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Intercropping in Semi-Arid Areas,
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Effect of Intercropping on the Severity of Powdery Mildew on Green-Gram

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Intercropping, or mixed cropping, is a common farming practice utilized by subsistence farmers in tropical and subtropical areas of the world. Three to five different crops growing in the same field at the same time are commonly found, with up to 15 crops growing together having been observed (Innis 1980).

The advantages of intercropping over monocropping have been reviewed by various investigators (Norman 1971; Finlay 1975; Innis 1980); however, there are also some disadvantages associated with intercropping (Finlay 1975).

Many investigations have been conducted to elucidate the agronomic aspects of intercropping. This is evident from several recent publications (Monyo et al. 1976; Anonymous 1977; Weber et al. 1979). Although it has been observed that, generally, intercropping provides better pest and disease control (Jana 1975; Finlay 1975; Mukiibi 1976; Innis 1980), most of these observations are empirical, lacking in quantitative data. This is particularly true in the case of pathogen-host-environment interactions in mixed cropping systems, especially under tropical conditions where there are more plant diseases than in temperate regions (Wellman 1969). Understandably, investigations on pests and diseases under mixed cropping systems are complex because each plant species is attacked by several insect pests and pathogens, which may cause damage to one or more of the component crops.

During the past several years, some reports have dealt with the effect of intercropping on plant diseases (Allen 1976; Arene 1977; Mukiibi 1976; Shoyinka 1976; Moreno 1975; Mora and Moreno 1978). Recently, Moreno (1979) studied the effect of intercropping on cassava diseases, as well as diseases of intercropped cowpeas and beans, in a very comprehensive manner.

It has been observed for several years at Morogoro that the incidence of powdery mildew (*Erysiphae polygoni*) on green-gram was markedly lower when green-gram was intercropped with sorghum or bulrush millet compared with green-gram in monoculture. Powdery mildew is one of the major diseases of green-gram. It causes a significant reduction in yield (Lyamuya 1977). This disease appears on green-gram at the flowering stage and attains epidemic proportions at podding if left unchecked. Experiments, therefore, were conducted to investigate the severity of powdery mildew on green-gram when intercropped with sorghum or millet compared with green-gram in monoculture.

Materials and Methods

The investigations were conducted at the university farm at Morogoro, Tanzania, which is located at an elevation of approximately 520 m above mean sea level and receives an average rainfall of 850 mm.

The experimental plots were 3 m $\times$ 4 m in area and the treatments were completely randomized. The experiments were conducted at three planting times. The last experiment, however, was abandoned due to adverse weather conditions. Planting dates for the early- and late-planted experiments were 31 March 1978 and 17 April 1978 respectively.

In each of the two sets of experiments, there were 27 plots that received the following treatments: (1) nine plots planted with green-gram variety IPA 5910 in monocrop (GG); (2) nine plots intercropped with green-gram and bulrush millet variety dwarf Cassidy (GM); and (3) nine plots intercropped with green-gram and sorghum variety Lulu (GS).

In the intercropped plots, green-gram rows were alternated with rows of sorghum or bulrush millet. Plant spacing was 15 cm for both cereals and legumes and the distance between rows was 30 cm. In the monoculture plots, within-row spacing was 15 cm, with 30 cm between rows.

Two weeks after seed germination, thinning to 1 plant/hole was carried out. All plots were weeded twice, at the time of thinning and approximately 8 weeks after seed germination. Insecticide (Dimecron 50% WP) was applied to control sorghum shoot fly and legume pests; DDT (50% dust) was applied to control sorghum stem borers.

Fungicidal Treatment

Fungicide was applied to 18 randomly selected plots to control powdery mildew on green-gram. It was done in order to assess the efficiency of intercropping in controlling powdery mildew compared with chemical control. The fungicide used was Saprol (triforine). Three treatments were used: 0, 0.188 g active ingredient/L, and 0.376 g active ingredient/L. Dosages were designed as control, normal, and double dose respectively.

Disease Assessment

The severity of powdery mildew on green-gram was assessed in both the monoculture and intercropped plots. Disease assessment commenced 2 weeks after the first appearance of symptoms and continued thereafter at 2-week intervals. Disease severity was rated on the Horsfall and Barrett (1945) scale. A total of three disease assessments was made during the course of three investigations in each experiment.

Yield Assessment

Three middle rows of green-gram and two middle rows of cereals from each plot were harvested and the data were subjected to an analysis according to the cropping pattern.

Results

Effect of Intercropping on the Severity of Powdery Mildew on Green-Gram

In all three disease assessments, it was observed that the severity of powdery mildew on green-gram was significantly higher in monoculture than when green-gram was intercropped with either sorghum or millet ($P<0.01$). On the other hand, no significant difference was observed in the severity of powdery mildew when the two intercropped systems were compared (Table 1). A similar trend was observed when the severity of powdery mildew was compared among the Saprol-treated plots.

The results of this investigation showed that intercropping was able to control the severity of powdery mildew on green-gram to, more or less, the same extent as through the application of Saprol in monoculture. However, if Saprol was applied to green-gram grown in intercrop, the disease severity was reduced still further, probably due to the additive effect of the intercropping and the presence of the chemical.

Effect of Planting Date on the Incidence of Powdery Mildew on Green-Gram

The incidence of powdery mildew on green-gram in both the early- and late-planted experiments was the same from the first appearance of the disease until flowering. During the pod-ripening period, however, the severity of the disease in the late-planted experiment was higher than in the early-planted experiment. The differences in the disease index between the two experiments, however, were not significant ($P = 0.05$).

Green-Gram Yield

It was observed that the yields of green-gram under monoculture were significantly higher than those from intercropped plots.

The regression lines in Fig. 1 show that intercropping reduced the loss in green-gram yield due

Table 1. Severity of powdery mildew on green-gram at different intervals of time under different cropping patterns with various treatments of Saprol.

Cropping pattern	Saprol treatment[a]	Disease index 2 weeks	4 weeks	6 weeks
Green-gram	0	2.5	5.7	7.9
	1	2.5	4.9	6.6
	2	2.1	4.2	6.3
Green-gram/ sorghum	0	2.1	4.7	6.4
	1	1.8	4.3	5.8
	2	1.9	3.7	5.6
Green-gram/ millet	0	2.1	4.6	6.0
	1	1.9	4.0	5.6
	2	1.8	3.6	5.3

[a] 0 = no chemical; 1 = normal dose Saprol; 2 = double dose Saprol.

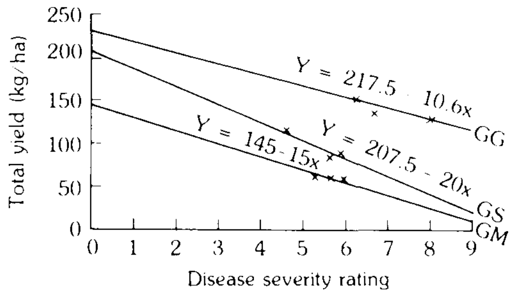

Fig. 1. Increase in the yield of green-gram due to the control of powdery mildew.

to powdery mildew. The slopes of the intercrop regression lines were greater than the slope of the regression line for green-gram in monoculture (20% for sorghum intercrop, 15% for millet intercrop, and 10.6% for green-gram in monoculture); hence, the expected yields of green-gram increase as the incidence of the disease decreases.

Discussion

Green-gram (*Vigna radiata*) is known to be susceptible to powdery mildew, caused by the fungus *Erysiphae polygoni*. It is capable of causing a reduction of between 10 and 50% in green-gram yield (Lyamuya 1977).

Despite the fact that powdery mildew can be effectively controlled through the use of fungicides and resistant varieties, for a subsistence farmer it is sometimes difficult to adopt these methods due to the expense involved, nonavailability of materials, and lack of skills required to apply the fungicides. Therefore, the only practical and economical alternative for the farmer to manage this disease is through the use of appropriate cultural practices.

It is only in recent years that attention has been directed toward the management of diseases by intercropping (Allen 1976; Shoyinka 1976; Mukiibi 1976; Moreno 1979; Clark 1980).

The present investigations showed that the severity of powdery mildew on green-gram was significantly higher in green-gram under monoculture than when green-gram was intercropped with either sorghum or bulrush millet. It was also observed that the severity of powdery mildew in sprayed monoculture was significantly higher than sprayed green-gram under intercropping. This may have been due to the additive effect of spraying and intercropping. In spite of the fact that the intensity of powdery mildew was lower in intercropped green-gram, the yield of green-gram was also reduced in intercropped plots. This may be due to physiological effects such as tillering, light interception, etc. of sorghum and millet on green-gram (Table 2). Similar observations have been recorded by other researchers (Enyi 1973; Keswani et al. 1977). The higher disease severity in pure stand or reduction in disease severity in intercropped green-gram could be a result of several factors.

Because rows of green-gram were alternated with rows of sorghum or millet, this could have made the transfer of inoculum much more difficult than in monocropped green-gram due to the filtering effect created by separating two rows of green-gram by a row of cereal, as suggested by Mukiibi (1976).

Under intercropping, wind velocity is also reduced, thus reducing the speed at which pathogen propagules spread. However, under intercropping conditions air circulation is better, effectively reducing humidity and changing the temperature of the microenvironment, which reduces the severity of infection because *Erysiphae polygoni* is known to favour low temperatures and low moisture (Yarwood 1952).

Furthermore, in the case of intercropped green-gram, the spread of pathogen inoculum due to rain splash may have been reduced, whereas in monoculture it will be much more.

Insects transfer pathogens during the process of pollination and during feeding on a host plant. Normally, an insect will fly directly from one plant to another but in the case of a cereal being present between two susceptible host plants this may not be possible. It is possible, therefore, that there was a reduction in the transfer of inoculum by insects and, hence, a reduction in the severity of disease.

Green-gram intercropped with sorghum or millet was taller and had a better canopy due to its competitive drive for light (Nangju 1973). This factor may also have contributed to a lower severity of powdery mildew in intercropped green-gram.

Several of these hypotheses still need to be tested experimentally because it has been es-

Table 2. Mean yields of green-gram (kg/ha) and cereal under different cropping patterns.

Cropping pattern	Disease index	Yield (kg/ha) Green-gram	Yield (kg/ha) Cereal	Monetary value (TSh)[a]
Green-gram	7.9	157.73	—	394.33
Green-gram/ sorghum	6.4	73.31	481.67	664.95
Green-gram/ millet	6.0	57.15	362.39	505.27

[a] Calculation is based on the price of green-gram being TSh 2.50 per kg and TSh 1.0 per kg for sorghum and bulrush millet.

tablished that different pathogens behave differently under different crop combinations (Moreno 1979). Therefore, at present, it may be difficult to generalize that there will be reduced disease severity under intercropping in all cases, especially when there are examples in the literature in which intercropping increases disease severity (Baker and Cook 1974; Cook and Rovira 1976).

It may be difficult, if not impractical, to apply the results from experiments such as these directly into farmers' fields because one does not often find a subsistence farmer practicing intercropping in definite rows with predetermined spacing, etc. However, because these experiments show a positive trend toward reducing disease severity, an attempt can, at least, be made to encourage the farmer to adapt these innovations.

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