Crop yields of sorghum and soybeans in an intercrop.

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Abstract

The yields of the three seasons of sorghum and soybeans are reported. In the first season, the sole crop yields of soybeans increased with increase in plant populations, contrary to the intercrops. Intercropping had significant influence of yields ($p = 0.05$). During this period, sorghum in sole stand increased with the increase in plant population. The increase was more pronounced in the case of sole stand of sorghum. Intercropping had a more significant effect on the yield of sorghum than density ($p = 0.01$). In the second cropping season, there was pronounced increase in yield with density in sole ($p = 0.05$). In the third cropping season, the yield of sorghum showed a generalised increase in yield with population increase in an intercrop. There was significant effect on intercropping on yields. Compared to soybean yield, there was no difference in the lower and normal density in the sole crop, however, for an intercrop the yield increased only at higher density. All these trends did not register any significant effect on yield.

Introduction

Intercropping as defined by Norman (1974) is a system with two or more different crops grown together on the same land during a single time period. This is a very common practice in many parts of the tropics. Several investigators (Willey and Osiru, 1972) have reported an increase in gross productivity per hectare within intercropping systems. Reasons for the increased crop yield in intercropping systems may be summarised as follows: efficient use of solar radiation, unilateral benefits in crop growth and/or reproduction, reduction in the parent autotoxic effects of certain crops, favourable changes in the incidence of pests and diseases, and potential compensatory growth from vagaries of the environment.

In many parts of East Africa, the practice of intercropping has been carried out at the subsistence level, with cereals and legumes constituting the most frequent pattern. Although intercropping has been practised for along time at subsistence level, there has been in recent years a desire to evolve an intercropping system for both subsistence and commercial purposes. At the present time there is no suitable legume/ cereal combination, which incorporates crops that would grow both in high and low agricultural potential areas of Kenya. Although the characteristics of soybean and sorghum would tend to fulfil the aforesaid requirements, there has been no serious work carried out in this direction in Kenya.

Biological dinitrogen fixation is the conversion of atmospheric nitrogen to ammonia. The process requires large amounts of energy from the metabolism of the host plant and concomitantly influence the process of dinitrogen fixation. Although several factors influence biological dinitrogen fixation, the major ones considered in the present study are environmental factors of light, water and agricultural practices such as density and crop diversity. The degree to which competition for environmental resources in intercrops and how dinitrogen fixation is affected by modifying environmental factors is not known. The environmental factors which, influence crop responses are so interdependent that a change in one alters the others. In monoculture soybeans systems, it has been shown that seed yield is dependent on the photosythnthesis and partitioning of assimilates. Leaf photosynthesis is dependent on the interception of solar radiation (Monteith, 1969). Penetration of light into the canopy is an important factor governing the size of the plant's metabolic source. In some plant species, the canopy surface may become light saturated, while leaves lower in the canopy would require additional light to enable them to photosynthesis maximally. This phenomenon is further compounded by intercropping, plant density and crop diversity. In monoculture experiments, Taylor (1980) observed that varying the intensity of competition through root spacing and plant density changed plant monopoly and reproductive potential markedly. Morphologically plants at higher densities are taller, have fewer branches, and lodge more often than at low densities (Weber et al; 1966). The emphasis on intercropping systems has been on agronomy (Willey and Osiru, 1972). However, there has been a gap on physiological aspects of crops in intercropping systems. The paper presents data on growth, yield, and dinitrogen fixation, in an intercrop of sorghum/soybean at varying plant densities.

Materials and Methods

Soybeans (Glycine Max Meril L.) cultivar Congo and sorghum were grown four times during the two short rains and long seasons at the Department of Botany Botanical Garden, University of Nairobi. The two crops were planted at varying densities in pure stands and two mixtures at a population of 1:1 at three densities LD, normal density (ND) and high density (HD), each with a plant density of 66 666 plants/ha or 7 plants/ m-2; 83 333 plants/ha or 8 plants/m-2 and 111,111 plants/ha or 11 plants/m-2 starting the first short rains of 1982 November-December 1982. The whole of 1984 was a dry year in Kenya, which is why there was no planting that year. The growing of these crops was resumed in 1885.

The design was a split plot with density as main plots (dimensions of 8m x 5m) with four replications. Each sub plot was planted with either monoculture or intercropped culture of two crops and surrounded by 75cm border of bare earth. The plants were established by planting the cereals seeds 3-5 seeds per hole and 2-3 per hole at a spacing of 75cm x 20cm, 60cm x 20cm and 44cm x 20 cm. After a week the plants were thinned to two plants/hole and eventually reduced to one plant after the fourth week of planting. All other agronomic practices were kept at optimum level except that nitrogen was not added. The legume plants were inoculated before planting with rhizobium strain 7210 supplied by mercen.

Phosphate was applied in the form of P_2O_5 at the rate of 45kg/ha. This was furrow dressed between lines on the day of planting. Most of the Kenyan soils are never deficient in potassium, hence this element was not supplied, and since the land used had not been planted with any crop for the three previous years it was not necessary to supply the potash fertilizer. Nitrogen was assumed to be supplied by the process of nitrogen fixation. Measurements of growth parameters were started 21 days after planting and varied from 14 to 7 day intervals. Plant growth and yield measurements were taken at appropriate times. Finally, grain yield was estimated from which other parameters were calculated, for example land equivalent ratio.

Results

The effects of plant density and intercropping on soybean sorghum grain yield of the first and fourth yields are presented in Figure 1. The yield of soybean in the third growing season and the land equivalent ratio based on sorghum yield are presented in Tables la and 1b. During the first season, the sole crop yields of soybeans increased in yield of intercrops. Although there was an increase in yield with increasing plant population, density did not have a significant influence on yield. However, intercropping had a significant effect on yield (P=0.05). Similarly, sorghum in sole crop increased in value with increasing plant population. Although there was an increase in yield with plant population in an intercrop of sorghum, this was not as pronounced as the case in sole stand of sorghum. Statistically, intercropping had a highly significant effect on yield of sorghum (P=0.05).

The yield of sorghum in the fourth growing season (Fig.1) showed a generalized increased in yield with population increase in an intercrop. Contrarily, the sole crop exhibited a reduction in yield with population increase especially at a higher plant population of 111 111 plants/ha. Neither density nor the interaction between density and intercropping showed significant influence on yield. However, there was a significant effect of intercropping on yield (P=0.05). The soybean yields were not different (Fig.1) in the lower (66 666) and normal (83 333) densities within the sole crop. However, for the intercrop, there was a yield increase only at normal densities; then it dropped at higher (111 111 plants/ha) densities. Analysis of variance showed that all these trends were insignificant.

The effects of population and intercropping on soybean during the third growing season are shown in (Table 1a.) There was a pronounced increase in yield as the plant density increased within the sole crop as compared to the intercrop. Statistical analysis showed that there was highly significant effect of density (P=0.01) and a significant effect intercropping (P=0.05) on yield. Table 1b shows the effects of plant density and intercropping on land equivalent ratio based on sorghum stands (LER). This ratio within the sole crop slightly increased between the lower plant population (66 666 plants/ha) and normal density (83 333 plants/ha) and then dropped. A similar trend was noted for crops within intercrop. On the whole, a population of (83 333 plants/ha) i.e., normal density had the highest value of LER for both sole and intercrop. Analysis of variance showed that only density had a significant effect on LER

Discussion.

Crop Yields

The literature points out that under good conditions, sorghum can yield up to 11 000 kg/ha with an average of 9000 kg/ha. However, better conditions give 3000 to 4000 kg/ha. On the other hand, under moisture-limiting conditions, the commonly recorded range is 300 to 1000 kg/ha. The above yields are for sorghum grown under sole conditions. This study shows that in the first season, sorghum in the intercrop yielded almost one half of the sole stands (sole average of 112 kg/ha while intercrop was 496 kg/ha). The trend was reversed within the fourth season, where generally the intercrop outperformed

Figure 1.

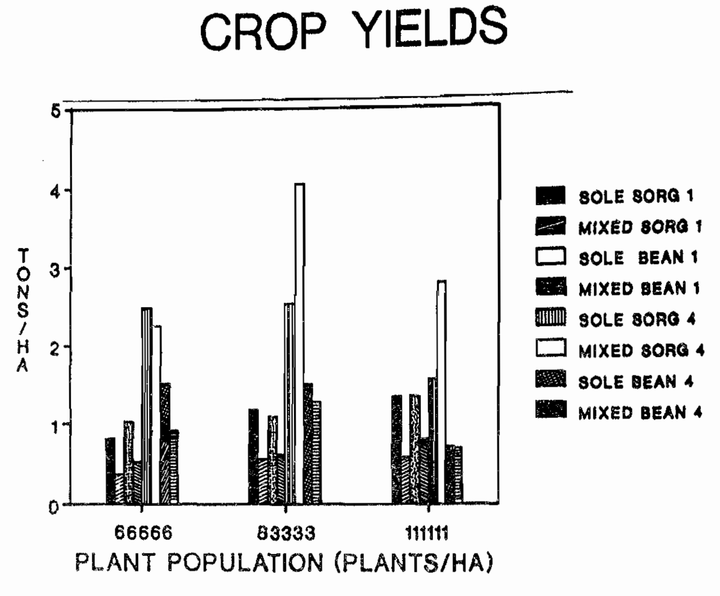

Table 1a.

SEASON 3 YIELDS			SEASON 1			
	Beans			Sorghum	Land Equivalent ration	
Plants/ha	Sole	Mixed	Mean	Sole	Mixed	Mean
66 666	2341	1791	2066	0.465	0.276	0.37
83 333	3624	2291	2957	0.527	0.69	0.608
111 111	5576	4369	4973	0.412	0.46	
Mean 3847	2817			0.412	0.46	
SED MD	454.5			0.0742 R=4		
SED MIC	414			0.0925 R=6		
SED MISD	717			0.1602 R=2		
SED IDXI	680.9			0.1354 R=2		
	D= * * *		D= * *			
D-DENSITY	C= * *		C= NS			
C-CROPPING	D X C =NS		D X C= NS			

SED MD - SED MEAN FOR DENSITY
SED MIC - SED MEANS OF INTERCROP
SED MISD - SED FOR MEANS OF INTERCROP AT SAME DENSITY
SED IDXI - SED OF INTERACTION DENSITY X INTERCROP

the sole crops (3034 and 2194 kg/ha, respectively). Soybean yields for the first season followed a trend similar to sorghum, while contrary to the fourth season, soybean had a reduction in yield within the intercrop, although the reduction was not so great (1247 kg/ha within sole as compared to 969 kg/ha with intercrop). Similarly, the soybean within the third season did better within the sole than the intercrop (Fig. 1). These results point out that both density and intercropping had significant effects in the yields of these crops. The observed enhanced performance of sorghum in the fourth season within the intercrop may be explained by the more efficient use of radiation, and efficient use of soil nutrients associated with different root depth of the two crops. This only occurs when there is ample supply of resources. The fourth season generally was a good period in terms of rainfall. On the average, it is apparent that the performance of sorghum whether in sole or intercropped stands was not very much influenced by density nor cropping system.

Soybean yields tend to vary from place to place depending on growth conditions. The average yields in the USA are from 1700kg/ha to 3400 kg/ha within monoculture systems. Egli (1973) showed that soybeans can produce the same yields over a wide variation of soybean yields depending on growth conditions. This is exhibited in this study, for example the yields of soybean during the first season through the fourth season were influenced by intercropping or varying magnitude. Intercropping caused almost one half in the reduction of yield within the first and third season while during the fourth season the reduction was not as high (see Table 1a).

The reported soybean yields fall within the reported ranges of yields in places where soybean is grown. Soybean appeared to be comparatively more amenable to intercropping than sorghum. It is apparent that under good environmental conditions, soybean was not greatly influenced by density nor cropping system. Density seems to have a great influence on soybean yields only when the conditions are not so favourable for growth. This is exemplified by the highly statistical significance of density during the third season. During this time, in 1984, Kenya was generally very dry and it was not possible to produce a crop of sorghum, however, soybean did receive moisture.

Willey and Osiru (1972) reported an increase in crop turnover of gross returns per hectare in intercrops, Comparatively, the LER with intercrops was slightly higher as compared to sole stands. With respect to density, the normal density had the highest value with the intercrop. This shows that plant population has a great influence on gross return per hectare within intercrops. This is further exemplified by the statistical significance of density on the land equivalent ratio. To maximize on this parameter, it may be suggested that plant population should be kept at what the environment can effectively accommodate.

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