"MIXED CROPPING OF MAIZE WITH BEANS WITH SPECIAL REFERENCE TO RELATIVE TIMES OF PLANTING OF THE TWO CROPS IN WESTERN KENYA"

by

JACKTON OLUOCH OWUOR

A THESIS SUBMITTED IN PART FULFILMENT OF THE DEGREE OF MASTER OF SCIENCE IN AGRONOMY IN THE UNIVERSITY OF NAIROBI

1977

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

J.O. OLUOR

(Candidate)

This thesis has been submitted for examination with our approval as University Supervisors.

Dr. N.M. FISHER

(University Supervisor)

Dr. D.M. MUKUNYA

(University Supervisor)

L I S T O F C O N T E N T S

ACKNOWLEDGEMENTS

For the success of this thesis, I wish to record my sincere appreciation and gratitude to the Ministry of Agriculture, Kenya for the scholarship and materials offered in support of this investigation. Thanks are also due to the Field Station, Faculty of Agriculture, University of Nairobi for the supply of Canadian Wonder seeds used in this study.

I am also deeply indebted to my two supervisors, Dr. N.W. Fisher and Dr. D.M. Mukunya both of the University of Nairobi, Crop Science Department for their valuable criticisms of the manuscript.

Helpful discussions and criticisms on the data analysis given by Mr. J.B.M. Matata and Mr. M.A. Foum of the Ministry of Agriculture, Scientific Research Division, Kenya, were very much appreciated and I am grateful to both of them.

I wish to thank all the staff of Western Agricultural Research Station, Kakamega, particularly those who took part in difficult field operations which led to the success of this project. It is also a pleasure for me to acknowledge the assistance of Mr. H. Lubia - Technical Assistant, who spent long hours in

assembling the data used in this thesis.

Lastly, but not least, I wish to thank Mrs. Mary Oloo for typing the manuscript, Mrs. Lily Ogola and Mrs. Sally Mutiso who did a good job of typing this thesis.

JACKTON OLUOCH OWUOR

S U M M A R Y

Previous research on mixed cropping experiments in the tropics cited in the literature review indicated clearly that the system is of great importance to the small farmers who would benefit greatly from improvements applicable to intercropping systems. In almost all of them the yields per unit area have shown some advantage from the mixtures compared to those from the pure stands of either crop.

The main objective of these experiments was to study the effect of mixing maize with beans crops on their respective yields. Additional information was sought on the effects of different time of inter-planting, of plant arrangement and of labour inputs required. This thesis was therefore designed to provide this information.

Mixed cropping conducted during 1974-1976 with special reference to relative times of planting of the two crops in Western Kenya are described. In all experiments, maize densities were the same in pure stands and mixtures and beans were added as a fraction of the pure stand densities.

The results showed that the total yields of maize-bean mixtures per unit area of land were

considerably higher than those obtained from the two crops grown separately. This was found to be so in each season. Late planting significantly reduced the yields of beans in all years and of maize in 1976 when time of maize planting was included as a treatment. Intercropping maize with beans led to a small increase in the maize grain yields, but to a reduction of bean seed yields. The presence of beans therefore maintained high yields of maize in the mixtures as compared to controls and there was a significant increase in one year.

In the first year of experiment (1974) maize yield from the mixtures seemed to have been higher than those from the pure stands though not significantly different. Bean yields from the mixtures were significantly lower than the pure stands. The total yield of maize-bean mixtures per unit area was higher than from monoculture. These trends were similar at the two sites, Kakamega and Sangalo.

A second experiment which was conducted in 1975 at Kakamega indicated that there was an apparent yield advantage in maize-bean mixtures when these were planted at the same time. There were no bean yields from the treatments

where beans were inter-planted after the first weeding of maize (20 days from the date of planting). The bean yield was not affected by the crop arrangements because the beans planted in maize rows gave the same yield as the beans planted between the maize rows.

In the 1976 experiments, the total yield production of mixed crops per unit area was higher than that obtained from monoculture of either crop. Time of planting of beans relative to maize was a very important factor for bean yields but not for maize yield.

In 1976, the bean yields were greatly lowered by late planting especially at Kakamega site due to the incidence of damping off disease on the beans resulting in a low bean stand count. The reduction of pod number due to their abscission was another primary cause of the lower yield of beans. Inter-planting maize in the growing beans was not found advantageous in the system, but inter-planting beans after 5 days from the date of maize emergence was found to be very suitable for both crops. Planting these crops at the same was also found to be suitable especially for the bean crop.

It is suggested that breeders should select for a bean variety which is resistant to pod abscission for the success of bean yields in this cropping system.

Significantly less labour input was required in the planting and weeding operations in the pure maize stand compared with beans or with mixtures. However, the cash gross returns from this treatment was significantly lower than that from the mixtures. The advantage of cash gross returns from the mixtures per unit area decreased with the delayed time of planting.

It is suggested that further work on labour input for the whole cropping period should be carried out under the same environmental conditions to give more information on the economy of this cropping system.

It is concluded that maize-bean mixtures planted early either at the same time or beans inter-planted at the emergence of maize is found to be a highly productive and profitable cropping system for the small farmers of Western Kenya.

1. INTRODUCTION

1.1 The Importance of Mixed Cropping in Kenya

Subsistance Agriculture in the developing World largely consists of intercropping systems which enable a farmer to grow more than one crop in the same field at any one time. In this system both grain and leguminous crops which comprise a large part of the diet are mostly found growing together.

In Kenya as in many other developing countries traditional agricultural systems are based on the growing of crops in mixtures. Mixed cropping has for many years been recognised as traditionally popular in Kenya. For most of the small farmers of Kenya living almost entirely on what they can grow, it is necessary that a variety of crops be grown to allow for varied diet. The farmer sees mixed cropping as a means of ensuring this diversification.

In Kenya as in other parts of the developing World where population pressure is reducing the area of cropping land at each family's disposal, mixed cropping systems may continue for many years if they are more efficient in using land. Already the system has been practiced for

centuries in almost all parts of the country where agriculture is possible until very recently when Western technology started to replace the system by introducing monocropping systems. The main justification of pure stand would be high level of mechanization which is not possible in these small farms. The scarcity and high cost of labour for weeding among the small farmers may be overcome by mixed cropping especially where maize and beans are involved. This is probably due to the fact that beans act as smother crop with a closed canopy. By providing better ground cover mixed cropping has encouraged the benefits of soil conservation and retention of soil fertility in most parts of the country.

In Kenya today at least 70% of the agricultural population derive their diet from mixed cropping subsistence agriculture. This indicates clearly that more research efforts should be redirected in order to promote and recognize the place of mixed cropping systems in Kenya and indeed in the rest of the developing countries without mechanized agriculture.

1.2 The Statistics of Production and Consumption of Maize and Beans in Kenya

In Kenya, maize is grown either in pure stands or in mixtures and is the most important staple food for the bulk of Kenya's population. The importance of maize can be seen in the one million hectares which is about 40% of the total arable land. No other crop in Kenya comes near to maize in this regard. Some 2,070,000 tonnes of maize are produced annually for both local consumption and export.

In Kenya beans provide the largest percentage of protein rich foods consumed in the daily diet and they are second to maize in acreage. Beans are grown in some 322,600 hectares either in pure stands or intercropped with other crops. Annually the production of beans is about 400,000 tonnes.

1.3 The Main Areas of Maize-Beans Mixtures in the Republic

Maize-beans mixtures are to be found in all small farming areas at medium altitude which includes Western Kenya, Central and Eastern parts of the country. The only important cropping area where they are not found is the coastal strip.

1.4 Climatic factors affecting their growth

The climatic requirements for the two crops appear similar except for some varieties which tend to require more pronounced longer rainy seasons. Maize and beans are normally grown at altitude between 1,000 and 3,000 m. Beans do not usually exceed 2,000 m altitude whereas some varieties of maize are well adapted to even higher altitudes. Rainfall requirements for both maize and beans range between 300 mm to 2,000 mm per season most of it falling during the period of more active growth. Beans however, tend to do better under rainfall regimes between 300 - 500 mm provided it is well distributed. Moderate soil and air temperatures and soil pH slightly higher than 5.2 are essential. The growth conditions described above appear to exist in large parts of Kenya where these crops are commonly grown.

1.5 Objectives of the study

The objective of the Kenya small scale farmer is primarily to produce sufficient food for himself and his family. He wants not only an abudant food supply, but also a varied one. To achieve this objective the small scale

farmers of Kenya have adopted mixed cropping systems, and with modern scientific methods, they could undoubtedly more than double their output from unit land area. But a great deal more active research into existing local methods of intercropping system should be considered. This is one of the objectives of this research work.

Mixed cropping of maize with beans is common in Kenya as well as in other parts of the tropics. Many reasons have been thought to account for this under indigenous farming conditions. These reasons are both technical and socio-economic. One of the economic reasons for example in Kenya is that in case of an early drought which is common along the lake zone, the farmer would not perhaps loose both crops, but only the maize. The beans which mature early would be harvested before the drought. The system therefore provides security for small farmers. Another risk is of an early hailstorm, which is very common particularly in highland areas of the west of Kenya. Farmers would harvest the bean crop which might not receive the same degree of damage due to the shelter provided by maize plants. Mixed cropping is probably the best compromise for

providing the beans which are a good source of protein for the farmers. The other economic reason is thought to be the higher total return of the yields from a unit area and per unit of labour. The reduction in weed problems, decrease in disease, insects attack and protection of soil against erosion are some of the possible technical reasons for the system.

For the small farmers to achieve their objectives a great deal more active research into existing local methods of food production through intercropping should be considered. This is undoubtedly one of the lines along which scientific research can help the small farmers of Kenya a great deal.

The study reported herein refers to mixed cropping maize with beans in Western Kenya. The objectives of this research work were:-

1. To test the effect of mixed cropping on the yields of maize and beans.
2. To examine the effect of beans on maize yields and maize on bean yields when these are planted together or at different times relative to each other.
3. To provide information relating to the best plant arrangement of maize and beans.

4. To provide information necessary to evaluate the optimum use of the farmer's time during the early part of the rainy season.

2. LITERATURE REVIEW

2.1 Previous Work on Mixed Cropping

Mixed cropping as a system of farming is an old traditional method used in many countries of the tropics. Literature on its various aspects in scanty but is accumulating fast. Leakey (1934) pointed out possible advantages of mixed cropping among the small farmers of Kenya. In the same paper he also expressed his opposition to Agriculturists who recommended that the small farmer in Africa should adopt pure stands of crops as in Europe. Some experiments with legumes and cash crops have shown some advantages in total return of the mixtures. Crowther (1949) quoted an experiment in Sudan where cotton and groundnuts gave a total return in excess of that from a pure stand of cotton. Anthony and Willimott (1957) reported from their cotton inter-planting experiments in the South-West Sudan that for successful field practice, the planting of legumes should not be delayed. They found that the yields of cotton with any other legumes were highest with the earliest sowings. Grimes (1963) cited the work of Munro (1958-59) in Nyasaland who compared alternate row cropping in which cotton and maize were grown on alternate ridges with pure stands of

each. His results indicated that yields of both cotton and maize were much higher twhen the crops were grown in alternate rows. Munro compared two planting dates with cotton and found that if cotton planting was delayed for three weeks the yields of maize under alternate row cropping was not increased, but the yields of cotton were reduced. Evans (1960) showed from his experiments conducted in Tanzania that intercropping groundnuts with maize or sorghum generally gave increased total production per unit land area compared with pure stands of these crops. He observed that about 12-49% more land under pure crop was required to produce the yield of one acre of intercropping depending on site and season. In addition Evans and Sreedharan (1962) reported increased returns in Tanzania for intercropping castor bean with groundnuts. Alexander and Genter (1962) observed from their work in the U.S.A. that maize can produce about 30% more yields, when planted in alternate pairs of rows with soyabeans for the area actually under maize, than when it was sown alone. They also confirmed that soyabeans produced approximately the same yields as would be expected under monoculture conditions. Similar reports were made by Joshi and Joshi (1965), from cotton intercropped with

groundnuts under irrigation as cited by Fisher (1972). In India somewwork was done on Castor mixed croped with groundnuts by Reddy and Rao (1965). Their recommendation was that there was an increase in cash return of as great as 62% over that of an equivalent area of a pure stand of either crop.

Evans (1963), has studied fertilizer and manure responses in mixed crops in Tanzania. He found that maize gives large, highly significant responses to fertilizer and manure and these responses were of the same order as for pure stands. Groundnuts did not respond when intercropped even though in pure stands responses were 250 and 300kg/ha for manure and fertilizer respectively. Webster and Wilson (1966) in their review of some previous experiments on mixed cropping in the tropics found in most of these experiments that more than one acre of pure stand was required to produce the yield of one acre of the mixtures and reached a conclusion that for the small farmer of the tropics, there was no advantage to be gained by the replacement of the traditional practice of mixed cropping.

In addition Agboola and Fayemi (1971) in their preliminary trials on the intercropping of maize with different tropical legumes in Western Nigeria found that the yields of either crops per unit area in the mixtures were lower than their respective pure stands. They found that legume yield was significantly suppressed by maize shade. Andrew (1972) also showed from his experimental results in Northern Nigeria that there was a total yield advantage of up to 80% from mixtures of sorghum with millet or cowpeas over the sole crop of sorghum. Willey and Osiru (1972) found from their studies on mixtures of maize and beans conducted at Kabanyolo, Uganda that yields of the mixtures were up to 38% higher than could be achieved by growing the crops separately. Osiru and Willey (1972) talked of 55% higher yields being achieved in mixtures of dwarf sorghum and beans over these same crops in pure stands. Norman (1971 and 1972) has indicated from his studies carried out in Northern Nigeria that, the profitability of crop mixture was about 60% higher than from sole crops. He also found that labour was used more efficiently. He based his data collection on annual crop varieties grown locally under indigenous technological conditions. In addition Fisher (1972) in his review of the

productivity of mixed cropping in the tropics expressed his strong support for the system and concluded that where hand tools are used for weed control and pesticide use is rare, there is no justification for imposing the biologically inferior European methods on the small farmer. Enyi (1973) reported from his work of intercropping maize or sorghum with cowpeas, pigeonpeas or beans in Tanzania that the grain yields of the cereal crops were reduced. He also found that intercropping maize with either beans or cowpeas decreased total grain yields of maize and legume per hectare. But intercropping sorghum with pigeonpeas increase total grain yield per hectare. In his results he showed that the grain yields of the legume crops was significantly higher in sorghum than in the maize plots. His work confirmed the earlier studies that the combined yields from the intercrop were higher than the yields of either crop as monoculture.

Recently more work has been carried out to determine the effect of growing cereals in combination with legumes in many parts of the tropics. Osiru (1974) conducted physiological studies of some annual crop mixtures near

Kampala, Uganda. He found that in maize beans mixtures, advantages declined from an average of 23.0% for simultaneous sowing to average of 6.3% when the beans were sown one month after the maize. In sorghum-bean mixtures the comparable effect was a decline from 33.1% to 10.6% with an early (80 day) or a late (120 day) soyabean variety. Erhane Gebrekidan (1976) reported his studies on the effect of intercropping legume with sorghum at Alemaya, Ethiopia. He suggested that although the economic advantage of intercropping over a sole crop was not impressive, the best combination of intercropping in the area was to use a late maturing sorghum and an early maturing legume both planted early. Hart and Magha Kewe (1976) showed from their preliminary results of intercropping trials in Zaire with maize and certain legumes that plots intercropped with a legume planted on the same day as maize significantly outyielded plots where a legume was planted after maize. They also found that plots intercropped with a legume highly significantly outyielded those plots which were not intercropped with a legume. Osiru and Willey (1976) reported from their studies on mixtures of maize and beans in Uganda that yield advantages decreased markedly with delayed planting of beans. They found that in some mixtures the yield advantages decreased from 20% when beans were planted the same

time as maize to only 2% when the beans were planted four weeks after. They concluded from these studies that differences in maturity periods of the component crops were probably the major factors contributing to the yield advantages in such mixtures. Baker and Yusuf (1976) reported their findings on mixed cropping research at Samaru, Nigeria. Their mixtures of a 1:1 ratio of millet and sorghum showed that yield of 1 hectare of both were higher in mixture than ½ hectare grown alone. They also found from their intercropping of maize with groundnuts reduced yields of groundnuts but with a higher return from the mixture of 30% than equivalent sole crop. They found large reduction of cotton yields when sown late under cereals.

Although in Kenya the system of mixed cropping has for many years assured the small farmers' subsistence, it was only started by research workers in the country about twenty years ago. The object of the small farmer is primarily to produce a reliable and varied food supply and this requirement leads him to favour mixed cropping. Leakey (1934) in describing a system in one part of Kenya mentioned that it was quite traditional and it was not easy to discourage farmers from it. He also observed that it seemed to have some advantages for the small farmers.

Generally, it has been observed that in the past many research workers in Kenya have not shown interest in mixed cropping. A few such as Wright (1955-56), Vickers (1960) and Grimes (1963) were apparently the first workers to carry out research on mixed cropping. The reluctance in the part of other workers may be due to the variable crop combinations in use and the association of the system with traditional hand farming methods at low levels of production. This has led some of the research workers to express their doubts whether any positive benefits of mixed cropping could be exploited at more advanced level in the country.

So far in Kenya, there is no comprehensive catalogue of all the mixed cropping experiments carried out by the Department of Agriculture. However some experiments on mixed cropping of maize with beans in particular have been carried out in recent years by research workers based at different Agricultural Research Station and Agricultural Institutions. The results and details of their work are in annual reports and other unpublished documents. As has been mentioned here, some early results were brought to light by Wright (1955-56), Vickers (1960) and Grimes (1963). Wright (1955 and 1956) reported the findings of his trials in the Coast Province of Kenya to compare inter-planting of maize and cotton with pure

stands of both crops. At one site he found that half acre of the pure stand maize outyielded one acre of interplanted maize sown at the same time. But from the other site he found that half an acre of pure stand maize produced a yield not significantly different from one acre of interplanted maize. He also confirmed that there was a steady fall in yield of maize with late planting. Generally there was no significant differences for cotton yields between ½ an acre pure stand and 1 acre of mixed. He also indicated from his findings that there was no advantage in intercropping cotton with groundnuts either. He concluded from his findings that relative yields of pure stands and interplanting is very much a matter of site and season. His results indicated that gross cash returns per acre from intercropping are usually higher. He also found from his results that the equivalent area for cotton-maize ranged between 0.94-1.06 with early planting of maize. In addition the results of Vickers (1960) indicated the advantage from mixed cropping of maize and beans in Kenya, where the beans were planted at the same time or at the time of maize emergence.

In the Coast Province of Kenya, Grimes (1963) found from his trials conducted on the effects of growing maize and cotton in alternate row cropping giving slightly higher yields of both maize and

cotton but the yield of one crop is depressed. He observed that cash returns were greater from alternate row cropping. Goldson (1969) reported his findings from maize-cotton interplanting trial carried out in the Coast Province of Kenya. He found that in the pure cotton and maize stands a planting delay of four weeks reduced cotton yields by 50% and in the maize by 24%. He also confirmed that interplanting maize in cotton reduces cotton yields at all spacings and all dates of planting. The greatest depression in yield is when maize is closely spaced and planted before the cotton. His findings also indicated that interplanting maize in cotton also reduces the yield of maize no matter what spacing or what date the maize is planted in relation to the cotton. He concluded from his work that interplanting only gives favourable results when the ratio of plant densities and the arrangement of the two crops are within certain limits.

In addition Brown (1971) found from his studies of interplanting cotton with beans at Tebere in Kenya that the yield of beans was very low when sown late. The reduction was in both pure stand and mixed stand plots. He also found from his work of interplanting cotton with maize or sorghum carried out at Kibos that 2 hectares of cotton and sorghum planted in alternate double rows

gave an increase of 29% gross cash return, and that of cotton and maize gave 7% increase when compared with 1 hectare of cotton and 1 hectare of either crop in pure stands. Makatiani (1974) indicated in the summary of his experiments of maize intercropped with beans conducted at Kakamega in Western Province that there was more yield return from plots with mixtures (maize-beans) than from pure stands. He also indicated that there was no advantage of second bean crop when intercropped in maize after harvesting the first crop of bean. Njeru (1973) showed from his preliminary observation at Embu that maize yields from interplanted plots was reduced by nearly 40% relative to pure stand. His main object was to test the effect of interplanted beans on maize yield. In addition Mbagaya (1974) found from his maize-bean time of planting trial conducted at Kisii that there was a decline in bean yield as time of interplanting beans was delayed. The same trend was also observed on the maize yields. Marimi (1975) showed in his paper on preliminary findings on the system of mixed cropping that maize-bean mixtures in a dry area of Kenya during the long rains of 1974 had advantages which were greater at those sites where the pure stand yield levels were highest. Laycock **et** al (1975) reported from their intercropping **maize** with beans at Kitale that maize yield slightly

increased in the mixed stands though not significantly.

Fisher et al (1976) found from their studies of intercropping maize with beans at three sites in Western Kenya that at none of the three sites was there a statistically significant effect of bean cultural treatment on maize yields. They also showed that the maize yields in the mixtures were not significantly different from those in pure stands. The bean yields indicated the importance of the relative time of planting but fertilizer response was not significant at any of the three sites. Fisher (1977[a]) found at Kabete (Nairobi) that in a long wet season a yield advantage from maize-bean mixtures was possible, but in season with low rainfall, the yield from the mixtures fell short of that of pure stands. He concluded that the poor performance of mixtures in the low rainfall season resulted from large yield reduction in maize attributable to competition from the beans. Nyaisava (1973-1976) - in his intercropping cotton-maize and cotton-sorghum studies at Kibos found that there was a marked decrease in total production per unit land area from the mixed stands compared with pure stands of these crops. He observed that the decrease in cash gross return per unit land area was about 49%.

He also found that equivalent area for maize-cotton ranged between 0.49 - 0.6 and that for sorghum-cotton was between 0.49 - 0.67 (for the period of 1973 - 1976). His findings were in great contrast with any other findings cited elsewhere.

In Western Kenya intercropping is a common practice and various crop combinations are used (author's personal observation). Mixed cropping of maize with beans is a common example in Western Kenya particularly Western and Nyanza provinces. Many reasons have been thought to account for this under indigenous farming conditions. As has been mentioned earlier these reasons are both technical and socio-economic. Makatiani (1974) reported one intercropping trials, but the system was only based on the time of interplanting beans.

In 1974 the writer started a research programme involving maize-bean crop mixtures at Kakamega and the first trial laid down during the long rains of 1974 was a simple one based on yield results only. This was continued in 1975 long rain with slight modifications of the treatments to include special arrangements of intercropping maize with beans. The results of 1974 and 1975 indicated that there is a yield advantage in mixture over pure stands.

2.2 Limitations and Weaknesses of Previous Work

From the foregoing literature review it is observed that no research worker has so far worked on the relative times of planting of the two crops. This factor will undoubtedly have some effects on yields and yield components. Most of the previous workers such as Vickers (1960), Makatiani (1974), Njeru (1973), Mbagaya (1974) and Fisher et al (1976) only based some of their findings on time of interplanting the beans crop with no variation of the other crop. They also gave no recommendation which could be used by our small scale farmers. What is needed is more detailed work aiming at producing firm recommendations. Nobody has examined what would result from planting beans before maize. It also seems that nobody has considered evaluation of the proper use of the farmers time during the early part of the cropping period, assuming that he will practice mixed cropping.

3. EXPERIMENTS OF 1974-1975

3.1 Objectives

The main objective of these experiments was to test the effect of mixed cropping maize with beans. To examine the effect of beans on maize yields and maize on bean yields when these are planted either at the same time or when bean is planted some few days later.

3.2 Materials and Methods

3.2.1 Description of Sites

One experiment was conducted in 1974 at two experimental sites. One at Kakamega Experimental Station and the second site at Sang'alo Research Station in Bungoma District. In 1975 one experiment was carried out at Kakamega Research Station. The experimental site at Kakamega Research Station lies at an elevation of 1,585 metres above sea level with an average rainfall of 1919 mm. The soil is deep, well drained fertile basaltic loam with an average pH of 5.5. Sang'alo Animal Research Station is at an altitude of 1,385 metres above sea level with an average rainfall of 1,573 mm. The soils of the area are free-drained sandy loams.

3.2.2 The Statistical Design

A randomised complete block design with six replications at each site was used in 1974. In 1975 a randomised complete block design with four replications was used.

3.2.3 The Treatments

In these experiments two mixtures of two different species were used. One maize population of 44,444 plants per hectare which is the field recommended one for these areas (Allan, 1968[b]) was evaluated both in pure and mixed stands. The pure stand bean plots were planted at a population of 148,148 plants per hectare. In the mixed plots a population of 88,888 bean plants per hectare was used in 1974 trials. The full range of treatments for 1974 was:-

A. Pure beans stand - (K 20)
B. Pure maize stand - (Hybrid 613[c])
C. Beans planted in alternate rows with maize rows 75cm apart and planted at the same time.

The complete range of treatments for 1975 was as follows:-

A. Pure stand of beans - (K 20)
B. Pure stand of maize - (Hybrid 613[c])
C. Beans planted in alternate rows with maize rows 75cm apart and planted at the

same time.

D. Beans planted between the maize within rows at the same time.

E. Beans interplanted in alternate rows with maize rows after the first weeding of maize.

F. Beans interplanted between maize within rows after the first weeding of maize.

In both years, maize was sown at the spacing of 75 cm between the rows by 30 cm within the rows for both pure and mixed plots. The pure stands of beans were planted at 15 cm within rows. In the mixtures as spacing of 75 cm between the rows was used, within - row spacing remained 15 cm. In 1974 the maize and beans components in the mixture were grown in alternate rows in one treatment and in the 1975 experiment, the two crops were grown in alternate rows in one treatment and the beans were grown within the maize rows at a spacing of 30 cm in the other treatment giving a spacing of 30 cm within rows for beans. The bean population in this case was 44,444 plants per hectare.

3.2.4 The Trial Details

The same plot size of 9m wide by 6m long was used for all trials of 1974 and 1975. Harvested plot area in these experiments also remained the same: 7.5cm wide by 6m long, which is 0.0045 ha.

In both seasons the trials were planted at the onset of the long rains. The trials were seeded with hybrid maize 613^{c}, from the Kenya Seed Company and the K.20 bean variety from the Western Agricultural Research Station, Kakamega. Seeding was done with 60kg/ha of P_2O_5 as single superphosphate and maize plots were further top-dressed with 60kg/ha. N as ammonium sulphate nitrate when maize was at knee-height. Two maize seeds were planted per hill and later thinned to one plant in order to achieve the intended population of 44,444 plants/ha. One seed bean was planted at each hill and no thinning was done. Fertilizer was added in the planting hole for maize and along the furrows for beans to allow for even distribution at planting time. The experiments were maintained clean weeded by hand and routine stalk-borer control by applying 5% DDT dust in the funnels was carried out for maize.

3.2.5 Measurements

Seed yields were measured for samples from 45m^2 within each plot. The number of plants of each crop within the harvested area was counted. All cobs and pods from the harvested area were threshed, cleaned and air dried thoroughly before taking the seed weight. Moisture content was taken with moisture meter (Ceratesta).

3.2.6 Statistical Analysis

The 1974 experiment was a randomised complete block design each with 3 treatments and six replicates. The 1975 experiment was a randomised complete block design and each block containing six treatments and four replicates. The results of the statistical analysis for seed yields and yield components for individual crop of each experiment and at each experimental site are given in Tables 1 to 12 in the appendix. The 1975 experiment was analysed using an orthogonal contrast procedure for the treatments effect for maize yield and maize stand count. The orthogonal contrasts were:-

Pure vs mixed	B	v	CDEF
Early vs late planted beans	CD	v	EF
Alternate rows vs within rows	CE	v	DF

But for the bean yields and stand count only the treatment means and standard error are calculated.

3.3 Results and Discussions

3.3.1 1974 Results and Discussions

Tables 1 and 2 give the yields of maize and bean in kilograms per hectare and plant stand count per hectare. The maize weights have been adjusted to 12.5% moisture content, but the beans were air-dried to constant weight.

Table 1: Comparative Yields and Stand Counts of Pure Stand and Mixed Stands of Maize and Beans at Kakamega 1974

Treatments	Mean Yield in kg/ha	SE mean	Mean Stand Count/ha	SE mean
Pure maize stand	4,911	702	29,147	1,688
Maize in mixture	6,867	702	31,073	1,688
Pure beans stand	1,092	74	134,000	2,444
Bean in mixture	279	43	65,333	4,444

Table 2: Comparative Yields and Stand Counts of Pure Stand and Mixed Stands of Maize and Beans at Sang'alo 1974

Treatment	Mean Yield in kg/ha	SE mean	Mean stand count/ha	SE mean
Pure maize	6,722	222	42,813	458
Maize in mixture	6,633	222	42,702	458
Pure bean stand	440	31	124,222	5,333
Bean in mixture	126	14	61,111	1,333

Maize yields obtained from Kakamega and Sang'alo sites were close to the average in these areas during the normal long rains season. The pure maize yields obtained from Kakamega site were however, lower than expected with that from the mixtures out yielding them. This was perhaps due to too much rainfall soon after planting which resulted in runoff and washing off seeds. The bean yields in the pure stand and from mixture of this experiment varied quite considerably at both sites which could be explained by the variable stand count. The bean yields from Kakamega site (Table 1) were however quite reasonable, especially that from the pure stand. The low bean yields in the mixtures can be attributed in part to their plant density being almost half of the pure stand, but also to reduction in yields per plant due to competition from maize.

Maize yields were not significantly different between mixtures and pure stands. At Kakamega maize yields from the mixtures seemed to have been higher than the pure stands though not significantly different. From Table 1, it can be seen that there were some significant differences between yields of pure bean stands and the intercrops. This as has been mentioned could have been partly due to the plant stands.

The yield results obtained from Sang'alo (Table 2) also indicated that maize yields were not significantly reduced by intercropping with beans. The results in this study have therefore confirmed the earlier conclusions reached by Vickers (1960), Milley and Osiru (1972) and Wakatiani (1974) that mixed cropping maize with beans give a higher total return per unit area. Even on the basis of maize yields there is no evidence that mixed cropping should be discouraged.

3.3.2 1975 Results and Discussions

Table 3 gives the yield results of maize and beans in kilograms per hectare and plant stand count per hectare obtained from Kakamega site in 1975. The maize weights have been adjusted to 12.5% moisture content, but the beans were air-dried to constant weight.. The results of the orthogonal contrast for maize yields show that the general mean of mixed stand v pure is significant and in favour of mixed. The general mean for the mixture was 5980kg/ha as against a mean of 5129kg/ha from pure stand. No other comparison was statistically significant.

Bean yields were as low as 72kg/ha from the mixtures, but reached 594kg/ha from the pure stand. The bean yields obtained from the mixtures was much less than a half from the pure stands which would

Table 3: Mean Yield and Stand Counts of Maize and Beans at Kokanega 1975

Treatments	Mean Yields in kg/ha	SE Mean	Mean Stand Count/ha	SE Mean	Mean Yield in kg/ha	SE Mean	Mean Stand Count/ha	SE Mean
A - Pure stand of beans	-	-	-	-	594	135	35,778	2,311
B - Pure stand of Maize	5,129	307	41,888	757	-	-	-	-
C - Beans inter-cropped between maize rows at the same time	6,067	307	42,388	757	88	18	17,111	2,466
D - Beans inter-cropped within maize rows at the same time	5,673	307	41,944	757	72	9	13,167	933
E - Beans inter-cropped between maize rows after 1st weeding of maize	6,296	307	41,333	757	-	-	-	-
F - Beans inter-cropped within maize rows after 1st weeding of maize	5,884	307	40,500	757	-	-	-	-

NB: There was no bean stand from treatments E and F interplanted after the first weeding of the maize crop in this trial.

be expected if the maize did not compete with beans.

In this experiment it was found that there were no bean yields obtained from the mixed treatments (E and F) where beans were interplanted after the first weeding of maize. Other experiments such as those of Makatiani (1974) and Fisher et al (1976) support this finding. The time of interplanting the bean crop is therefore very important. It is observed from this experiment that the longer period it takes before interplanting the beans, reduced or zero bean yield will be obtained from such treatments.

3.4 Conclusion

The finding of an apparent advantage from mixed cropping of maize with beans from the 1974-1975 experiments confirms the validity of earlier reports made by Vickers (1960), Willey and Osiru (1972) and Makatiani (1974). The yield levels of (1974) seems to be better than those of 1975 and this is probably due to later planting in 1975(11/4/75). The low yields of beans from the mixtures occurred in all experiments. Table 3 shows no bean yields from some of the mixed treatments such as E and F. From these experiments it is evident that time of interplanting the beans should be early. The other point to note from these experiments is that time of interplanting beans may not have great

effect on maize yield as might have been thought earlier. The major objective was to examine whether pure stands yielded more per unit area, and this was shown to be true since maize yields were not different and the bean yields, though low were therefore additive.

Before any firm conclusion could be reached more work based especially on the relative times of interplanting maize-beans was necessary.

4. TIME OF PLANTING EXPERIMENTS 1976

4.1 Objective

An experiment was conducted to establish the best time of intercropping maize and beans in relation to each other. This included treatments in which maize was planted before beans and vice-versa to give information necessary for optimization of the farmer's time during the early part of the rainy season.

4.2 Materials and Methods

4.2.1 Description of Sites

The experiment was carried out at two sites. One was at Western Agricultural Research Station, Kakamega and the other at Alupe Sub-station in Busia District. The experimental site at Kakamega Research Station lies at an elevation of 1,585 metres above sea level with an average annual rainfall of 1919 mm. The soil is a deep well drained fertile volcanic loam with an average pH of 5.5. Alupe sub-station is at an an altitude of 1,300 m. above the sea level with an average annual rainfall of 1,779 mm. The soil of the area is sandy loam of relatively low fertility. At Alupe the soil had been cropped for two years with maize; whereas at Kakamega, the site was newly cleared from a three year natural pasture.

The experiment was conducted during the long rainy season of 1976.

4.2.2 The Statistical Designs

A factorial design of 3 maize times of planting combinations with 3 beans times of planting was for mixed crops with 6 additional pure stand treatments in the three randomised complete blocks, each with 15 plots. The times of planting were spread at seven days intervals and there were three cropping systems namely pure maize (hybrid 613^{c}), pure beans (Canadian Wonder) and maize-bean mixtures. The mixed crops were arranged in alternate rows and pure stands grown for comparison at each planting time.

4.2.3 Experimental Materials

Maize seed was obtained from Kenya Seed Company, Kitale, The long maturity Hybrid 613^{c} was used at Kakamega Experimental Station site, and the medium maturity 512 was used at Alupe sub-station site. Bean seed of the variety Canadian Wonder, were obtained from the farm of the Faculty of Agriculture, University of Nairobi and used at both sites. At both locations 60kg/ha of P_2O_5 as single superphosphate were applied in the planting hole for maize and along the furrows in the case of beans and maize plots were further top-dressed with 60kg/ha of N as Ammonium Sulphate Nitrate.

4.2.4 The Treatments

The details of the Experimental treatments applied were as given in Table 4.

Table 4: The Details of the Experimental Treatments 1976. Planting Dates. Day from 5th April (Kakamega) and 6th April Alupe

Treatments	Maize	Beans	
M_1	0	-	Pure stands in maize
M_2	7	-	
M_3	15	-	
B_1	-	0	Pure stands of Beans
B_2	-	7	
B_3	-	15	
M_1B_1	0	0	Mixed plots (combinations)
M_1B_2	0	7	
M_1B_3	0	15	
M_2B_1	7	0	
M_2B_2	7	7	
M_2B_3	7	15	
M_3B_1	15	0	
M_3B_2	15	7	
M_3B_3	15	15	

M - Maize
B - Beans
1 - First date of planting
2 - Second date of planting
3 - Third date of planting

First planting immediately followed the onset of long rains. At Kakamega the first treatment was planted on 5th April and subsequent treatment at one week intervals. At Alupe the first time of planting was on 6th April and subsequent treatment at one week intervals. Routine work included clean hand-weeding and dusting maize plants against stalk-borer with 5% DDT dust.

4.2.5 The Trial Details

The plot size was 4.5 m x 6.m with a harvested area of 3.0 m wide x 4.8 m long. In the mixtures, both crops were grown in rows 75cm from the next row of the same crop. Alternate single rows of maize and beans were therefore spaced 37.5cm between rows. Thus the mixed stands had maize spaced at 75cm x 30 which was identical to the pure stands. The bean spacing in mixtures was 75cm x 15cm half the density in pure stands with 37.5 x 15cm spacing. The mixed stands therefore consisted of the full pure stand maize plants density plus half the pure stand bean density. Where one crop (maize)is so little affected by the presence of the other (Fisher et al, 1976), it is considered more meaningful to compare this crop at the same density as in pure stand rather than to reduce the density and adopt a replacement series (Willey and Osiru, 1972). This corresponds closely with small-farmer practice.

Two maize seeds were planted per hill and later thinned to one plant in order to achieve the required plant population. One seed of bean was planted at each hill and no thinning done. Fertilizer was added in the planting hole for maize and along the furrows in the case of beans to allow the even distributions at planting time. Top-dressing using ammonium sulphate nitrate was done in maize plots when maize was at knee-height.

The harvest area consisted of the four centre rows of maize after discarding 2 plants at both row ends in either pure or mixed stands per plot. In the pure stands of beans 8 rows were harvested but in the mixtures only 4 rows were harvested after discarding 4 plants at both row ends in either case. The harvested area in all cases remained 4.8m long x 3.0m wide i.e. 14.4m^2 - (0.00144 ha).

4.2.6 Measurements and Records Taken

From the specified harvest area the number of maize plants per plot and the number of maize cobs per plot were counted. Similarly the number of bean plants per plot, and the number of pods per plot were also counted. A sample (200g) of clean seed of both crops was dried in an oven at 90^{o}C for 20 hours and dry weight determined.

The daily rainfall in the areas where this experiment was conducted was recorded for the whole year of experiment (1976).

The time taken per plot in each operation involved in this experiment (especially planting and weeding was recorded at each site for comparison of labour requirements in the different cropping systems.

4.2.7 Statistical Analysis

The experimental design was a 3^2 factorial arrangements of mixed treatments plus 6 pure stands in a randomised complete block design with 15 treatments in 3 replications. The results of the statistical analyses for seed yields and yield components for individual crops at each experimental site are given in Tables 13 to 30 in the appendix. Maize data were analysed as 4 x 3 factorial with pure stands and mixtures together. But for the beam crop the pure stands were analysed separately from the mixtures because of large difference in the error variance between pure stand and mixtures. Table 31 and 32 show the statistical analyses for the equivalent areas.

The statistical analysis for man-hour requirements were done for each site as shown in Tables 33 to 36 in the appendix.

4.3 Results

Before embarking on these results it seems necessary to review briefly the rainfall pattern during the experimental year (1976) in the areas where the trial was conducted.

4.3.1 Rainfall

The daily rainfall figures for the year 1976 were available from the experimental sites and are shown in Table 5. During the growing season, (April - September) monthly rainfall at Kakamega was close to or above average and August was exceptionally wet. At Alupe, rainfall was less than at Kakamega except in September and was well below average in April. Beans were harvested between 2nd and 8th July at both locations. Maize was harvested on 10th September at Alupe location and on 22nd October at Kakamega site.

From Table 5 it can be seen that the amount of monthly rainfall total received compared well with the monthly means at the respective sites.

Table 5: Rainfall Figures in mm During the Year of Experiment 1976 and Monthly Mean for 53 Years at Kakamega and 16 Years at Alupe Experimental Sites

Month	Kakamega		Alupe	
	Monthly total	Monthly mean (53yrs)	Monthly total	Monthly mean (16yrs)
January	66.6	57.0	31.1	69.5
February	95.7	98.6	149.7	84.8
March	118.9	146.9	119.7	142.6
April	219.1	255.5	161.1	278.1
May	312.4	263.1	252.5	249.8
June	158.8	186.2	128.1	110.2
July	148.0	168.6	129.3	77.0
August	330.6	223.2	116.4	141.7
September	163.7	175.3	194.3	169.2
October	48.2	139.1	95.9	179.3
November	130.0	117.6	110.2	190.9
December	67.1	86.7	54.8	85.8
Total	1,859.1	1,918.8	1,543.1	1,779.3

The generally high rainfall at Kakamega (Table 5) during the experimental period is reflected in high maize grain yields (Table 6) and low yields of bean crop (Table 8). The low bean yields are usual in season with heavy rain and are attributable to high disease incidence, especially in the Canadian wonder type.

4.3.2 Grain Yields

The full results for yield and yield components for each crop at individual experimental sites are given in the appendix. The mean data for maize grain in quintals per hectare for the 12 combinations of intercropping maize with bean treatments are presented in Tables 6 and 7.

Table 6: Mean Yield of Maize Grain at 12.5% Moisture (wt. in q/ha): Kakamega 1976

	B_0	B_1	B_2	B_3	Mean	SE mean
M_1	99.8	100.8	85.3	91.5	94.3	3.9
M_2	84.2	82.4	87.3	96.4	87.6	
M_3	71.3	66.8	76.1	81.9	74.0	
Mean	85.1	83.3	82.9	89.9		
SE mean	4.6					

(B0=pure stand of maize) SE body of the table 7.9

L.S.D.	5% level	1% level
For M means	11.5	15.6

Table 7: Mean Yield of Maize Grain at 12.5% Moisture (wt. in q/ha) Alupe 1976

	B_0	B_1	B_2	B_3	Mean	SE mean
M_1	42.0	23.1	37.6	38.5	35.5	
M_2	34.9	39.0	33.1	37.3	36.1	
M_3	33.3	22.6	30.6	29.9	29.1	2.7
Mean	36.7	28.2	33.8	35.3		
SE mean		3.1				

SE body of table 5.3

The mean maize grain yields from Kakamega were higher than those obtained from Alupe, as expected with overall mean of 85.3 q/ha and 33.5 q/ha respectively. It was also noted that maize yield realized at Alupe fell short of the long term average for the station (Goldson 1963).

The results of maize grain yield from both sites indicated very clearly that the time of maize planting caused some remarkable difference in yield. The highest yields were obtained with the early planting of maize particularly at Kakamega although this was not significant. It was observed that the presence or absence of beans and even their time of planting was not significant and had no obvious effect on maize yields at Kakamega, but at Alupe the trend is that the early planted beans may have some

adverse effect on maize yields.

Tables 8 and 9 show the mean grain yields in kg/ha at Kakamega and Alupe experimental sites respectively. At Kakamega, the time of planting effect of beans were found insignificant and smalll in pure standsbut large and significant in mixtures. At Alupe location the time of planting effects were significant both in pure stand and mixtures. The coefficient of variation for the pure stands was very large. 1165kg/ha of pure stand beans were obtained from 1st date of planting at Alupe and 650kg/ha from Kakamega. The results indicated that the yields were considerably reduced especially at Kakamega. If the bean yields in mixtures were compared to those in corresponding pure stands mixed cropping is clearly seen to reduce yields to 14-36% of pure stands.

Table 8: Mean Yield of dry bean grains in kg/ha at Kakamega 1976

Pure stand:

B_1	B_2	B_3	Mean
647.5	597.2	531.7	592.1

SE mean 61.8

Mixed stand:

	B_1	B_2	B_3	Mean	SE mean
M_1	233.3	278.9	76.2	196.1	12.2
M_2	244.7	181.7	86.1	170.8	
M_3	269.7	135.0	102.1	169.0	
Mean	249.2	198.5	88.1	178.6	

SE mean 12.2

SE body of table 21.2

L.S.D.	5% level	1% level
Main treatment effect of B	36.6	50.4
Interaction effect of M x B	89.7	123.6

Table 9: Mean yield of dry bean grains in kg/ha at Alupe 1976

Pure stand:

B_1	B_2	B_3	Mean
1164.8	301.6	353.9	606.8

SE mean 147.8

L.S.D.	5% level	1% level
T.O.P. effect	580.2	-

Mixed stand:

	B_1	B_2	B_3	Mean	SES mean
M_1	410.0	297.2	149.8	285.6	21.7
M_2	465.0	301.6	121.1	295.9	
M_3	484.7	149.8	101.6	245.4	
Mean	453.2	249.5	124.2	275.6	

SE mean 21.7

SE body of table 37.6

L.S.D.	5% level	1% level
Main treatment of B	65.0	89.6

The mean gross return in shillings per hectare for various treatments is given in Tables 10 and 11 derived from December 1976 local market prices of 85 cents per kg. of shelled maize and shs. 2/= per kg. of clean bean seeds. Generally at both sites,

the results clearly indicated that intercropping maize with beans gave higher gross cash returns from the same unit land area than either crop grown alone in pure stand. Some treatments are shown to be generally more profitable than the others due perhaps to the time of planting. There were some significant differences among the treatments at both sites.

Table 10: Mean grain yields and gross return of crops in Shs/ha at Kakamega 1976

RANK	TREATMENT	YIELD IN KG/HA MAIZE	BEANS	GROSS RETURN IN SHS./HA.
1	M_1B_1	10,080	230	9,028.00
2	M_1	9,900	-	8,415.00
3	M_2B_3	9,440	90	8,204.00
4	M_1B_3	9,150	80	7,939.50
5	M_1B_2	8,530	280	7,810.50
6	M_2B_2	8,730	180	7,780.50
7	M_2B_1	8,240	250	7,504.00
8	M_3B_3	8,190	100	7,161.50
9	M_2	8,420	-	7,157.00
10	M_3B_2	7,610	140	6,748.50
11	M_3B_1	6,680	270	6,218.00
12	M_3	7,130	-	6,060.50
13	B_1	-	650	1,300.00
14	B_2	-	600	1,200.00
15	B_3	-	530	1,060.00

Notes: The local market prices as in December, 1976.

(a) Shelled maize at 85 cents per kilogramme.

(b) Shelled clean bean seeds at shs. 2/= per kilogramme.

Table 11: Mean grain yields and gross return of crops in Shs./ha. - at Alupe 1976

RANK	TREATMENTS	YIELDS IN KG/HA MAIZE	BEANS	GROSS RETURN IN SHS./HA.
1	M_2B_1	3,896	465	4,241.60
2	M_1B_2	3,763	297	3,792.55
3	M_1B_3	3,854	150	3,575.90
4	M	4,201	-	3,570.85
5	M_2B_2	3,313	302	3,420.05
6	M_2B_3	3,736	121	3,417.60
7	M_2	3,493	-	2,969.05
8	M_3B_2	3,056	150	2,897.60
9	M_3B_1	2,264	485	2,894.40
10	M_3	3,333	-	2,833.05
11	M_1B_1	2,305	410	2,779.25
12	M_3B_3	2,993	102	2,748.05
13	B_1	-	1,165	2,330.00
14	B_3	-	354	708.00
15	B_2	-	302	604.00

Notes: The local market prices as in December, 1976

(a) Shelled maize at 85 cents per kilogramme.

(b) Shelled clean bean seeds at shs. 2/= per kilogramme.

From tables 10 and 11 given above, it appears that intercropping maize with beans may be beneficial to small farmers in the region. These results also indicated that to gain the advantage in mixed cropping, both crops must however be planted early.

4.3.3 Equivalent Areas

The equivalent ar as (Tables 12 nd 13) give the summary of the production of mixed crops in terms of the total area of pure stands of the component crops (maize and beans) which would have been required in the same sites to give the same yield for each crop (Fisher 1977[b]).

Table 12: Equivalent Areas for mixed Treatments:1976 at Kakamega

	B_1	B_2	B_3	Mean	SE mean
M_1	1.39	1.36	0.99	1.25	
M_2	1.37	1.31	1.21	1.30	0.064
M_3	1.38	1.31	1.26	1.32	
Mean	1.38	1.33	1.15		
SE mean		0.064			

SE body of table 0.11

Table 13: Equivalent Areas for mixed Treatments: Alupe 1976

	B_1	B_2	B_3	Mean	SE mean
M_1	0.98	1.70	1.26	1.31	
M_2	1.62	1.95	1.47	1.68	0.13
M_3	1.28	1.33	1.32	1.31	
Mean	1.30	1.66	1.35		
SE mean		0.13			

SE body of table = 0.23

$$\text{Equivalent area} = \frac{\text{Yield of maize in mixture}}{\text{Yield of maize in pure stand}} + \frac{\text{Yield of bean in mixture}}{\text{Yield of bean in pure stand}}$$

In this calculation each time of intercropping was dealt with separately i.e. pure stand of each time of planting was compared with the corresponding time of planting the intercrop in each block at each time.

From tables 12 and 13, a valve less than 1.0 indicates that the cropping system (mixtures) used were less productive than pure stands of either crop. At both sites mixtures had values higher than 1.0 with exception of M_1B_1 treatment at Alupe and M_1B_2 treatment at Kakamega, but these were not significantly less than 1.0. The B effects illustrated a decrease in the advantage from mixing with delay in planting of beans at Kakamega though this was not significant. At Alupe there were no obvious trend.

4.3.4 Components of Yield for Maize and Beans

At both experimental sites maize plant densities at harvest in both pure stand and mixtures (tables 14 and 15) were approximately the same but the planned density of 44,444 plants/ha was not achieved.

Table 14: Results of Maize stand count/ha: Kakamega 1976

	B_0	B_1	B_2	B_3	Mean	SE mean
M_1	43,981	44,213	43,750	43,898	43,458	506.9
M_2	43,056	39,815	41,435	43,750	42,014	
M_3	42,130	40,740	42,361	43,056	42,069	
Mean	43,056	41,590	42,514	43,903		
SE Mean		583.3				

SE body of table 1,006.9

Table 15: Results of Maize stand count/ha: Alupe 1976

	B_0	B_1	B_2	B_3	Mean	SE mean
M_1	37,037	32,407	34,028	37,731	35,299	1,245
M_2	36,343	37,261	36,574	29,398	34,896	
M_3	40,741	34,722	38,194	33,333	36,750	
Mean	38,042	34,799	36,264	33,486		
SE mean			1,437			

SE body of table 2,489

There was a big difference in the maize stand count between the two experimental sites. At Kakamega (Table 14) the actual plant densities fell just short of planned values (44,444 per ha) but at Alupe some treatments were far from the planned maize count. This was thought to be due

to termite damage and Striga weed which occurred on this site.

The presence or absence of beans and the time of planting had no significant effect on maize stand counts but at both sites, pure stands had a slightly higher count than mixtures.

Tables 16 and 17 indicate maize yields per plant obtained at Kakamega and Alupe sites respectively. There was no significant effect or interaction at any site. According to the main effect means, the early planting of beans tended to reduce maize yield at Alupe but this was not clearly shown at Kakamega. Late planting of maize reduced maize yields both in pure stand (B_0) and generally in mixtures.

Table 16: Results of maize seed weight in grams per plant (oven dry): Kakamega 1976

	B_0	B_1	B_2	B_3	Mean	SE mean
M_1	227.20	227.85	194.99	223.77	218.45	8.89
M_2	195.46	206.89	211.28	220.30	208.48	
M_3	170.07	161.49	178.10	189.79	174.86	
Mean	197.58	198.74	194.79	214.62		
SE mean		10.27				

SE body of table 17.79

Table 17: Results of maize seed weight in grams per plant (oven dry) Alupe, 1976

	B_0	B_1	B_2	B_3	Mean	SE mean
M_1	113.21	72.30	111.02	103.33	100.22	8.47
M_2	97.10	105.12	92.16	131.08	106.37	
M_3	85.24	64.01	80.33	80.33	92.67	
Mean	98.52	80.48	94.50	109.36		
SE mean		9.78				

SE body of table 16.94

The average number of usable ears per plant at the two experimental sites are shown in tables 18 and 19 (lowest number per plant was 0.8 and the highest was 1.05). There were no significant differences among the treatments at both sites. At Kakamega the main effect of M indicates steady decrease in the number of ears per plant as the time of planting is delayed. Thus the number of barren plants per hectare is reduced by early planting of maize. The time of planting the beans seems to have very little effect on maize ears per plant. However, the presence of beans shows better results than their absence though not significant at either site. It seems that the absence of beans caused more barren plants per unit area than their presence for example at Kakamega site there were 6,028 plants/ha without ears against, 2,912 plants/ha

in the treatments with beans. The late planting of beans tended to give some advantages to the cob formation at Alupe. The maize yields per plant decreased in all cases as the number of cobs per plant decreased.

Table 18: Results of number of usable ears/plant. Kakamega 1976

	B_0	B_1	B_2	B_3	Mean	SE mean
N_1	0.94	1.00	0.89	0.97	0.95	
N_2	0.84	0.98	0.93	0.90	0.91	0.03
N_3	0.81	0.80	0.87	0.92	0.85	
Mean	0.86	0.93	0.90	0.93		
SE mean		0.03				

SE body of table 0.05

Table 19: Results of number of usable ears/plant Alupe 1976

	B_0	B_1	B_2	B_3	Mean	SE mean
N_1	0.85	0.91	0.88	0.92	0.89	
N_2	0.88	0.96	0.93	1.05	0.96	0.05
N_3	0.95	0.83	0.88	1.05	0.93	
Mean	0.89	0.90	0.90	1.01		
SE mean		0.05				

SE body of table 0.09

The bean yield components are shown in Tables 20 to 27. At both experimental sites bean plant densities in mixtures were approximately half of those in pure stand (tables 20 and 21), both the planned population of 177,177 plants/ha for pure stand and 88,888 plants/ha for the mixtures were not achieved. At both sites all the treatments fell far below the planned densities. This was probably due to damping off disease which is common in years with excessive rainfall. At Kakamega there were no significant differences among the treatments but at Alupe site there were significant differences among the main effects but the M x B interaction was not significant.

Table 20: Results of bean stand count/ha: Kakamega 1976

Mixed stand:

	B_1	B_2	B_3	Mean	SE mean
M_1	57.176	58,796	47,685	54,556	3,106
M_2	55,787	53,935	50,463	53,396	
M_3	52,778	54,166	43,981	50,306	
Mean	55,250	55,631	47,375	52,752	

SE mean 3,106

SE body of table 5,380

Pure stand

B_1	B_2	B_3	Mean
106,944	105,069	89,583	100,540

SE mean 145

Table 21: Results of bean stand count/ha: Alupe 1976

Pure stand

B_1	B_2	B_3	Mean
120,833	108,541	108,125	112,499

SE mean 8,426

Mixed stand

	B_1	B_2	B_3	Mean	SE mean
M_1	58,101	46,296	41,898	48,764	2,173
M_2	61,805	55,324	46,528	54,556	
M_3	53,009	42,361	45,833	47,069	
Mean	57,638	47,993	44,750	50,129	
SE mean	2,173				

SE body of table 3,763

At both sites the bean stand count decreased as planting was delayed. Time of planting the maize also had some effect on the bean stand at Alupe. Even in the pure stand treatments late planting reduced stand count with the 3rd planting date resulting in the lowest bean stand count per unit area of land especially at Kakamega location.

The mean seed yields per plant of beans in the mixture were lower than those in pure stands by 46.3% at Kakamega and greater by 2.5% at Alupe.

These differences in yield per plant of beans were a reflection of the number of pods per plant at each site. Time of planting effect on the mean bean yields per plant at both sites are indicated in Tables 22 and 23.

Table 22: Bean grain yields in grams/plant (oven dry) :- Kakamega 1976

Pure stands

B_1	B_2	B_3	Mean
6.41	6.10	6.08	6.20

SE mean 0.34

Mixed stands

	B_1	B_2	B_3	Mean	SE mean
M_1	4.00	4.73	1.65	3.46	
M_2	4.39	3.37	1.79	3.18	0.16
M_3	5.16	2.54	2.29	3.33	
Mean	4.52	3.55	1.91	3.32	

SE mean 0.16

SE body of table 0.27

Table 23: Bean grain yields in grams/plant (oven dry): Alupe 1976

Pure stands

B_1	B_2	B_3	Mean	SE mean
9.47	2.79	3.22	5.16	0.98

Mixed stands

	B_1	B_2	B_3	Mean	SE mean
M_1	7.05	6.57	3.56	5.73	
M_2	7.53	5.36	2.63	5.17	0.38
M_3	9.15	3.52	2.20	4.96	
Mean	7.91	5.15	2.80	5.29	
SE mean		0.38			

SE body of table 0.66

At Alupe the effects of time of planting were large and highly significant in both pure stands and mixtures. The early planting of beans tended to give better results of bean yields per plant at both sites than late planting. The M x B interactions were significant at both sites because the early and late planted beans (B_1: B_3), benefited from late planting of maize but the second time of bean planting showed the opposite trend. Tables 24 and 25 show the results of the number of pods per plant at Kakamega and Alupe respectively.

Main effects of B were significant at both sites. The main effect of M was only significant at Kakamega. However the number of pods per plant were higher in pure stands than in mixtures except for B_2 at Alupe due to the component from maize crop in the mixtures. The time of planting effect of beans indicated that the early planted beans give better results than late planted ones at both experimental sites. The only exception was B_2 at Kakamega where number of pods were greatly reduced perhaps due to a stresson the plants at a critical stage for pod retention. The time of planting maize seemed to affect the number of pods per plant even if the bean crop was planted early. Tables 24 and 25 indicate these effects clearly.

Table 24: Number of pods per plant: Kakamega, 1976

Pure stand

B_1	B_2	B_3	Mean
4.87	2.55	3.63	3.68

SE mean 0.73

Mixed stand

	B_1	B_2	B_3	Mean	SE Mean
M_1	3.07	1.33	1.20	1.87	0.21
M_2	2.17	1.90	1.23	2.10	
M_3	3.80	2.03	1.80	2.54	
Mean	3.34	1.76	1.41	2.17	

SE mean 0.21

SE body of table 0.37

Table 25: Number of pods per plant: Alupe 1976

Pure stand

B_1	B_2	B_3	Mean
5.67	2.73	2.63	3.68

Mixed stand

	B_1	B_2	B_3	Mean	SE mean
M_1	4.90	3.53	2.87	3.77	0.60
M_2	5.27	4.90	1.97	4.04	
M_3	6.17	2.90	2.67	3.91	
Mean	5.44	3.78	2.50	3.91	

SE mean 0.60

SE body of table 1.03

It is seen from these tables that late planting of maize allows more pods per bean plant than early planted maize with the exception of main effect of M_2 at Alupe site.

Tables 26 and 27 indicate that the mean seed weight per pod was reduced by 5.9% and 3.4% in mixtures compared with pure stands at Kakamega and Alupe sites respectively. The decrease in seed weight per pod was slight, but consistent. At both sites the seed weight per pod was significantly reduced in the mixtures by the late planting of either crop except beans at Kakamega but there was no significant effect on pure stands. The high seed weight per pod in B_2 at Kakamega seems to be a compensation for greatly preduced pod numbers, perhaps due to a stress on the plant at a critical stage for pod retention. Generally the seed weight per pod was fairly low and this corresponds with the seed weight per plant at both sites.

Table 26: Seed weight in grams/pod (oven dry)
Kakamega 1976

Pure stand

B_1	B_2	B_3	Mean
1.52	2.38	1.69	1.86

SE mean 0.28

Mixed stand

	B_1	B_2	B_3	Mean	SE mean
M_1	1.35	4.00	1.42	2.26	0.24
M_2	1.51	2.05	1.48	1.68	
M_3	1.36	1.26	1.32	1.31	
Mean	1.41	2.44	1.41	1.75	

SE mean 0.24

SE body of table 0.42

Table 27: Seed weight in grams/pod (oven dry)
Alupe 1976

Pure stand

B_1	B_2	B_3	Mean
1.94	1.19	1.32	1.48

SE mean 0.43

Mixed stand

	B_1	B_2	B_3	Mean	SE mean
M_1	1.56	1.86	1.32	1.58	0.12
M_2	1.60	1.20	1.34	1.38	
M_3	1.75	1.45	0.81	1.34	
Mean	1.64	1.50	1.16	1.43	

SE mean 0.12

SE body of table 0.22

4.3.5 Labour Requirements

The treatment means for planting operation are presented in tables 28 and 29 for Kakamega and Alupe sites respectively. At both experimental sites pure bean planting took significantly more labour than maize. Planting pure maize required significantly less labour input than either pure beans or maize-bean mixtures presumably because of the seed population which was less in the case of pure maize stands. Interplanting maize with beans at the same time or maize first and beans interplanted after the emergence of maize appear to be of some advantage over beans first though not significant. The time required for weeding at Kakamega and Alupe presented in tables 30 and 31 show nearly the same picture as in planting. In both cases there was no significant variation in labour requirements among the mixtures.

Table 28: Labour input for Planting in hrs/ha. Kakamega 1976

Pure Time of planting	Pure stand Maize	Pure stand Beans		Mixtures B_1	Mixtures B_2	Mixtures B_3	Mean	CE mean
1st	72	148	M_1	142	124	124	130	
2nd	68	93	M_2	138	126	117	127	5
3rd	56	109	M_3	121	134	115	124	
Mean	65	117	Mean	134	128	119	127	
CE mean	10		SE	5				

SE body of table 9.

Table 29: Labour input for Planting in hrs/ha: Alupe 1976

Time of planting	Pure stand Maize	Pure stand Beans		Mixtures B_1	Mixtures B_2	Mixtures B_3	Mean	SE
1st	58	154	M_1	107	109	93	103	10
2nd	74	124	M_2	148	124	136	136	
3rd	58	89	M_3	152	142	126	140	
Mean	63	122	Mean	136	125	118	126	
SE	16		SE	10				

SE body of table 16

Table 30: Labour Input for Weeding in hrs/ha Kakamega 1976

Time of planting	Pure stands Maize	Pure stands Beans		Mixtures B_1	Mixtures B_2	Mixtures B_3	Mean	SE
1st	154	185	M_1	228	154	124	169	
2nd	148	148	M_2	136	179	136	150	6
3rd	99	173	M_3	148	142	124	138	
Mean	134	169	Mean	171	158	128	152	
SE	17		SE	6				

SE body of table 11

Table 31: Labour input for Weeding in hrs/ha: Alupe 1976

Time of Planting	Pure stands Maize	Beans		Mixtures B_1	B_2	B_3	Mean	SE
1st	105	173	M_1	142	117	124	128	7
2nd	124	142	M_2	124	154	111	130	
3rd	111	148	M_3	161	105	130	132	
Mean	113	154	Mean	142	126	121		
SE	11		SE	7				

SE body of table 12

Tables 32 and 33 give the summary of labour input in hours per hectare, cash value and output per man hour in shillings of each treatment used in these experiments. Output per man hour is based on early season labour only because this is the time of peak labour requirement. The results indicate that time of planting greatly affected the output per man hour at Kakamega but to lesser extent at Alupe. Even in the mixtures early planting of maize gave better output per man hour than most of the other treatments. The time of planting pure beans at Kakamega gave a negligeable difference in output per man hour and this is thought to be due to disease attack. At Alupe early planted pure beans gave higher output per man hour (Table 33).

Table 32: Labour input in hrs/ha. Cash Value (Shs/Ha.) and Output per man hour in Shillings: - Kakamega 1976

Treatments		Planting	Weeding	Cash	Output/ man hrs
M_1)	Pure	72.0	154.3	8,415.00	37.00
M_2)	Stand	67.9	148.2	7,157.00	33.00
M_3)		55.6	98.8	6,061.00	39.00
B_1)	Pure	148.2	185.2	1,300.00	4.00
B_2)	Stand	92.6	148.2	1,200.00	5.00
B_3)		109.1	172.8	1,060.00	4.00
M_1)	Main effect of M in mixtures	129.7	169.0	8,259.00	28.00
M_2)		126.9	150.0	5,496.00	20.00
M_3)		123.5	138.0	6,710.00	27.00
B_1)	Main effect of B in mixtures	133.7	171.0	7,583.00	25.00
B_2)		127.6	158.0	5,114.00	18.00
B_3)		118.7	128.0	7,768.00	31.00

5. DISCUSSIONS

Wide variation in mean grain yield levels from one season to another can be expected in any type of crop experiment. This is mainly due to variations in many complex environmental factors such as soil conditions, rainfall, cultural practices and incidence of pests and diseases. Most of the differences observed in the 1974-1976 results were because of either less rainfall, low soil fertility, incidence of pests and diseases attack or late planting of treatments (Wright, 1955-56, Evans, 1960, Grimes, 1963, Allan, 1971 and Acland, 1971).

In general the main objectives of 1974-1976 experiments were to give the necessary information on the effects of intercropping maize with beans on the production of either crop or total production per unit area under environmental conditions of Western Kenya. At both Kakamega and Sang'alo sites, the soils are of high fertility with reasonably well distributed and adequate rainfall. But at Alupe, the soil is of low fertility with low rainfall which in most years is irregularly distributed during the cropping period.

In spite of seasonal variability mean grain yields from the different treatments, the results have clearly shown that the intercropped

treatments substantially increased production per unit area of land in each of the 3 years of experiment. These findings undoubtedly support the early results of the majority of field experiments in the tropics reported by Crowther (1949), Munro (1958-60.), Grimes (1963), Evans (1960), Andrews (1972), Willey and Osiru (1972), Osiru and Willey (1972 and 1976), Enyi (1973, Wakatiani (1974), Marimi (1975), Fisher et al (1976) and Fisher (1977[b]) that mixed cropping systems are more productive per unit area than monoculture.

The evidence that mixed cropping of maize with beans give higher total production per unit area of land was clear in the first year of experiment (1974). The results of 1974 from Kakamega site (Table 1) show that the maize yields in the mixtures were higher than in pure stands though not significant. This suggests that the maize yield may be influenced by the presence of intercropped beans. The bean yields in the mixtures were significantly reduced (Table 1) due to competition from the maize crop. This supports the findings of Vickers (1960), Willey and Osiru (1972), Wakatiani (1974, Marimi (1975) and Fisher et al (1976) all of whom found that the beans had reduced yield in mixture. At Sang'alo site, maize yields were slightly

higher in the pure stands than in the mixtures but not significantly different. These results agreed in part with the findings of Njeru (1974) from his preliminary observations at Embu that maize yields from interplanted plots were reduced by nearly 40% relative to pure stands. Enyi (1973) and Agboola and Fayemi (1971) also found similar responds from their work. Fisher (1977[b]) found that maize yields were reduced in some seasons and attributed this to competition for water in the low rainfall seasons. This might also explain the results of Njeru (1974). The results of the bean yields from Seng'elo (Table 2) were lower than anticipated especially from pure stands. This is thought to be due to too much rainfall soon after planting which resulted in runoff and washing away of seeds leading finally to variable bean stand count.

In 1975 only one experiment was conducted at Kakamega site to provide information relating to the best arrangements of maize and beans and time of interplanting beans. The results obtained using the orthogonal contrast for maize yields show that the general mean of mixed stands vs pure is significant and in favour of mixed. The mixture mean was 5980kg/ha. as against a mean of 5129kg/ha. from pure stand. The variable crop arrangement of maize-bean mixtures did not significantly

affect the yield of maize or of beans. There was no bean yield obtained from the second time of interplanting which was done about 20 days after the first weeding of maize (Table 3). But the bean yields within the first time of intercropping were not significantly affected by crop arrangement. The time of planting might have affected the bean yields in this experiment. This is supported by the findings of Makatiani (1974), Ibagaya (1974), Fisher et al (1976) and Osiru and Willey (1974). In general bean yields in some of the mixtures were only a fraction of those in pure stands.

From this experiment it is observed that the time of interplanting the beans is more important than the crop arrangement. The longer the period before interplanting the beans, the more the yield is reduced.

In 1976 the results from the two experimental sites showed generally that higher yield production per unit area was obtained by intercropping maize with beans. This corresponds with the earlier findings of similar trials by Vickers (1960), Norman (1971 and 1974), Fisher et al (1976), Willey and Osiru (1972), Makatiani (1974) and Fisher (1977[b]). These results clearly demonstrated that the grain yields of each of the two crops involved decreased with late planting

at both locations in pure stand and in mixtures. It is also seen from these results that the advantages of the mixtures decreased markedly with delayed planting of either crop. This pattern of results is supported by the earlier findings of Goldson (1963) on the effect of time of planting of maize grain yields in Kakamega and Busia districts. It is also in agreement with the results of Vickers (1960), Allen (1968[a] and 1971), Makatiani (1974), Osiru (1974), Mbagaya (1974), Wort&Waghe Kere (1976), Osiru and Willey (1976) and Fisher et al (1976).

The different effects of various methods used in intercropping these trials on the grain yields can be seen in Tables 6 to 27 where the mean data shows the performance of the 3 relative times of planting of the two crops in Western Kenya. Although the yields of either one or both crops in the mixtures have been shown to be lower than their respective yields in pure stands in some cases (beans) the combined yields from the mixtures have been higher than the yields of either crop in pure stand. Tables 10 and 11 indicate clearly that gross cash returns per unit area from both experimental sites for 1976 have been greater from maize-bean mixtures than monoculture.

The only exception is the pure maize planted early at Kakamega which tends to give higher gross returns per unit area than most of the mixtures probably due to disease attack on beans at this location which reduced the bean yields greatly. This finding is in line with the results of Mukhtani (1974). It is also supported with the results of some early work done on maize mixed with other cash crops like cotton or legumes by Wright (1955-56), Grimes (1963), Reddy and Rao (1965), Norman (1971 and 1974) and Brown (1971). In contrast some recent work on maize-cotton and maize-sorghum carried out at Kibos in Western Kenya by Nyaisawa (1973-1976) show that decrease in cash gross returns from the mixtures per unit land area was about 49% as compared to that from pure stands of either crop. Generally the gross cash return per unit area from Kakamega site is higher than that from Alupe. This variable gross return from one site to another is due to different yields caused by the variability in soil fertility - (low soil fertility at Alupe) and also to the incidence of disease attack on beans at Kakamega as has been mentioned here earlier. Maize gave a large highly significant response to early planting in both mixtures and pure stands. Beans responded in the same trend with the third time of planting giving the least

yield at both sites. This suggests that it may be possible to get the highest yield from maize-bean mixtures by intercropping these crops early at the onset of rains. Allen (1971) Osiru and illey (1976) and Fisher et al (1976) also made the same suggestions from their respective experiments with either pure maize or maize-bean mixtures. The same suggestion applies for the beans.

From the yield component results it is possible to assess the effect of intercropping maize with beans on either maize or bean yields in relation to their time of planting. The mean data from the two experimental sites (Kabanega and Alupe) during the long rains of 1976 indicated that maize grain yields per plant was higher in the mixtures than in the pure stand of comparable planting time. But in these experiments maize stand count in pure stand and in the mixtures remained the same. Osiru and illey (1976) using the replacement method found increased maize yields per plant from their studies on maize-bean mixtures with particular emphasis on the time of planting beans at Kabanyolo, Kampala Uganda. In some of their treatments where $\frac{2}{3}$ maize + $\frac{1}{3}$ bean mixtures were used, maize was the dominant crop and had therefore less competition from the beans than from the maize

plants which they replaced. These results suggested that the presence of beans tended to decrease the levels of barreness and increased the number of ears per plant. The results also suggested that competition from the beans did not reduce the maize yields (1976 experiments), probably as a result of no competition for water at critical stage of growth (Table 18). The early planted maize gave more ears per plant than the late planted maize but this was not significant. Late planting greatly affected the maize yields per plant. This kind of response was highly reflected in the production of maize yields per plant. The late interplanted beans showed some advantage effect on the number of ears per maize plant at both sites. These effects were found to be linear and positively related to the relative time of planting the two crops.

Maize yields per plant were increased where beans were interplanted after the emergence of maize or where these crops were intercropped at the same time and early at the onset of rains. This suggested that when beans were interplanted after the emergence of maize the disturbance caused on the maize growth by the planting team was less to the growing crop. This is thought to be better than interplanting the bean crop at the time maize is just starting to emerge because the planting team

may easily walk over the young seedlings which are about to emerge through the soil. Generally interplanting maize after beans gave no definite advantage to maize yields in these experiments.

The beans grain yields per plant in the mixtures were sharply reduced by maize competition at Kakamega. The yield component results show that this reduction in yield per plant could be attributed to a very large reduction in pod number/plant (Tables 24 and 25) and a small reduction in seed weight/pod. The reduction of bean yields in these trials was also thought to be attributed to increased pod abscission (Fisher, 1977[b]). These results are in line with the earlier results obtained by Vickers (1960), Mukatiani (1974) and Fisher et al (1976). Agboola and Fayemi (1971) also found from their maize-legume mixtures that legume yields were suppressed by maize competition. These unexpected findings also suggested that more research work was required into the cause of pod abscission. The findings suggested that breeders should select for a bean variety which is resistant to pod abscission for improved bean yields in mixtures with maize.

The results indicate that the time of planting effects of either beans or maize were large and highly significant both in pure stands and mixtures at Alupe. But at Kakamega the effect was only significant in mixtures. Early planting of beans has generally shown higher yielding potential per plant than late planting irrespective of when maize is planted at both sites (Tables 22 and 23). The early planted or early intercropped beans give better pod yields per plant than the late planted beans. Late planted beans were more subject to reduction in pod number by competition from the maize than early planted beans. The results also suggested that interplanting of maize later or its absence in the bean crop gave beans better chance to produce higher yields (Tables 8 and 9). The decrease in bean yields relative to late planting has been shown by Vickers (1960), Makatiani (1974), Mbagaya (1974), Tsehane Gebrekidan (1976) Osiru and Willey (1976), Fisher et al (1976) and Anthony and Willimott (1957) who reported that legumes respond to early planting.

Delayed time of planting or interplanting beans significantly decreased bean stands. The effect of time of planting was particularly observed in

the pure stand count with the 3rd planting date resulting in the lowest bean stand count per unit area of land which might have been partly responsible for low bean yields.

When comparison of the productivity of maize-bean mixtures with the pure stand yields of these crops planted at the same time was made the equivalent area (Table 12 and 13) were usually greater than 1.0. The only treatments whose values were slightly less than 1.0 were M_1B_1 and M_1B_3 at Alupe and Kakamega respectively. This indicated that in these experiments there was greater return per unit area in the mixtures than that obtained from a corresponding pure stand of either crop. Both Kakamega and Alupe sites where these experiments were conducted appeared to show almost equal response to mixing with the overall means of 1.29 and 1.43 for Kakamega and Alupe sites respectively. This may be due to variation in soil fertility of the two areas which might have led to high maize yields both in mixtures and pure stands at Kakamega. The findings from the equivalent area results that there is some advantage from maize-bean mixtures at both experimental sites corresponds well with the earlier findings of Evans (1960), Vickers (1960), Willey and

Osiru (1972), Fisher et al (1976) and Fisher (1977[b]). There was no significant effect of time of planting of either crop or M x B interaction, but better results of equivalent areas were obtained with the first or second planting. This is in agreement with the results of the work of Fisher et al (1976) conducted in Western Kenya on maize-bean mixtures with special reference to bean cultural treatments. This is also supported with the findings of Osiru (1974), Hart and Magha Kewe (1976) and Osiru and Willey (1976). Highest equivalent area at Alupe with lowest maize yields agrees with the results of Fisher et al (1976) who found that high equivalent areas were associated with lowest maize yields at three sites in the west of Kenya.

The present study was not designed to determine the economics of production of maize-bean mixtures as compared to pure stands of either crop, however, incorporation of such a study would undoubtedly lead to more suitable recommendation for the system in the region. To give some rough ideas on the labour input, cash gross return and output per man hour some calculations were made from the results of 1976 experiments. The results were based on the maize-bean mixtures with special reference

to relative time of planting of the two crops in Western Kenya. More and highly significant labour was required for planting pure beans than almost all other treatments. This was thought to be due to the closer spacing of the pure bean stands. Planting and even weeding puré maize stands required significantly less labour input than either pure beans or maize-bean mixed stands perhaps because of the seed population which was less for pure maize stands. Labour inputs for either planting or weeding the mixtures at different planting dates were not significantly different.

The output per man hour was calculated using the local selling prices for maize and beans (Tables 10 and 11). The labour requirement used in this text was based on time taken in planting and weeding in hours per hectare. The early planted pure maize stand gave higher output per man hour than most of the other treatments. Pure bean stand generally gave the lowest output per man hour. This was because of less production per unit area compared to either that of pure maize stands or mixtures. Early planting of maize either in pure stand or in mixtures gave good output per man hour (Tables 32 and 33).

The results obtained in this study support the findings of Norman (1971 and 1974) and Makatiani (1974) that more gross return is made from mixtures than from pure stands of either crop. But this was found to be in contrast with the output per man hour-where pure maize stand with early planting gave higher results at both sites. The cash advantage was highest at Kakamega where the equivalent area was lowest and lowest at Alupe where the equivalent area was highest. It is also seen from the summary of results that planting maize in the growing beans had more labour input with less output per man hour compared to beans interplanted after maize. This suggested that in the treatments where no extra care was needed to avoid trampling on the germinating beans the labour was cheap. The results also indicated that it is not advantageous to interplant maize after the beans.

6. CONCLUSIONS AND FURTHER RESEARCH

Total productivity per unit area of land has been one of the basic considerations in evaluating these experiments on maize-bean mixtures carried out in Western Kenya during 1974-1976 long rains. The most obvious conclusion to be drawn from these experimental results over several sites and seasons is that total yield production of maize-bean mixtures per unit area of land was considerably higher than that obtained from the two crops grown separately. From these results it is not easy to relate the higher yield results obtained from the mixtures to any of the factors which have been suggested for the advantage of mixtures under the small scale farming conditions in the tropics. There was no crop failure due to either drought or disease.

The results indicated that there was no evidence of maize yields being reduced by interplanting beans and in fact maize yields in the mixtures were in general slightly higher than those from pure stands. This was found to be true throughout the 3 years of experiments except possibly at Alupe in 1976. This slight overall advantage of maize yields in the mixtures requires more detailed study.

It will be seen from the foregoing brief discussion of 1975 experimental results that the planting pattern of the intercrops did not affect the yield of beans. The beans planted in the maize rows giving the same response as the beans planted between the maize rows. Delaying the planting of the beans until the first weeding of the maize which was done after 20 days reduced the yield of bean to zero (Table 3).

In 1976 it has been seen that the effect of late planting is of great disadvantage for both crops in their final grain yields. Late planting of either maize or beans reduced their yields quite considerably. Planting at the onset of rains is therefore essential.

The yield increases resulting from maize-bean mixtures steadily declined with late planting. The same trend was true even with the control treatments. It is therefore concluded from these results that the advantage in maize-bean mixtures is dependent on early planting at the onset of rains.

It is concluded from the 1976 experimental results that interplanting beans later than 14 days from the date of planting maize is not advisable to farmers. On the other hand

interplanting beans when maize is just starting to emerge needed more care to avoid trampling on the germinating maize seedlings. It is therefore suggested that interplanting beans not later than the 7th day from the date of maize emergence would be most appropriate. Planting maize and beans at the same time seems to give highest bean yields but perhaps should not be encouraged if it means that maize planting is delayed. From the 1976 experimental results it is concluded that the presence of beans might raise the yields of later planted maize, but this is not definite.

There is enough evidence from the present results to show that there is no yield advantage gained in interplanting maize in the growing beans. The summary of results also indicates that planting maize in the growing beans takes more labour input compared to beans interplanted in maize.

Production of pure beans requires more labour for both planting and weeding operations than pure maize stands and most of the mixtures. Planting maize and beans at the same time took relatively shorter time perhaps because there were no growing seedlings to be avoided when planting.

The highest financial return were obtained from the earliest planting and these were

considerably reduced with delay in planting thereafter. Late planted treatments in 1976 long rains gave very low financial returns. This was found to be true even in the output per man hour in most cases.

It is quite clear from the results presented that further work on labour costs would provide information of considerable practical importance on this farming system. This has often been ignored because the small farmers who are the majority in this farming system need no labour outside their families. This has always made it very difficult to arrive at accurate figures for net returns per unit area. To provide better information similar experiments should be repeated over some years say 2-3 years under the same environmental conditions before such could be of any value to the small farmers of the tropical countries, especially Kenya.

In this study it was found easy to compare the productivity of the mixtures because we already know the possible management requirements for maize and beans when grown in pure stands.

The experience in this project of maize-bean mixtures shows that extension advice in the form of recommended practices, is not too difficult

for small farmers of Western Kenya to follow. For, example maize should be planted first at the onset of rain and after the 7th day from the date of maize emergence bean can be interplanted, or the two crops could be planted at the same time. Recommended rates of fertilizers should be given to these crops especially maize. Maize should be planted at the spacing of 75 cm between the rows by 30 cm in the rows in most parts of Kenya (Allan, 1971). It is not necessary to vary this in order to get the advantage from mixtures. Beans can be planted between the maize rows by 15 cm in the rows. Much of the maize which is Kenya's main staple food of small scale farmers is produced by intercropping maize with beans. The production of beans which provide the largest percentage of the protein-rich food consumed in the daily diet is cheaply obtained through this cropping system of maize-bean mixtures in the region.

The results obtained from these experiments generally indicate that the maize-bean mixtures as a cropping system should be highly recommended to the small farmers of Western Kenya.

REFERENCES

Acland, J.D. (1971), East African Crops; Longman London.

Agboola, A.A. and Fayemi, A.A.(1971) Preliminary trials on the intercropping of maize with different tropical legumes in Western Nigeria. J. agric. Sci., Camb., 77 219-225

Akahurst, B.C. and Greedharan, A.(1965) Time of planting. A brief review of experimental work in Tanganyika, 1956-62 E. Afri. Agric. For. J 30 189-201.

Alexander, M.W. and Gater, G.F. (1962) Production of Soyabeans in alternate pairs of rows. Agron. J. 54 233-234.

Allan, A.Y. (1968[a]) Better husbandry in maize growing. Kenya Weekly News, No. 2193 of 23rd Feb., 1968.

Allan, A.Y. (1968[b]) Maize population and spacing Recommendation for 1968. Kenya Weekly News No. 2190 of 2nd Feb., 1968.

Allan, A.Y. (1971). The influence of agronomic factors on maize yields in Western Kenya with special reference to time of planting. Ph.D. Thesis, University of East Africa, Makerere, Uganda.

Andrews, J.D.(1972) Intercropping with sorghum in Nigeria, Expl. Agric. 8 139-150.

Baker, E.F.I. (1975) Research on mixed cropping with cereals in Nigeria farming systems: a system for improvement. International crops Research Institute for Research in the Semi-Arid Tropics, International workshop on farming systems: Hyderabad, India, ICRISAT, 1975, 287-302.

Baker; E.F.I. and Yusuf, Y. (1976) Mixed cropping research at the Institute for Agricultural Research, Samaru, Nigeria. Proceedings of the symposium on intercropping in Semi-Arid areas, Morogoro, Tanzania, 1976.

Brhane, Gebrekidan (1976) Intercropping with sorghum at Alemaya, Ethiopia. Proceedings of the symposium on intercropping in Semi-Arid area, Morogoro, Tanzania. 1976: p. 17.

Cochran, W.G. and Cox, G.M. (1957) Experimental Designs. John Wiley and Sons Inc. New York. 2nd Edition.

Eijnatten, C.L.M. van (1975) Report on a literature review and field study of agriculture in Kirinyaga District with special reference to beans (Phaseolus vulgaris.). Technical Communication No. 13. Department of Crop Science Faculty of Agriculture, University of Nairobi.

Enyi, B.A.C. (1973) Effects of intercropping maize or sorghum with cowpeas, pigeon peas or beans. Expl. Agric. 9 83-90.

Evans, A.C. (1960) Studies of intercropping 1. Maize or sorghum with groundnuts. E. Afric. Agric. For. J. 26 1-10.

Evans, A.C. (1963) Soil fertility studies in Tanganyika. 111. On the Kikungu and Luseni Soil types of the Lake and Western Regions. E. Afr. Agric. For. J. 28. 231.

Evans, A.C. and Sreedharan, A. (1962) Studies of intercropping. 11. Caster-bean with groundnuts or soya-beans. E. Afric. agric. For. J. 28 7-8.

Fisher, N.M. (1972) The productivity of mixed cropping in the tropics: A review of some theoretical considerations and experimental findings. Sc. Comm. No. 1., Dept. of Appl. Pl. Sc: University of Nairobi, Kenya.

Fisher, N.M., Laycock, D., Masyanga, B.B.K. and Owuor, J.O. (1976) Report on mixed cropping experiments in West of Kenya during the 1975 season. University of Nairobi, Department of Crop Science, Technical Communication No. 16 (Mimeo)

Fisher, N.M. (1977[a]) Studies in mixed cropping. 1. Seasonal differences in relative productivity of crop mixtures and pure stands in Kenya Highlands. Expl. Agric. 13 177-184.

Fisher, N.M. (1977[b]) Studies in mixed cropping. 2. Population pressure in maize-bean mixtures. Expl. Agric. 13 185-191.

Goldson, J.R. (1963) The effect of time of planting on maize yield. E.Afr. agric. For. J. 34 160-163.

Grimes, R.C. (1963) Intercropping and alternate row cropping of cotton and maize. E. Afric. Agric. HJ. 28 161-163.

Hart, M.G. and Magha Kewe (1976) Preliminary results of intercropping trials in Zaire with maize and certain legumes. Proceedings of the symposium on intercropping in Semi-Arid area, Morogoro, Tanzania, 1976: p. 27-28.

Hesselmark, O. and Lorenzl, G. (1976) Structure and problems of the maize marketing systems in Kenya. Department of Agric. Economics, Faculty of Agric., Univ. of Nairobi.

Kenya, Dept., Agriculture, Ann. Report for 1955 Vol. 2, record of Investigations.

Kenya, Dept., Agriculture, Ann. Report for 1956 Vol. 2, record of investigations.

Kenya, Dept., Agriculture, Ann. Report for 1969 Vol. 2, record of investigations.

Laycock, D., Allan, A.Y. Were, A. and Wafula, A. (1975) Intercropping maize with beans. Annual Report of the National Agricultural Research Station, Kitale, for 1974: p. 80.

Leakey, L.S.B. (1934) "Science and the African, "re-edited as a mimeo-graphed publication by C.L. . Leakey in 1970.

Makatiani. J.B.S. (1974) Intercropping maize with beans. In Annual Report Part II of Western Agricultural Research Station, Kakamega, for 1973: p. 17-18.

Marimi, A.M. (1975) Preliminary findings on mixed cropping of maize and beans in marginal potential Eastern Kenya. Kenya Ministry of Agriculture, mimeographed report.

Mbagaya. G.A. (1975) Maize-bean time of intercropping interplanting trial. In Annual Report of Nyanza Agricultural Research Station, Kisii, for 1974: p. 9-10.

Mukunya, D.M. and Keya, S.O. (1975) Phaseolus bean production in East Africa. Faculty of Agriculture, University of Nairobi.

Njeru, N. (1974) Intercropping maize with beans. In the Annual Report of Embu Agricultural Research Station, for 1973: p. 33-34.

Norman, D.M. (1971) Intercropping of annual crops under indigenous conditions in the northern part of Nigeria. Rural Economy Research Unit, Ahmadu Bello University, Samaru, Zaria, Nigeria, p. 14.

Norman, D.W. (1974) Crop mixtures under indigenous conditions in the northern part of Nigeria. Samaru, Nigeria, Institute for Agricultural Research, Ahmadu Bello University, Samaru Research Bulletin No. 205.

Nyaisawa, J.N.(1976) Republic of Kenya, Ministry of Agriculture, Cotton Agronomy Research work at Cotton Research Station, Kibos, (Mimeo).

Ogada, F. (1969) The role of maize research in stimulating Agricultural progress in Kenya, N.A.R.S., Maize Research Section, Kitale.

Ogada, F. (1975) The effect of selection for prolifacacy in two composite populations of maize. Kampala, Uganda, Makerere University, Ph.D. Thesis.

Osiru, D.S.O. and Willey, R.W. (1972) Studies on mixtures of dwarf sorghum and beans (phaseolus vulgaris) with particular reference to plant populations. J. agric. Sci. 79 531-540.

Osiru, D.S.O. and Willey, R.W. (1976) Studies on mixtures of maize and beans with particular emphasis on the time of planting beans. Proceedings of the symposium in inter-cropping in Semi-Arid areas, Morogoro, Tanzania, 1976.

Osiru, D.S.O. (1974) Physiological studies of some annual crop mixtures. Kampala, Uganda, Makerere University, (Ph.D. Thesis).

Republic of Kenya: Statistical Abstract (1975) Nairobi, Government Printer.

Republic of Kenya, Ministry of Agriculture, Horticultural Information Hand Book, Vol. 2 (1976). 10 Beans, Printed by Agricultural Information Centre, Ministry of Agriculture, Nairobi.

Steel, R.G.D. and Torrie, J.H. (1960) Principles and procedures of statistic with special reference to the biological sciences. McGraw-Hill Book Co. Inc., New York.

Willey, R.W. and Osiru, D.S.O. (1972) Studies on mixtures of maize and beans with particular reference to plant populations. J. agric. Sci. Camb., 79 517-529.

Yates, F. (1937) Design and Analysis of Factorial Experiments. Commonwealth Bureau of Soil Science, Tech. Comm. 35.

A P P E N D I X

A P P E N D I X

Table 1: Yield Results in Kg/plot of Dry Maize Grains(at 12.5% Moisture): Kakamega, 1974

Treatments	BLOCKS I	II	III	IV	V	VI	Treatment total
B-Pure Maize	28.1	17.3	28.2	19.1	21.4	18.4	132.5
C-Maize in mixtures	24.0	40.2	26.2	24.1	34.7	36.2	185.4
Block total	52.1	57.5	54.4	43.2	56.1	54.6	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	11	579,59		
Block	5	65.62	213.12	0.22 ns
Treatment	1	233.20	233.20	3.90 ns
Error	5	298.77	59.75	CV = 29%

Table 2: Results of Maize Stand Count/Plot at Kakamega 1974

	BLOCKS						
Treatments	I	II	III	IV	V	VI	Treat total
B-Pure Maize	117	151	120	122	144	133	787
C-Maize in Mixtures	149	125	144	158	126	137	839
Block total	266	276	264	280	270	270	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	11	2,047.00		
Blocks	5	91.00	18.20	0.05 ns
Treatment	1	,225.33	225.33	0.65 ns
Error	5	1,730.67	346.13	CV=14%

Table 3. Yield results in gram/plot of dry bean grains:- Kakamega 1974

Treat ments	B L O C K S 1	11	111	IV	V	VI	Treat Total
A-Pure beans	5,013	4,365	5,997	5,740	3,990	4,370	29,475
C-Beans in mixture	715	1,905	802	1,050	1,640	1,427	7,539
Block total	15,728	6,270	6,799	6,790	5,630	5,797	

ANALYSIS:

Treat.	Kg/ha. mean	SE mean
A -	1091.8	73.9
C -	279.3	43.3

NB: In the analysis only the treatment means and SE means are calculated.

Table 4. Results of bean stand count/plot at Kakamega 1974

Treat ments	B L O C K S I	II	III	IV	V	VI	Treat. Total
A- pure beans	620	602	560	610	638	590	3,620
C-Beans in mixture	307	230	272	370	314	271	1,764
Blocks total	927	832	832	980	952	861	

Analysis:- In the analysis only the means of the bean stand and SE mean are calculated

Treat.	Stand Count/ha	SE mean
A -	134,000	2,444
C -	65,333	4,444

Table 5. Yield results in Kg/plot of dry maize grains (at 12.5% moisture):-Sang'alo 1974

	B L O C K S						
Treatments	I	II	III	IV	V	VI	Treat. Total
B-Pure maize	30.9	22.7	34.2	32.8	32.2	28.7	181.5
C-Maize in mixture	27.8	26.8	33.6	28.9	35.8	26.2	179.1
Block Tot.	58.7	49.5	67.8	61.7	68.0	54.9	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	11	163.41		
Blocks	5	132.81	26.56	4.41 ns
Treat.	1	0.48	0.48	< 1 ns
Error	5	30.12	6.02	CV = 8%

Table 6. Results of maize stand count/plot at Sang'alo 1974

	B L O C K S						
Treatments	I	II	III	IV	V	VI	Treat. Total
B-Pure maize	199	194	187	191	196	189	1,156
C-Maize in mixture	195	190	199	184	192	193	1,153
Block total	394	384	386	375	388	382	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	11	329.00		
Blocks	5	100.50	20.10	< 1 ns
Treatments	1	0.833	0.83	< 1 ns
Error	5	127.67	25.53	CV = 3%

Table 7. Yield results in gram/plot of dry bean grains at Sang'alo 1974

Treat-ments	BLOCKS I	II	III	IV	V	VI	Treat. Total
A-Pure beans	1,994	1,582	1,910	2,413	1,651	2,322	11,872
C-Bean in mixture	561	362	694	421	733	634	3,405
Block total	1,555	1,944	2,604	2,834	2,384	2,956	

ANALYSIS: In the analysis only the treatment means and SE are worked out.

Treat.	Mean in Kg/ha	SE mean
A	439.7	30.8
C	126.1	13.6

Table 8. Results of bean stand count/plot at Sang'alo 1974

Treat ments	BLOCKS I	II	III	IV	V	VI	Treat. Total
A-Pure beans	565	571	525	621	459	610	3,351
C-Beans in mixture	253	267	290	275	275	291	1,652
Block total	818	838	815	897	734	901	

Analysis: In the analysis only the treatment means and SE are worked out.

Treat.	Mean stand count/ha	SE mean
A-pure beans	124,222	5,333
B-Beans in mixture	61,111	1,333

Table 9. Yield results in kg/plot of maize (at 12.5% moisture):- Kakamega 1975

Treatments	BLOCKS I	II	III	IV	Treat. Total
B	23.2	21.6	22.4	25.1	92.3
C	22.9	29.2	31.0	26.1	109.2
D	27.9	24.8	25.6	24.3	102.1
E	27.9	30.6	30.8	24.0	113.3
F	22.0	25.9	32.1	25.9	105.9
Block Total	123.4	132.1	141.9	125.4	

ANALYSIS OF VARIANCE.

Source	df	SS	MS	F
Total	19	196.94		
Blocks	3	41.76	13.92	1.83 ns
Pure v mixed	1	46.97	46.97	6.18 **
Top effects (T)	1	3.90	3.90	< 1 ns
Plant arrangement	1	13.14	13.14	1.73 ns
T x A	1	0.01	0.01	< 1 ns
Error	12	91.16	7.60	CV = 11%

* Signifant at the 1% level of probability

Table 10: Maize Stand Count/Plot: Kakamega, 1975

Treatment	BLOCKS I	II	III	IV	Treat. total
B	182	187	187	198	754
C	179	199	190	195	763
D	186	182	191	196	755
E	188	189	189	178	744
F	185	173	182	189	729
Block total	920	930	939	956	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	19	938.06		
Blocks	3	140.15	46.72	1.01 ns
Pure v mixed	1	78.13	78.13	1.68 ns
Top effects (T)	1	126.56	126.56	2.73 ns
		33.06	33.06	< 1 ns
Plant arrangement	1	3.06	3.06	< 1 ns
Error	12	557.10	46.43	CV = 4%

Table 11. Yield results in grams/plot of dry bean grains at Kakamega 1975

Treatments	BLOCKS I	II	III	IV	Treat Total
A	3,815	3,531	1,204	2,141	10,691
C	202	524	343	513	1,582
D	416	218	326	334	1,294
Block Total	4,433	4,273	1,873	2,988	

Analysis: In the analysis only the treatment means and SE mean are worked out.

Treatment	Mean Yield in kg/ha	SE mean
A	594.00	135.78
C	88.00	17.11
D	72.00	9.11

Table 12: Bean Stand Count/Plot: Kakamega 1975

B L O C K S

Treatment	I	II	III	IV	Treat. total
A	156	184	169	135	644
C	56	108	68	76	308
D	64	48	58	67	237
Block total	276	340	295	278	

Analysis: In the analysis only the treatment means and SE are worked out.

Treatment	Stand count/ha	SE mean
A	35,778	2,311
C	17,111	2,466
D	13,167	933

Table 13. Yield results in kg/plot of dry maize grains.(at 12.5% moisture):- Kakamega 1976

	BLOCKS			
Treatment	I	II	III	Treat.Total
M_1	15.59	16.32	11.21	43.12
M_2	12.83	11.97	11.56	36.36
M_3	10.35	11.34	9.12	30.81
M_1B_1	15.17	13.91	14.44	43.52
M_1B_2	11.28	12.45	13.10	36.83
M_1B_3	14.66	11.91	12.93	39.50
M_2B_1	12.16	10.14	13.28	35.58
M_2B_2	11.40	11.99	14.38	37.77
M_2B_3	13.18	15.65	12.82	41.65
M_3B_1	5.28	12.67	10.92	28.87
M_3B_2	7.89	11.89	13.10	32.88
M_3B_3	10.70	10.76	13.92	35.38
Block Total	140.49	151.00	150.78	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	35	169.45		
Blocks	2	6.01	3.005	1 ns
M	2	53.07	26.5332	6.85 **
B	3	5.77	1.9225	1. ns
M x B	6	19.38	3.2303	2 ns
Error	22	85.2200	3.8736	CV = 15%

** Significant at 1% level of probability.

Table 14. Yield results in kg/plot of dry maize grains (at 12.5% moisture):- Alupe 1976

	B L O C K S			
Treatment	I	II	III	Treat.Total
M_1	6.86	7.80	3.49	18.15
M_2	6.83	5.20	3.06	15.09
M_3	7.59	3.23	3.58	14.40
M_1B_1	4.26	3.05	2.65	9.96
M_1B_2	7.68	4.03	4.55	16.26
M_1B_3	6.35	7.86	2.44	16.65
M_2B_1	7.19	4.89	4.76	16.84
M_2B_2	4.56	7.44	2.30	14.30
M_2B_3	5.81	6.11	4.21	16.13
M_3B_1	3.20	4.59	1.99	9.78
M_3B_2	4.45	4.90	3.86	13.21
M_3B_3	4.84	4.13	3.96	12.93
Block Total	169.62	63.23	40.85	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	35	103.0009		
Blocks	2	38.0391	19.0195	10.61 **
M	2	7.2569	3.6285	2.02 ns
B	3	7.7734	2.5911	1.45 ns
M x B	6	10.4979	1.7497	0.98 ns
Error	22	39.4336	1.7924	CV = 27%

** Significant at 1% level of probability.

Table 15. Yield results in grams/plot of dry bean grains:- Kakamega 1976

	B L O C K S			
Treatments	I	II	III	Treat.Total
B_1	1147	1021	629	2797
B_2	812	960	808	2580
B_3	901	692	704	2297
M_1B_1	481	294	233	1008
M_1B_2	458	323	424	1205
M_1B_3	99	95	135	329
M_2B_1	378	405	274	1057
M_2B_2	317	257	211	785
M_2B_3	137	133	102	372
M_3B_1	427	416	322	1165
M_3B_2	204	205	174	583
M_3B_3	225	117	99	441
Block Total	5586	4918	4115	

ANALYSIS OF VARIANCE (Puro stands).

Source	df	SS	MS	F
Total	8	230,416		
Blocks	2	92,773	46,386	1.94 ns
Time of planting	2	41,909	20,954	/ 1 ns
Error	4	95,735	23,934	CV = 18%

ANALYSIS OF VARIANCE(Mixtures)

Source	df	SS	MS	F
Total	26	403,605		
Blocks	2	32,234	16,117	5.79 **
M	2	8,623	4.311	1.55 ns
B	2	253.302	126.651	45,51 **
M x B	4	64,928	16,232	5.83 **
Error	16	44.520	2,783	CV = 21%

** Significant at the 1% level of probability.

Table 16. Yield results in grams/plot of dry beans grains:- Alupo 1976

	B L O C K S			
Treatments	I	II	III	Treat.Total
B_1	2,126	1,025	1,881	5,032
B_2	449	362	492	1,303
B_3	304	610	615	1,529
M_1B_1	602	587	582	1,771
M_1B_2	357	520	407	1,284
M_1B_3	147	217	283	647
M_2B_1	716	670	623	2,009
M_2B_2	414	296	593	1,303
M_2B_3	103	171	249	523
M_3B_1	661	866	567	2,094
M_3B_2	216	144	287	647
M_3B_3	129	220	90	439
Block Total	6,224	5,688	6,669	

ANALYSIS OF VARIANCE(pure stands)

Source	df	SS	MS	F
Total	8	3,654,723.5556		
Blocks	2	196,876.2223	98,438.1111	< 1 ns
Time of planting	2	2,914.169.5556	1,457.084.7778	10.72*
Error	4	543,677.7777	135,919.4444	CV =42%

* Significant at the 5% level of probability.

ANALYSIS OF VARIANCE(Mixtures)

Source	df	SS	MS	F
Ttotal	26	1,297,591.8519		
Blocks	2	8,619.9630	4,309.4815	< 1 ns
M	2	26,636.9630	13,318.4815	1.52 ns
B	2	1,029,646.2963	514,823.1482	58.67 **
M xB	4	92,291.9259	23,072.9815	2.63 ns
Error	16	140,396.7037	8,774.7940	CV = 24%

** Significant at the 1% of probability.

Table 17. Results of maize stand counts/plot:-
Kakamega 1976

Treatment	BLOCKS I	II	III	Treatment Tot
○ M_1	62	64	64	190
M_2	64	63	59	186
M_3	56	62	64	182
M_1B_1	64	64	63	191
M_1B_2	64	61	64	189
M_1B_3	57	61	63	181
M_2B_1	54	57	61	172
M_2B_2	62	57	60	179
M_2B_3	61	64	64	189
M_3B_1	54	61	61	176
M_3B_2	56	63	64	183
M_3B_3	60	62	64	186
Block Total	714	739	751	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	35	328.22		
Blocks	2	59.39	29.70	4.69 *
M	2	33.39	16.69	2.64 ns
B	3	24.22	8.07	1.28 ns
M x B	6	71.94	11.99	1.89 ns
Error	22	139.28	6.33	CV = 4.1%

* Statistically significant at the 5% level of probability.

Table 18. Results of maize stand counts/plot:-
Alupe 1976

	BLOCKS			
Treatment	I	II	III	Treat.Total
M_1	51	56	53	160
M_2	48	61	48	157
M_3	52	60	64	176
M_1B_1	47	40	53	140
M_1B_2	50	53	44	147
M_1B_3	51	54	58	163
M_2B_1	56	46	59	161
M_2B_2	49	52	57	158
M_2B_3	45	35	47	127
M_3B_1	49	55	46	150
M_3B_2	50	59	56	165
M_3B_3	50	58	36	144
Block Total	598	629	621	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	35	1520.00		
Block	2	43.17	21.59	< 1 ns
M	2	47.17	23.58	< 1 ns
B	3	214.44	71.48	1.85 ns
M x B	6	367.06	61.18	1.59 ns
Error	22	848.17	38.55	CV = 12%

Table 19. Yield results of No. of usable ears/plot

Kakamega 1976

Treatments	BLOCKS I	II	III	Treat.Total
M_1	0.98	1.06	0.77	2.81
M_2	0.84	0.83	0.86	2.53
M_3	0.86	0.89	0.69	2.44
M_1B_1	0.84	0.95	1.03	3.01
M_1B_2	1.03	0.89	0.94	2.67
M_1B_3	1.05	0.92	0.94	2.91
M_2B_1	1.02	0.88	1.03	2.93
M_2B_2	0.84	0.98	0.98	2.80
M_2B_3	0.97	0.80	0.94	2.71
M_3B_1	0.70	0.84	0.87	2.41
M_3B_2	0.73	0.94	0.95	2.62
M_3B_3	0.95	0.82	0.98	2.75
Block Tot.	10.81	10.80	10.98	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	35	0.3273		
Blocks	2	0.0017	0.0017	1.03 ns
M	2	0.0594	0.0297	3.42 ns
B	3	0.0254	0.0085	$\angle$ 1 ns
M x B	6	0.0494	0.0082	$\angle$ 1 ns
Error	22	0.1914	0.0087	CV = 10%

Table 20. Yield results of number of usable ears/ plant:- Alupe 1976

	B L O C K S			
Treatments	I	II	III	Treat. Total
M_1	0.90	0.91	0.74	2.55
M_2	0.96	0.84	0.84	2.64
M_3	1.10	0.82	0.92	2.84
M_1B_1	0.83	1.07	0.83	2.73
M_1B_2	0.96	0.85	0.84	2.65
M_1B_3	0.98	0.87	0.90	2.75
M_2B_1	0.96	0.98	0.93	2.87
M_2B_2	0.96	0.98	0.84	2.78
M_2B_3	1.09	1.29	0.77	3.15
M_3B_1	0.71	0.87	0.91	2.49
M_3B_2	0.92	0.95	0.77	2.64
M_3B_3	1.02	0.71	1.42	3.15
Blocks Total	11.39	11.14	10.71	

ANALYSIS OF VARIANCE

Source	df	SS	MS	F
Total	35	0.7268		
Blocks	2	0.0197	0.0099	$\angle$ 1 ns
M	2	0. 0243	0.0123	$\angle$ 1 ns
B	2	0.0813	0.0271	$\angle$ 1 ns
M x B	6	0.0547	0.0091	$\angle$ 1 ns
Error	22	0.5468	0.0249	CV = 19%

Table 21. Yield results in grams/plant of dry maize grains (at 12.5%- Moisture):- Kakamega 1976

	BLOCKS			
Treatments	I	II	III	Treat.Total
M_1	251.45	255.00	173.15	681.60
M_2	200.46	190.00	195.93	586.39
M_3	184.82	182.90	142.50	510.22
M_1B_1	237.00	217.34	229.20	683.54
M_1B_2	176.20	204.09	204.68	584.97
M_1B_3	257.19	208.90	205.23	671.32
M_2B_1	225.18	177.80	217.70	620.68
M_2B_2	183.87	210.30	239.66	633.83
M_2B_3	216.06	244.53	200.31	660.90
M_3B_1	97.77	207.70	179.01	484.48
M_3B_2	140.89	188.73	204.68	534.30
M_3B_3	178.33	173.54	217.50	569.37
Block Total	2349.22	2460.83	2411.55	

ANALYSIS OF VARIANCE:

Source	df	SS	MS	F
Total	35	38,417.1854		
Blocks	2	521.3983	260.6992	0.27 ns
M	2	12,518.3018	6259.1509	6.59 **
B	2	1,445.1102	481.7034	0.51 ns
M x B	6	3,048.9993	508.1666	0.54 ns
Error	22	20,883.3758	949,2444	CV = 15.4%

** Statistically significant at the 1% level of probability.

Table 22. Yield results in grams/plant of dry maize grains (at 12.5% - Moisture):- Alupe 1976

	B L O C K S			
Treatments	I	II	III	Treat.Total
M_1	134.51	139.29	65.83	339.63
M_2	142.29	85.25	63.75	291.29
M_3	145.96	53.83	55.94	255.73
M_1B_1	90.64	76.25	50.00	216.89
M_1B_2	153.60	76.04	103.41	333.05
M_1B_3	124.51	145.56	42.93	313.00
M_2B_1	128.39	106.30	80.68	315.37
M_2B_2	93.06	143.08	40.35	276.49
M_2B_3	129.11	174.57	89.57	393.25
M_3B_1	65.31	83.45	43.26	193.02
M_3B_2	89.00	83.05	68.93	240.98
M_3B_3	96.80	71.21	110.00	278.01
Block Total	1393.18	1237.88	814.65	

ANALYSIS OF VARIANCE.

Source	df	SS	MS	F
Total	35	45,514.9842		
Blocks	2	14,942.7412	7471.3706	8.68 **
M	2	4,359.8382	2179.9441	2.53 ns
B	3	3,850.2676	1283.4225	1.49 ns
M x B	6	3,423.8926	570.6488	0.66 ns
Error	22	18,938.1946	860.8270	CV = 30.7%

** Statistically significant at the 1% level of probability.

Table 23. Results of bean counts/plot:Kakamega 1976

Treatments	BLOCKS I	II	III	Treat.Total
B_1	190	192	80	462
B_2	174	184	96	454
B_3	161	130	96	387
M_1B_1	96	86	65	247
M_1B_2	96	75	83	254
M_1B_3	49	80	77	206
M_2B_1	89	90	62	241
M_2B_2	94	78	61	233
M_2B_3	86	87	45	218
M_3B_1	92	75	61	228
M_3B_2	93	66	75	234
M_3B_3	87	61	42	190
Block Total	1,307	1,204	843	

ANALYSIS OF VARIANCE(pure stand)

Source	df	SS	MS	F
Total	8	16,103.5556		
Blocks	2	13,236.2223	6,618.1111	15.25 **
Time of planting	2	1,130.8889	565.445	1.30 ns
Error	4	1.736.4444	434.1111	CV =14%

** Statistically significant at the 1% level of probability.

ANALYSIS OF VARIANCE (Mixtures)

Source	df	SS	MS	F
Total	26	6,486.9630		
Blocks	2	2,507.6297	1,253.8149	6.96 **
M	2	179.6297	89.8148	< 1 ns
B	2	810.2963	405.1482	2.25 ns
M xB	4	108.3703	27.0925	< 1 ns
Error	26	2,881.0370	180.0648	CV = 10%

** Statistically significant at the 1% level of probability.

Table 24. Results of bean counts/plot:- Alupe 1976

Treatments	BLOCKS I	II	III	Treat.Total
B_1	183	152	187	522
B_2	177	142	150	469
B_3	132	157	178	467
M_1B_1	85	83	83	251
M_1B_2	77	62	61	200
M_1B_3	58	62	61	181
M_2B_1	89	87	91	267
M_2B_2	77	72	90	239
M_2B_3	70	66	65	201
M_3B_1	83	76	70	229
M_3B_2	72	45	66	183
M_3B_3	69	67	62	198
Block total	1172	1071	1164	

ANALYSIS OF VARIANCE(pure stand)

Source	df	SS	MS	F
Total	8	3,116.0000	350.3334	
Blocks	2	700.6667	350.3334	/ 1 ns
Time of planting	2	648.6667	324.3334	/ 1 ns
Error	4	1,766.6666	441.6667	CV = 13%

ANALYSIS OF VARIANCE(Mixtures)

Source	df	SS	MS	F
Total	26	3,426.0741		
Blocks	2	200.0741	100.0371	2.36 ns
M	2	574.7408	287.3704	6.77 **
B	2	1,676.9630	838.4815	19.75 **
M x B	4	295.0370	73.7593	1.74 ns
Error	16	679.2592	42.4537	

** Statistically significant at the 1% level of probability.

Table 25 Yield results in grams/plant of dry bean grains: Kakamega 1976

Treatments	BLOCKS I	III	III	Treat. Total
B_1	6.04	5.32	7.86	19.22
B_2	4.67	5.22	8.42	18.31
B_3	5.60	5.32	7.33	18.25
M_1B_1	5.01	3.42	3.58	12.01
M_1B_2	4.77	4.31	5.11	14.19
M_1B_3	2.02	1.19	1.75	4.96
M_2B_1	4.25	4.50	4.42	13.17
M_2B_2	3.37	3.29	3.46	10.12
M_2B_3	1.59	1.52	2.27	5.38
M_3B_1	4.64	5.55	5.28	15.47
M_3B_2	2.19	3.11	2.32	7.62
M_3B_3	2.59	1.92	2.36	6.87
Block Total	46.74	44.67	54.16	

Analysis of Variance (Pure stands)

Source	df	SS	MS	F
Total	8	14.1966		
Blocks	2	12.6173	6.3087	18.25 **
Time of planting	2	0.1970	0.0985	< 1 ns
Error	4	1.3823	0.3456	CV = 5.5%

** Statistically significant at the 1% level of probability.

Analysis of Variance (Mixtures)

Source	df	SS	MS	F
Total	26	45.0295		
Blocks	2	0.2099	0.1050	< 1 ns
M	2	0.3446	0.1723	< 1 ns
B	2	15.5954	15.5954	70.12 **
M x B	4	9.7256	2.4314	10.93 **
Error	16	3.5586	0.2224.	CV = 14%

** Statistically significant at the 1% level of probability.

Table 26 Yield results in grams/Plant of dry bean grains: Alupe 1976

Treatments	BLOCKS I	II	III	Treat. Total
B_1	11.62	6.74	10.06	28.42
B_2	2.54	2.56	3.28	8.38
B_3	2.30	3.89	3.46	9.65
M_1B_1	7.08	7.07	7.01	21.16
M_1B_2	4.64	8.39	6.67	19.70
M_1B_3	2.53	3.50	4.64	10.67
M_2B_1	8.05	7.70	6.85	22.60
M_2B_2	5.38	4.11	6.59	16.08
M_2B_3	1.47	2.59	3.83	7.89
M_3B_1	7.96	11.40	8.10	27.46
M_3B_2	3.00	3.20	4.35	10.55
M_3B_3	1.87	3.28	1.45	6.60
Block Total	58.44	64.43	66.29	

Analysis of Variance (pure stands)

Source	DF	SS	MS	F
Total	8	98.0793		
Blocks	2	2.6490	1.3245	0.46 ns
Time of plant.	2	83.9475	41.9738	14.62 **
Error	4	11.4828	2.8707	CV = 32.8%

** Statistically significant at the 1% level of probability.

Analysis of Variance (Mixtures)

Source	df	SS	MS	F
Total	26	168.8104		
Blocks	2	5.3783	2.6892	2.05 ns
M	2	2.8272	1.4136	1.08 ns
B	2	117.7103	58.8552	44.83 ns
M x B	4	21.8867	5.4717	4.17 *
Error	16	21.0079	1.3130	CV = 21.7%

**Statistically significant at the 1 % lebel of probability.

* Statistically significant at the 5% level of probability.

Table 27 Yield results of the No. of pods/plants: Kakamega 1976

	B L O C K S			
Treatments	I	II	III	Treat. Total
B_1	6.4	5.2	3.0	14.6
B_2	2.3	2.6	2.7	7.6
B_3	3.2	3.3	4.4	10.9
M_1B_1	4.4	2.1	2.7	9.2
M_1B_2	1.0	2.0	1.0	4.0
M_1B_3	1.2	1.3	1.1	3.6
M_2B_1	3.8	3.7	2.0	9.5
M_2B_2	1.1	2.7	1.9	5.7
M_2B_3	1.0	1.2	1.5	3.7
M_3B_1	3.7	4.4	3.3	11.4
M_3B_2	2.0	2.2	1.9	6.1
M_3B_3	1.7	2.0	1.7	5.4
Block Total	31.8	32.7	72.2	

Analysis of Variance (pure stands)

Source	df	SS	MS	F
Total	8	15.0956		
Blocks	2	0.5423	0.2711	< 1 ns
Time of planting	2	8.1756	4.0878	2.56 ns
Error	4	6.3778	1.5944	CV = 34%

ANALYSIS OF VARIANCE (MIXTURES)

Source	df	SS	MS	F
Total	26	29.3163		
Blocks	2	1.1474	0.5737	1.40 ns
M	2	2.1341	1.0670	2.60
B	2	19.1430	9.5715	23.32 **
M x B	4	0.3259	0.0815	< 1 ns
Error	16	6.5659	0.4104	CV = 30%

**Statistically significant at the 1% level of probability.

Table 28 Yield results of number of usable pods/ plant: Alupe 1976

T	B L O C K S			
Treatments	I	II	III	Treat. Total
B_1	3.5	6.3	7.2	17.0
B_2	2.2.	4.2	1.8	8.2
B_3	1.8	4.0	2.1	7.9
M_1B_1	6.9	4.3	3.5	14.7
M_1B_2	3.4	4.0	3.2	10.6
M_1B_3	1.8	3.9	2.9	8.6
M_2B_1	7.8	4.8	3.2	15.8
M_2B_2	7.3	3.2	4.2	14.7
M_2B_3	1.1	2.3	2.5	5.9
M_3B_1	5.2	10.2	3.1	18.5
M_3B_2	4.4	1.6	2.7	8.7
M_3B_3	2.6	3.7	1.7	8.0
Block Total	48.0	52.5	38.1	

ANALYSIS OF VARIANCE (PURE STANDS)

Source	df	SS	MS	F
Total	8	31.4156		
Blocks	2	8.1689	4.0845	3.01 ns
Time of plan.	2	17.8156	8.9078	3.56 ns
Error	4	5.4311	1.3578	

ANALYSIS OF VARIANCE (MIXED STANDS)

Source	df	SS	MS	F
Total	26	112.058		
Blocks	2	11.4629	5.7315	1.7912 ns
M	2	0.3474	0.1737	< 1 ns
B	2	39.2407	19.6204	6.1318 *
M x B	4	9.1804	2.4526	< 1 ns
Error	16	51.1971	3.1998	CV = 46%

* Statistically significant at 5% level of probability.

Table 29 Yield results of seed weigh in gramms/pod (oven dry): Kakamega 1976

	BLOCKS			
Treatment	I	II	III	Treat. Total
B_1	0.94	1.02	2.59	4.55
B_2	2.06	1.98	3.11	7.15
B_3	1.77	1.61	1.68	4.06
M_1B_1	1.13	1.60	1.33	4.06
M_1B_2	4.77	2.11	5.11	11.99
M_1B_3	1.74	0.90	5.11	4.25
M_2B_1	1.12	1.23	2.19	4.54
M_2B_2	3.05	1.22	1.87	6.14
M_2B_3	1.56	1.32	1.55	4.43
M_3B_1	1.25	1.25	1.58	4.08
M_3B_2	1.11	1.44	1.22	3.77
M_3B_3	1.56	0.98	1.41	3.95
Block Total	22.06	16.66	25.25	

Analysis of Variance (pure stands)

Source	df	SS	MS	F
Total	8	3.80		
Block	2	1.61	0.81	3.52 ns
Time of plant.	2	1.27	0.64	2.78 ns
Error	4	0.92	0.23	CV = 25%

Analysis of Variance (Mixtures)

Source	df	SS	MS	F
Total	26	27.03		
Block	2	0.30	0.15	< 1 ns
M	2	4.08	2.04	3.92 *
B	2	6.33	3.17	6.09 *
M x B	4	7.94	1.99	3.82 *
Error	16	8.38	0.52	CV = 41%

* Statistically significant at the 5% level of probability.

Table 30. Yield results of seed weight in grams/ pod (oven dry): Alupe 1976

	B L O C K S			
Treatments	I	II	III	Treat.Total
B_1	3.34	1.07	1.40	5.81
B_2	1.16	0.61	1.79	3.56
B_3	1.28	0.97	1.71	3.96
M_1B_1	1.03	1.63	2.03	4.69
M_1B_2	1.37	2.11	2.11	5.59
M_1B_3	1.44	0.90	1.62	3.96
M_2B_1	1.03	1.62	2.16	4.81
M_2B_2	0.74	1.28	1.58	3.60
M_2B_3	1.34	1.14	1.54	4.02
M_3B_1	1.54	1.11	2.60	5.25
M_3B_2	0.68	2.06	1.60	4.34
M_3B_3	0.71	0.89	0.84	2.44
Block Total	15.66	15.39	20.98	

Analysis of Variance(Pure stands)

Source	df	SS	MS	F
Total	8	4.94		
Block	2	1.74	0.87	1.55
Time of planting	2	0.96	0.48	< 1 ns
Error	4	2.24	0.56	CV = 50%

Analysis of Variance (Mixtures)

Source	df	SS	MS	F
Total	26	6.79		
Blocks	2	2.14	1.07	7.64 **
M	2	0.31	0.15	1.07 ns
B	2	1.11	0.55	3.93 *
M x B	4	0.95	0.24	1.70 ns
Error	16	2.28	0.14	CV =26.2%

**Statistically significant at the 1% level of probability.

* Statistically significant at the 5% level of probability.

Table 31 Equivalent areas for various treatments: Kakamega 1976

	BLOCKS			
Treatments	I	II	III	Treat.Total
M_1B_1	1.38	1.13	1.65	4.16
M_1B_2	1.29	1.09	1.69	4.07
M_1B_3	1.05	0.74	1.18	2.97
M_2B_1	1.28	1.24	1.58	4.10
M_2B_2	1.16	1.27	1.51	3.94
M_2B_3	1.17	1.33	1.12	3.62
M_3B_1	0.92	1.53	1.70	4.15
M_3B_2	1.01	1.26	1.65	3.92
M_3B_3	1.28	0.97	1.54	3.79
Block Total	10.54	10.56	13.62	

ANALYSIS OF VARIANCE:

Source	df	SS	MS	F
Total	26	1.6689		
Blocks	2	0.6982	0.349[illegible]	9.46 **
M	2	0.6255	0.0128	< 1 ns
B	2	0.02502	0.1251	3.39 ns
M x B	4	0.1045	0.0261	< 1 ns
Error	16	0.5905	0.0369	CV = 15%

** Statistically significant at the 1% level of probability.

Table 32 Equivalent areas for various treatments - Alupe 1976

	BLOCKS			
Treatments	I	II	III	Treat.Total
M_1B_1	0.90	0.97	1.07	2.94
M_1B_2	1.93	1.03	2.13	5.09
M_1B_3	1.25	1.37	1.17	3.79
M_2B_1	1.39	1.60	1.88	4.87
M_2B_2	1.61	2.27	1.96	5.84
M_2B_3	1.18	1.46	1.77	4.41
M_3B_1	0.73	2.27	0.85	3.85
M_3B_2	0.97	1.34	1.67	3.98
M_3B_3	1.07	1.64	1.24	3.95
Block Total	11.03	13.95	13.74	38.78

ANALYSIS OF VARIANCE.

Source	df	SS	MS	F
Ttotal	26	5.0753		
Blocks	2	0.5895	0.2948	1.86 ns
M	2	0.8166	0.4083	2.58 ns
B	2	0.6823	0.3412	2.16 ns
M x B	4	0.4577	0.1144	< 1 ns
Error	16	2.5292	0.1581	CV = 28%

Table 33 Labour requirements for planting (Time in Minutes)/Plot:- Kakamega 1976

Treatments	BLOCKS I	II	III	Treat.Total
B_1	24	26	22	72
B_2	15	15	15	45
B_3	24	17	12	53
M_1	12	10	12	34
M_2	9	10	14	33
M_3	8	8	11	27
M_1B_1	25	22	22	69
M_1B_2	18	22	20	60
M_1B_3	18	18	24	60
$M2_B1$	24	22	21	67
M_2B_2	20	16	25	61
M_2B_3	19	15	23	57
M_3B_1	18	21	20	59
M_3B_2	20	20	25	65
M_3B_3	20	18	18	56
Block Total	274	260	284	819

Analysis of Variance (All treatments):

Source	df	SS	MS	F
Total	44	1,088.2	24.73	
Treats.	14	868.53	62.038	8.57 **
Blocks	2	17.0	8.5	1.17 ns
Error	28	202.67	7.24	CV = 9%

** Statistically significant at the 1% level of probability.

Analysis of Variance(Mixtutes):

Source	df	SS	MS	F
Total	26	192.74		
Blocks	2	33.18	16.600	2.500 ns
M	2	4.518	2.260	0.341 ns
B	2	27.185	13.593	2.05 ns
M x B	4	21.70	5.425	0.818 ns
Error	16	106.153	6.634	

Table 34 Labour requirements for weeding(time in Minutes): Kakamega 1976

	BLOCKS			
Treatments	I	III	III	Treat.Total
B_1	24	30	35	89
B_2	21	20	31	72
B_3	33	18	32	83
M_1	25	23	28	76
M_2	23	26	22	71
M_3	18	15	15	48
M_1B_1	34	34	44	112
M_1B_2	23	24	28	75
M_1B_3	26	13	21	60
M_2B_1	30	20	16	66
M_2B_2	32	33	21	86
M_2B_3	25	21	21	67
M_3B_1	27	16	28	71
M_3B_2	26	18	26	79
M_3B_3	23	14	22	59
Block Total	390	325	390	1105

Analysis*of Variance (All treatments):

Source	df	SS	MS	F	
Total	44	1901.111			
Breats	14	1,048.44	74.89	3.154	**
Blocks	2	187.78	93.89	3.954	**
Error	28	664.891	23.746	CV = 11%.	

** Statistically significant at the 1% level of probability.

Analysis of Variance (Mixtures)

Source	df	SS	MS	F	
Total	26	1,032.000			
Blocks	2	160.222	80.111	8.226	**
M	2	124.222	62.111	6.380	**
B	2	234.00	117.000	12.017	**
M x B	4	357,778	89.445	9.187	**
Error	16	155.778	9.736	-	

** Statistically significant at the 1% level of probability.

Table 35. Labour requirements for planting (time in minuts)/plot:- Alupe 1976

Treatments	BLOCKS I	II	III	Treat.Total
B_1	25	33	17	75
B_2	25	20	15	60
B_3	11	19	13	43
M_1	14	10	4	28
M_2	11	8	17	36
M_3	8	11	9	28
M_1B_1	20	17	15	52
M_1B_2	21	13	19	53
M_1B_3	12	16	17	45
M_2B_1	27	27	18	72
M_2B_2	23	19	18	60
M_2B_3	24	23	19	66
M_3B_1	25	31	18	74
M_3B_2	18	20	31	69
M_3B_3	18	25	18	61
Block Total	282	292	248	822

Analysis of Variance(All treatments):

Source	df	SS	MS	F
Total	44	1,845.0	41.93	1.97
Reps	2	71.13	35.57	1.67 ns
Treatments	14	1,176.33	84.02	3.937 **
Error	28	597.54	21.34	CV = 15%

**Statistically significant at the 1% level of probability.

Analysis of Variance(Mixtures)

Source	df	SS	MS	F
Total	26	618.67		
Blocks	2	20.67	10.333	< 1 ns
M	2	194.67	97.335	4.608 *
B	2	38.222	19.110	< 1 ns
M x B	4	27.108	6.778	< 1 ns
Error	16	338.00	21.125	

*Statistically significant at the 1% level of probability.

Table 36 Labour requirements for the weeding
Time in minutes: Alupe 1976

	BLOCKS			
Treatments	I	II	III	Treat.Total
B_1	30	29	26	85
B_2	25	22	21	68
B_3	28	20	25	73
M_1	17	15	20	52
M_2	22	15	22	59
M_3	20	17	18	55
M_1B_1	25	28	16	69
M_1B_2	18	17	21	56
M_1B_3	23	20	17	60
M_2B_1	21	22	17	60
M_2B_2	30	25	19	74
M_2B_3	20	17	18	55
M_3B_1	23	32	22	77
M_3B_2	17	16	18	51
M_3B_3	24	18	20	62
Block Total	343	313	300	955

Analysis of Variance (All treatments):

C.F. = 20,267.2222

Source	df	SS	MS	F
Total	44	884.78		
Treat	14	519.45	37.10	4.026 **
Blocks	2	107.31	53.66	5.823 **
Error	28	258.02	9.215	CV = 8%

** Statistically significant at the 1% level of probability.

Analysis of Variance (Mixtures):

Source	df	SS	MS	F
Total	26	474.667		
Blocks	2	68.670	34.335	2.794 ns
M	2	54.889	27.445	2.233 ns
B	2	1.556	0778	< 1 ns
M x B	4	152.892	28.223	3.110 *
Error	16	196.660	12.291	-

* Statistically significant at the 5% level of probability.