and Lal, 1986) have been suggested. Nitrogen fixing legumes generally do not need N fertilizer, whereas, the non-legume requires addition of mineral nitrogen for optimum growth. Accordingly, sufficient nitrogen fertilizer must be applied to support the growth of non-legume. Besides supplying its own nitrogen requirement, legumes may contribute additional nitrogen to the soil which can be used by the component crop in the intercrop or to the succeeding crops. (LaRue and Patterson, 1981).

The objective of this study was to investigate the effects of intercropping field pea with canola or mustard under two levels of nitrogen fertility on canopy development and the final grain yields.

2.0. LITERATURE REVIEW

2.1. Terminology.

There are many terms that are used to describe the growing of two or more crops in a given unit of land in a season which has resulted in confusion on the usage of these terms.

Intercropping is the growing of two or more crops simultaneously on the same area of land. The crops are not necessarily sown at the same time and their harvest times may be quite different, but they are usually simultaneous for a significant part of their growing periods. Willey (1979) defined intercropping as any form of cropping system in which there is some competition between the intercrops.

Andrews and Kassam (1976) published standardized terms which included four main types of intercropping:

Relay intercropping: growing two or more crops simultaneously during part of their life cycles. A second crop is planted after the first crop has reached its reproductive stage of growth but before it is ready for harvest.

Mixed intercropping: growing two or more crops simultaneously with no distinct row arrangement.

Row intercropping: growing two or more crops simultaneously where one or more crops are planted in rows.

Strip intercropping: growing two or more crops simultaneously in different strips wide enough to permit independent cultivation but narrow enough for the crops to interact agronomically.

Component crop: refers to either of the individual crops making up the intercropping situation.

Sole crop: refers to a component crop being grown alone and unless otherwise indicated is assumed to be grown at optimum population and spacing.

2.2. Background.

Intercropping has long been recognized as a common practice throughout the developing tropics (Willey, 1979). Early cropping systems were mixtures of desirable species used for food, fibre and other needs in the community (Francis, 1989). Sole cropping is a relatively recent innovation in agriculture. The farmers over the centuries selected mixtures of species to make better use of rainfall and the native soil fertility, and the choices of patterns were made among the best performing combination observed through experience.

Combination of crops are determined by the length of the growing season and the adaptation of crops to particular environments (Ofori and Stern, 1987). In northern Nigeria, early maturing and drought tolerant crops dominate in areas with annual rainfall of less than 600 mm and where the growing season is short (Andrews, 1972; Baker, 1979). In areas with annual rainfall greater than 600 mm, non-legumes and legumes of varying maturities are used. In tropical regions the non-legume component is usually maize, sorghum, millet or rice and the legume is usually cowpea, groundnut, soybean, chickpea, bean or pigeon pea (Ofori and Stern, 1987). It was reported by Baker (1979) that both the early and late maturing crops are combined to ensure efficient utilization of the whole growing season. A common crop combination is maize and cowpea in west Africa (Okigbo and Greenland, 1976) whereas maize and different types of beans dominate in South and Central America (Francis et al, 1976). Combinations of rice and legumes are prevalent in South East Asia (Harwood and Price, 1976). In some temperate regions, with warm climates, intercrop systems consist of wheat, oats, or barley as non-legume component and the field bean, vetch, lupin, or soybean as the legume component (Ofori and Stern, 1987).

Quantitative estimates suggest that 98% of cowpea grown in Africa are intercropped (Anorn, 1972) and 90% of beans in Colombia, and 80% of beans in Brazil are intercropped (Francis et al.,1986). The percentage of the cropland actually devoted to intercropping varies from as low as 17% in India to a high of 94% in Malawi (Vandermeer, 1989). Vandermeer (1989) also indicated that intercropping was common in temperate North America before the widespread use of modern varieties and mechanization. Historically, however, intercropping has been regarded as a primitive form of agriculture which would eventually give way to sole cropping as a natural and inevitable consequence of agricultural development (Willey, 1979).

It has been realized more recently that many intercropping systems persist today on farms on which resources are limited and the level of technology is low. It has also been realized that little improvement of the intercropping situation is likely to result from research which considers only sole crops. Francis (1989) reported that intensive cropping systems often with mixtures of species have reached high yield levels through the use of pesticides, improved cultivars and other high input technology in countries such as China, Taiwan, the Philippines, and Thailand.

Since intercropping is not only a common practice, but there is also a possibility that it can provide yield advantages, research should be strengthened in order to facilitate better understanding of this kind of farming system.

2.3. Advantages of intercropping.

2.3.1 Assessment of advantages.

The evaluation of the advantages of intercropping situations can be difficult. Evaluation of intercropping advantages arises due to difficulties associated with the choice of terms or units in which advantages should be measured (Willey,1985). Willey (1985) attempted to simplify these difficulties by recognizing two distinct objectives in the evaluation process of intercropping. i.e biological and practical objectives.

The biological objective aims at finding out whether there is biological efficiency in intercropping as compared to sole cropping and the units used are usually relative. A common unit used is the Land Equivalent Ratio.

The practical objective embraces the aims and the constraints that determine the amounts of crops to be grown. It was suggested by Willey (1979) that three criteria could be used when considering practical assessments of intercropping advantages.

(i) Where intercropping must give full yield of a main crop and some yield of the second crop. It involves a situation where the primary requirement is for a full yield of some staple food or a commercial crop. A good example of this situation is where the main crop has weak stems and thus needs support in order to avoid lodging and therefore facilitate easy harvesting and to obtain cleaner seeds. It is an easily defined situation since a yield advantage occurs when there is a yield of the second crop and the yield of the main crop is not significantly affected by the second crop.

(2) Where the combined intercrop yield must exceed the higher sole crop yield. This advantage criterion is based on the assumption that unit yield of each component crop is equally acceptable and therefore the requirement is simply for maximum yield regardless of the crop from which it comes. This has been traditionally used to assess advantages in grassland mixtures (Donald, 1963) and for assessing a wider range of intercropping situations (Trenbath, 1974).

(3) Where the combined intercrop yield must exceed a combined sole crop yield. A criterion of this kind considers factors which influence farmers decision making. It assumes that the farmer needs to grow more than one crop in order to guard against market risks, to satisfy dietary needs, to spread labour peaks etc. In this situation yield advantage occurs when intercropping results in higher yields

than growing sole crops separately. It is the commonest situation in practice.

The practical objective is evaluated depending on the purpose for which the crops are crown. The units of measurement can be in monetary, nutritional, relative or absolute values.

2.3.1.1. Land Equivalent Ratio

The land equivalent ratio (LER) is the measurement most frequently used to evaluate both the biological and the practical objectives of intercropping advantages (Mead and Willey, 1980). LER is defined as the relative land area under sole crops that is required to produce the yields achieved in intercropping. When LER = 1, there is no intercropping advantage in comparison to sole cropping. A LER which is greater than unity implies that a larger area of land is required to produce same yield of sole crop of each component grown separately than an intercropped mixture. For example, when the LER = 1.15, then 15% more land is needed to produce the same yield from the component crops in sole stands.

The value of LER is influenced by several factors including competitive ability of component crops, duration of growth, and the agronomic factors that affect the growth and development of individual crop species (Natarajan and Willey, 1980; Fawusi et al., 1982).

Willey (1979) recommended that LER values be presented along with absolute yields because the practical significance can only be fully assessed when related to the actual yields.

2.3.2.0. Efficiency of resource use

2.3.2.1. Competition and yield advantages

One cause of yield advantage of intercropping documented in the literature is better use of resources. Francis (1989) reported that although relationships between and among crop species grown in mixture have been described, results have most often been expressed in final yield and on occasion total dry matter. Yield is a valid indicator of the competitiveness of that component for the scarce growth resources under any given set of conditions.

Terms have been developed to describe the partitioning of inter and intra-specific competition (Hill and Shimamoto, 1973; Trenbath, 1974). Willey (1979) attempted to simplify the types of competition by recognising three broad categories of interactions that affect intercrop yields. The first category is a situation where the actual yield of each species is less than when grown alone. Yield response in this category is rare in the field situation but a few cases have been reported (Allgren and Aamodt, 1939; Donald, 1946; Harper, 1961).

The second category is a situation in which each species produces more when two crops are planted together, than when planted alone. The third category, and most common is termed compensation. In this situation one crop produces more and the other produces less than as sole crop. Relationship of this kind involves a more competitive crop (dominant) and a less competitive (dominated) crop in the mixture (Huxley and Maingu, 1978).

2.3.2.2. Light use

Solar energy cannot be captured and stored for later use in the way that other natural resources are managed. Light is instantaneously available and needs to be instantaneously intercepted and used if this resource is going to be useful to produce photosynthate and plant dry matter (Donald, 1961). Competition for light is between leaves rather than between plants, and a leaf that receives below the compensation point will soon perish (Etherington, 1976). Plants that are favoured in the mixture are not necessarily those with the most leaves and foliage, but those with the leaves in the best position to intercept solar radiation (Francis, 1989). If water and nutrient requirements of crops are met, then light is most frequently the limiting resource (Willey, 1979).

Trenbath (1976) reported that both photosynthesis and plant growth of each component crop will be proportional to the amount of radiation that each component intercepts. There are both temporal and spatial ways in which multiple cropping systems use light more efficiently than sole crops. A mixture of crops may cover the ground over a greater portion of the year and thus intercept more light. It was concluded by Willey and Roberts (1976) that light energy was often the most important factor in over yielding by crop mixtures that exhibited temporal complementarity.

The amount of light intercepted over the entire growing season is primarily the function of leaf area duration (LAD) of one or more of crops developing the canopy. Zandstra (1978) observed that although the LAD of each of the intercrop components is reduced, the overall LAD of the mixed canopy can be greatly increased. This increased LAD for the growing season is particularly true for relay intercropping.

Intercrops have potential to intercept light in different ways than sole crops (Francis, 1989). Intercrops may involve crops with dissimilar growth habits. The differences in growth habits results in a better vertical distribution of leaves in the intercrop canopy. Component crops with similar morphology may compete severely for growth factors.

Regnier et al. (1989) reported that common cocklebur competed strongly with soybeans because its growth in height is similar to soybeans and both species develop lower leaf canopy under shaded conditions. Common cocklebur and soybeans thus exploit the same above ground environment and are in direct competition for light and space within the canopy.

The inclination of the leaves influence the amount of light which is intercepted by the canopy of the tall component and hence the amount which is available to the short component. A tall crop, especially a cereal with C_4 light response intercropped with a shorter dense crop with C_3 response could enhance the total light use (Crookston and Hill, 1979). Willey (1979) concluded that better spatial use of light could be achieved through more efficient use of light rather than greater light interception and could hold the most promise for further increasing yield potential of crop mixtures.

Natarajan and Willey (1980) found that in a sorghum-pigeon pea combination the amount of light intercepted relative to incoming incident radiation at 55 days was 84% in sole crop of sorghum, 65% in sole crop of pigeon pea and 80% in the intercrop mixture. In a maize-pigeon pea intercrop system, interception of light was low with the slow increase in leaf area index in a maize-pigeonpea intercrop system and above 80% when the leaf area index reached about three (Sivakumar and Virmani, 1980). They also observed that the intercrop system attained LAI of three in 45 days, compared to 50 days in sole crop of maize and 115 days in sole of pigeon pea.

The energy conversion efficiency, defined by the dry matter produced per unit of light energy absorbed, of groundnut-millet intercrop was higher than in sole stand at maximum leaf area index (Marshall and Willey, 1983).

2.3.2.3. Nutrients and Water use

The use of water by a crop mixture provides a condition under which competition for a limited resource might occur. Water, as a resource, interacts with many other plant growth factors. Water is often the most limiting factor in crop growth, especially in the tropics, and thus the ability of roots to explore a large soil volume and extract water is critical (Etherington,1976). Intercrops may be more efficient in exploring a larger soil total volume if the component crops have different rooting habits (Willey,1979). There is evidence from a number of studies that a deeper rooting component crop may be forced to develop even deeper roots if grown together with shallow rooted crops (Whittington, and O'Brien,1968; Fisher, 1976). Where moisture is the most limiting resource, intercrops may offer both a temporal and spatial advantage in water use (Baker and Norman,1975).

Mobility of soluble ions such as nitrate is the same as that of water in the soil and roots may attract nitrates from as much as 25 cm away in the soil solution (Trenbath, 1976). Nutrients such as ammonium, calcium, phosphorous, and potassium are strongly held on surfaces of soil particles and are present in low concentrations in the soil solution and they move almost entirely by diffusion. The ability of an intercrop to make more efficient use than sole crops of soluble and non soluble nutrients depends on the extent of root growth of component species, soil water levels, and how completely the intercrop mixture explores the entire soil mass in the rooting zone. Biological efficiency is likely to result when the intercrops explore a larger soil volume or explores the same soil mass more completely compared to sole plantings of the same species. There is also a possibility of differences in time of peak demand for different nutrient elements by components in the mixture (Willey, 1979).

Higher total nutrient uptake by intercrops than sole crops has been reported (Dalal, 1974; Hall, 1974). Differences in total yield by intercrops has been explained by greater nutrient uptake (Willey,1979). Baker and Blaney (1988) reported that uptake of nitrogen by sorghum-soybean intercrop was less compared to sole cropped sorghum but intercropping still produced significantly higher yields than sole cropping. Competition for nutrients, especially in pasture mixtures was reviewed by Haynes (1980). He concluded that legumes in general are poor competitors with grass species for nitrogen. Rates of nutrient uptake vary with plant age, and the period of maximum nutrient demand for one species may not coincide with that of the other species in the