Intercropping - A Food Production Strategy for the Resource Poor farmers

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Abstract: Intercropping is practiced by majority of farmers in the tropical and subtropical regions of the world. This group of farmers produce majority of the food in our markets. This system of cropping suppresses weeds, reduces pest disease infestation, gives yield advantage and there is stable yield over time. Intercropping encourages high nutrient uptake than in sole cropping and water use efficiency is high because of intercoopertive interaction between the intercrops. It encourages high soil fertility maintenance especially where legumes are used as component crop they provide continuous soil cover, which prevents direct impact of raindrops, which causes erosion. By intercropping, a simple combination of maize/cassava can increase CE and pH as well as increase Mn content in the soil. It is a cheap way of food production as one input such as manure can be applied once and used by all the crop components in the farm thereby saving time for the farmer. It reduces risk of crop failure and ensures the farmer's stable income over time. Intercropping helps the farmer to spread his harvest over the season and so ensures a regular supply of food. The farmer makes optimal and maximal use of the land at any cropping season. Intercropping is done with crop rotation to break weed, diseases and pests' cycles and also provides complementary fertilization to crops in sequence with each other. [Nature and Science. 2007;5(1):46-59].

Introduction

The farmer is the central person in crop production. He is the planner and executor of any farm enterprise, and performs all functions involved in food crop production including clearing, planting, weeding, staking and training of vines, fertilizer application, harvesting, processing, storage and marketing. With the large variety of crops, the number of risks involved in crop production is numerous. These risks are centered on farm economics and farm management in connection with the duration of the growing period of the plant, the destination of the crop produce and the scale of production (ILACO 1985). Most crops are annual crops. In the smallholder farmers practice, the most important factors determining the date of planting and harvesting and the crop varieties selected for planting are the annual rainfall and temperature. The farmer starts early, utilizing the early rains before the soil temperature gets cold where he suspects that germination or sprouting as the case may be will not be realized again. Rain fed agriculture has been practiced in crop production for many years before the advent of irrigation agriculture and most smallholder farmers practice all sorts of irrigation farming especially in the dryer regions of the world. Farmers are great people because of their superb initiative to adapt to varied conditions and situations in order to feed their family and world population. Intercropping is practiced to reduce labour at planting time and harvesting .In fact, intercropping is indigenous to the wetter zones of West Africa and Southeastern Nigeria in particular. In home gardens intercropping is practiced at advanced and sophisticated level

The major annual crops which are of great importance to most categories of farmers include the grain cereals – maize, sorghum, millet and rice; tubers – cassava, yam, sweet potatoes and Irish potatoes; others include beans, cow pea, Soya bean and many varieties and species of vegetables. The world food revolve around these crops and the farmers makes use of factors of production - land labour, capital to ensure the feeding of the human race. There are some other crops whose growing period is over 12 months and they are referred to as perennial crops. Some of them become productive within their first year, such crops include sugar cane and others only become productive after a number of years example is oil palm, rubber, cocoa etc.

Throughout the world, farmers are classified into large-scale, medium scale and small-scale farmers. The focus of this paper is on the last category the small scale of which the subgroup in this category the resource poor farmers is drawn attention to. This group plant below one hectare of land and they are in majority mostly in the tropical environment. At least 55% of world farmers are resource poor found mainly in Africa, Asia and Latin American. The smallholder farmer produces crops for his family consumption and sales the surplus to the market. By so doing, the surpluses from these farmers when pulled together is very great that they contribute numerously in feeding majority of our people especially in the tropical a subtropical world.

Intercropping

A cropping system is an aspect of farming system or agricultural production system which consists of one or more enterprises, or business activities in which sets of resources and inputs are uniquely managed by the farmer in the production of one or more commodities to satisfy human needs for food, fibre, various products, monetary income and other objectives (Okigbo, 1982). This however differs from one region or zone to the other to confirm with the culture of the people.

Intercropping is the growing of two or more crops in proximity to promote interaction between them. In line with this definition, Wahua (1982), Ikeorgu (1983), Okigbo (1978) explained that intercropping is the growing of two or more crops simultaneously on the same field such that the period of overlap is long enough to include their vegetative stage. Further to this definition, Gomez and Gomez (1986), stated that where the overlap in time is too small for example only four weeks out of a growing season of 3-4 months, the term relay crop is used.

Sequential cropping, which is the growing of individual crop in sequence during one growing season on the same piece of land and intercropping, are the two basic principles of multiple cropping (Ruthenberg, 1971, Andrew and Kassam, 1975). They noted that, Agro-silviculture i.e. the growing of arable crop mixtures involving the intercropping of arable crops mainly is among the three broad areas of intercropping.

Intercropping is a common feature of agriculture in the tropical Africa as well as in the Asian and American tropics (Papendick et al. 1976, Okigbo 1978, Kurt 1984 and Dalrymple 1971). Specific intercropping systems have developed over the centuries in the different regions and they are closely adapted to the prevailing ecological and socio-economic conditions. Kurt (1984) explained that intercropping system differs frequently from one area to another with changes in soil and local climate while social and cultural conditions may superimpose on the ecological and economical zones. Thus, as regions and ethnic groups differ in their food preferences, so also do they differ in their cropping system Lagemann (1977) observed that the increasing demand for cassava in the densely populated area of southern Nigeria combined with migration of the active male population to urban areas, has caused a decline in yam cultivation in favour of cassava. He stressed that .the population pressure in southeastern Nigeria has also led to an intensification of intercropping in order to increase the production per unit area. In general, there is a high indication in the importance of intercropping since it has for sometime now become government policy to increase production by improving intercropping systems (Kurt, 1984).

Yam and Yam Based Cropping Systems

Yams rank second to cassava as the most important tuber crop in Africa. In turn, Africa accounts for nearly 98% of world yam production. A total of about 26 million tones of yams are produced on the continent annually (Onwueme, 1989) but from more recent report IITA (2005) explained that according to FAO statistics 37.5 million tones of yam were produced worldwide in the year 2000, 96% of this in Africa and Nigeria is leading producer with 26 million tones. According to a popular Igbo saying, “yam was given to man by God.” Hence it is closely linked to the origin of mankind. Yam is part of the religious, social and cultural heritage of many Nigerian tribes and up to date often plays a key role in religious ceremonies (Arinze, 1970). The new yam festival marking the onset of the harvest period is still an outstanding social event almost everywhere in the yam-growing belt of West Africa (Coursey and Coursey 1971). It has been shown that several yam species originated from West Africa (Coursey, 1975, Ustimenko-Bakumovsky, 1983, Howard and Warren 1988, Onwueme and Sinha 1991, Degras, 1993) Thus, yam is truly an indigenous crop in the cultural and biological sense (Lothar 1982). Above all, yam has remained widespread among West African farmers up to date. The center of production however, lies in Nigeria (Lothar 1982, Onwueme 1978, Coursey 1975, Onwueme and Sinha 1991).

Yam, Dioscorea is a monocot (Onwueme and Sinha 1991). It is a large genus of over 600 species with subterranean tubers or rhizomes and it belong to the family Dioscoreaceae (Ustemenko-Bakumovsky 1983, Daisy 1987, Onwueme and Sinha 1991, Degras, 1993). The gender Dioscorea which include many species predominantly are spread in the tropical and partially in the subtropical countries of the world (Ustimenko-Bakumovsky 1983, Daisy 1987, Onwueme and Sinha 1991, Howard and Warren 1988). The tubers are storage organs and often grown to a considerable size. They produce short fibrous roots and annual shoot, which are twining except in the dwarf species and the direction of twining is specific (Daisy 1987, Onwueme 1978, Onwueme and Sinha 1991, Degras 1993). Some of the yams species produce bulbils in the axils of the leaves, which have the morphology and appearance of a condensed stem, and in a few instances are relatively large and tuberous. Yams usually flower and the flowers are small, and borne on long racemes, with male and female flowers separate and mainly borne on different plants (Ustimenko-Bakumovsky 1983, Daisy 1987, Onwueme 1978, Degras 1993). According to Degras, (1993), Onwueme and Sinha (1991) all cultivated species of yam are large leafed with a thin coiling or lodging stem and juicy tubers. The most widely distributed species of yams are the Dioscorea alata, Dioscorea rotundata, Dioscorea esculenta Bourk and the Guinea yam Dioscorea cayenensis which are wide spread in West Africa. Yam is a perennial plant and the tubers mature in 6-10 months and remain dormant for 3-6 months when stored, depending on species and cultivars.

Yams grow best in deep, well-drained soils with a rainfall of 1000-3000mm in the absence of frost. Dioscorea alata for instance may be grown up to an altitude of about 2000m (Onwueme 1978, Bourke 1982 Daisy 1987, Onwueme and Sinha 1991, Degras 1993). The freshly harvested yam tuber consists of 70% water, 25% starch, 1-2% protein and only traces of sugar and vitamin (Onwueme and Sinha 1991, Howard and Warren 1988). The yam tuber can be boiled and eaten with oil, can be roaster or processed into yam flour. Some other processed yam forms include yam chips, which are used as snacks and yam flakes (Onwueme 1978, Onwueme and Sinha 1991, Degras 1993, Daisy 1987).

Many researchers reported that the average yield of yam is at 10-12 tonnes per hectare but may range from less than 10 to more than 50t/ha (Onwueme 1978, Bourke 1982, Ustimenko-Bakumovsky 1983, Quin 1984, Daisy 1987, Onwueme and Sinha (1991), Degras 1993).

Yams are usually intercropped with maize, and vegetables such as cucurbits, pumpkins, peppers and Okra (Daisy 1987). Monoculture is increasing in certain areas of West Africa and Caribbean. However, in yam producing areas of Nigeria, mixed intercropping with maize and cassava or sorghum is prevalent. Kurt (1984), reported that yam is normally planted after bush clearance early and late yam (D. rotundata and D. alata) are usually planted in the same field, either mixed or sole and interplant with cowpea or low populations of maize, cassava, vegetables and plantain. In terms of crop gender relation, yam is man's crop with the men preparing the land, planting the yam and selling the harvest. Women only help in weeding and interplant their crops at the foot or between the mounds. In the subsequent year, maize and/or rice are planted also intercropped with various minor crops while groundnut and cowpea are the main legumes intercropped with yam. Okigbo and Greenland (1976) reported that over 59% of yams and 75% of maize grown in Nigeria are intercropped. Yam/maize/melon and yam/maize/cassava are the most dominant yam based crop combination in the acid soils of the rain forest zone of Nigeria (Agboola 1979, Ezeilo et. al. 1975).

Yam/maize/cassava intercrop is productive and compatible mainly because maize is a short season crop while cassava and yams are long duration (7-12 months) crops (Ibeawuchi, 2004). The two component crops of yam and cassava provide an example of the presence of competition gap within the period each of the component crops makes maximum demands on the environmental growth resources (soil-moisture, soil nutrients, light etc) and this results in higher total yields than the sole crops (Andrew 1972, Kassam and Stockinger 1973, Okigbo and Greenland 1976, Ikeorgu et al 1989). In most traditional yam based farming systems, yam is usually the first or one of the first crops to be planted after the land is cleared from bush fallow (Onwueme and Sinha 1991, Degras1993). This is because of its high fertility requirements, its relatively long growing season and the high value that farmers attach to the yam crop. In continuous cropping, yam usually occupies a portion in the rotation where it can benefit from high soil fertility, usually after following a legume, except for a nematodes legume crop carrier.

Yam breeding is difficult due to loss of efficient sexual reproduction, a consequence of prolonged vegetative propagation. Another important factor contributing to the paucity in developing new commercial high yielding yam lines may likely be due to limited sustainable attempts at breeding the crop for high yields (Nwachukwu and Igbokwe, 2002). However, some researchers (Nwachukwu and Obi, 1999, 2000, Nwachukwu et al 2002) have shown that yam lines developed by hybridization and mutation induction by gamma ray irradiation of true yam seeds out yielded our local cultivars by more than 50%.

Ikeorgu (2002) while studying the use of maize and Telfairia occidentalis to improve the productivity of irrigated yam grown during the dry season explained that in tropical rain forest of Nigeria growing of yam during the dry season is not yet common. There is hardly any report on dry season yam production apart from the few practiced along Niger River flood plains in Bayelsa and Anambra states. However, maize, Telfairia occidentalis and maize/telfairia occidentalis components depressed yam yield by 34.32%, 11.76% and 16.89%, respectively, indicating that the total calorie productivity and monetary value were highest where the three crops were intercropped. Ibeawuchi et al (2005) examined the effect of Okra and Melon introduction on the productivity of yam mini-sett and they reported that introduction at 10 WAP gave significantly higher tuber yields ($P \geq 0.05$) and low yield of melon seeds than introduction made at 0 and 5 WAP. They observed 44% yam mini-sett tuber depression at 5WAP in Okra /melon plots whereas, combination with melon alone gave a 22% yam mini-sett tuber depression possibly because the melon crop failed. They also reported that introduction at 0 week depressed yields of yam mini sett tubers by 41,39 and 48% respectively in crop combinations with Okra, Melon and Okra/Melon.

Cassava and Cassava Cropping System

Cassava (Manihot esculenta L. Crantz) is a dicotyledonous plant growing 1-3m high and belonging to the family Euphorbiaceae (Spurge) the Manihot gender. The plant originated in Brazil with Central America as a likely additional center of origin (Onwueme 1978, Howard and Warren 1988, Ustimenko-Bakumovsky 1983, Pierre 1989, Onwueme and Sinha, 1991). Its world production of 136 million tones in 1985 puts cassava in the sixth position after wheat, maize rice, potato and barley. It is widely spread throughout tropical Africa, Asia and South America, being particularly important in Brazil, Thailand, Indonesia, Zaire and Nigeria (FAO Production Year Book 1985). Nigeria is currently the world-leading producer. Cassava is today grown to some extent in practically every country within the tropical belt. The greatest production is found in West Africa and the Congo basin. Nigeria, Zaire, Tanzania, Mozambique and Ghana are the leading countries for cassava production in Africa (Onwueme and Sinha 1991). Cassava a diploid species (2n=36) is one of the principal plants of use to man because of the important role it plays as food (Pierre, 1989). In Nigeria cassava is prepared as cassava fufu and served with vegetable soups. Boiled cassava and cassava chips are eaten with coconut, groundnuts, fish or meat. Salads made with cassava are usually well balanced and nutritious (Onwueme 1978, Pierre 1989). Industrially, cassava chips are used for animal feed. Also, cassava is processed to make syrup and mono-sodium glutamate, which enhances the flavour of other processed foods. It is used in the manufacture of biscuits, ice cream, glue and textile (Ustimenko-Bakumovsky 1983), Mayhew and Penny 1988). Cassava is currently increasing in importance, particularly in drier areas, because it is a hardy drought resistant crop that can give acceptable yields on low fertility soils (Larsen 1984, Thaman and Thomas 1982, Bourke 1982, Richard and Coursey 1981). Cassava is propagated from stem cuttings and requires weeding until canopy is established. The roots mature in 10-14 months, but are not harvested until required (Howard and Warren 1988). The roots deteriorate after 1-3 days exposure to air in the tropics. The plant is unique in that its roots are not organs of dormancy and hence has no natural functions in preservation of the plant through an adverse season (Coursey 1982). The poor storage qualities of cassava present a major problem (Richard and Coursey 1981, Richard 1985). The approach of not harvesting it until required is disadvantageous because large areas of land are occupied in storage of mature cassava (Coursey 1982). The average yield of cassava worldwide is 9.6t/ha which is less than that for sweet potato and yams, but greater than that for taro (FAO Production Yearbook 1985). Pests and diseases of cassava are severe in Africa (Halm et al 1979) but the crop is free of most pests and disease problems in the pacific (Bourke 1982). However, the major confronting problem with cassava is its cyanide content founded in free and bound forms (Howard and Warren 1988) although most of the cyanide can be removed by post harvest treatments and cooking (Conn 1973; Cooke and Coursey 1981). Cultivars of cassava may contain from 1 to 100mg HCN/100g fresh peeled tuber and there are larger amounts present in the peel and the leaves (Howard et al 1988).

According to Kurt (1984) although cassava is most common in the forest region and in the southern Guinea savannah, cassava based cropping systems are mainly found on poor sandy soils of the coastal belt where food crops other than cassava hardly give satisfactory yield except coconut or oil palm. He further explained that cassava is commonly associated with maize and cowpea. With the increasing length of the cultivation period, and decreasing soil fertility, cassava is the predominant staple crop in many regions of the rain forest and southern Guinea Savannah, replacing especially other root and tuber crops like cocoyam and yam, and maize to some extent.

Onwueme (1978) reported that cassava crop is usually relay-intercropped with yam (Dioscorea spp), maize, melon and okra as the last component. Mixture yields of cassava in cassava/maize, or cassava/beans or cassava/groundnuts were reported to be similar to that of sole crop yield (CIAT 1980). Hart (1975) compared cassava/maize/beans mixture with their respective sole crops and reported the highest net economic returns when the three crops were intercropped without fertilizer. The study showed that the variation in crop morphology were such that beans did not allow weed invasion during the first two months, the maize crop also excluded weeds between three and four months after planting during which cassava component developed enough canopy to cover the rows. Adetiloye and Ezuma (1988), while assessing the performance and production of plantain and cassava intercropping systems noted that growth, harvestable yield and productivity of intercrop components were essentially influenced by the population of individual crops more than the population of other components. It is best to introduce maize three weeks after cassava for cassava/maize intercrop while cassava should be introduced 28 days after planting yam/maize and in each case fertilizer must be applied. Ikeorgu et al (1988) and Jerome et al (1988) reported that in a cassava/maize association, the maize component depressed the fresh storage root yields of cassava by 38%, and that this depression increased with increasing maize population. However, 10,000 plants/ha for cassava and 20,000plant/ha for maize in a cassava/maize intercrop gave the best combination and appeared to be optimum population.

Evaluating the productivity of cassava-yam-maize in the rain forest of Nigeria, Unamma et al (1988) reported that by intercropping, the farmer can obtain the same output as for sole cropping cassava, yam or maize and still have a two year average of 45-67 per cent more land available for other purposes. Similar results were obtained whether the three crops were planted the same day or the cassava component was introduced at 28 or 56 days after planting and maize with or without fertilizer application. The report further observed that on the monetary terms, the mixture in which cassava (Cultivar Abii) was introduced at 56 days after planting maize with fertilizer gave the highest income of N13298.00 per hectare, which was 45 percent greater than the best sole crop income of N6, 818. 00/ha realized from Nwopoko Cultivar that received fertilizer. Based on energy value, the mixture in which cassava was introduced at 56 days after planting yielded 13x104Kcl/ha out-performing the rest of the alternative treatments and produced 38 percent more calories than the best sole crop of cassava as it yielded 8 x 104 Kcal/ha). Ofoh and Lucas (1988) reported that intercropping significantly reduced the yield of cassava and melon but did not affect the yield of maize. However, cassava and maize reduced the yield of melon significantly ($P \leq 0.05$) but cassava had more depressive effect on melon. They reported that there were no significant difference in soil N, P, K Mg Ca, organic carbon and pH resulting from the various cropping systems investigated. They concluded that soil temperatures were significantly low ($P \leq 0.05$) in plots of mixture of legumes and the four crop mixtures. In intercropping of cassava/maize with Mucuna pruriens, Canavalia ensiformis and cowpea, and the corresponding sole cropping of these component, Usman et al. (2002) reported that Mucuna pruriens with application of 100 kg N/ha, 60 kg P_2O_5/ha and 60 kg K_2O/ha, produced significantly higher plant biomass while the lowest was obtained from cowpea with or without application of fertilizers. They reported that cassava/maize/mucuna intercrop produced significantly higher yield of cassava than other treatments and that maize yield was highest when it was preceded by cassava/maize/mucuna with NPK application. The potentials of Mucuna pruriens was observed in Cassava/Maize/mucuna which gave higher yields of cassava roots and high returns at end of the cropping period (Ibeawuchi, 2004)

Maize and Maize-Based Cropping Systems

Maize (Zea mays L.) originated in Mexico in Central America. It is the most important cereal crop in the world after wheat and rice (AID, 1974; Ustimenko-Bakumovsky, 1983; Onwueme and Sinha, 1991; Purseglove, 1972). It is a major item in the diet in many tropical countries whereas in the temperate regions maize is the main grain used for animal feed (Purseglove, 1972). Maize belongs to the family gramineae to which most of the grass species belong. It is an annual monoecious plant. In many African countries, maize is the basic food for subsistence farmers, miners and city dwellers; its importance is as great as that of wheat in the mid East and rice in South East Asia (NRC, 1988).

According to Byerlee and Winkelmann (1981), Africans consume nearly one-fourth of the world's total maize. Onwueme and Sinha (1991) pointed out that the major maize producing countries in tropical Africa are Tanzania, Kenya, Zimbabwe, Zambia, Nigeria, Ethiopia, Malawi, Ghana, Cameroon, Cote d'Ivoire, Mozambique and Zaire. They reported that in 1989 the total maize production was 36.4 million tones. In the tropics, maize is eaten in many different ways. It is prepared and consumed in a multitude of way that can be grouped as follows – ground or pounded and baked or fried, boiled whole, roasted whole, fermented. In Nigeria maize is consumed mainly in two forms (ogi) (pap) and (agidi). Maize is industrially important chiefly for the production of alcohol, oil and starch (Onwueme and Sinha, 1991; Mayhew and Penny, 1988). Ustimenko-Bakumovsky (1983), RRIM (1975), Mayhew and Penny (1988) further stated that in the industry maize is processed for technical oil, ascorbic acid and glutamic acid. They explained that the extracts from maize style (spadix filaments) are used in medicine while the stalks can be used in making papers and cardboards, plastics, menthol and tar.

Due to high variability in climatic conditions, diverse soil types, population density and socio-economic factors, maize cropping systems are very diverse. They include intercropping systems for risk management and efficient use of land and labour resources and sole cropping systems. Sole cropping maize can be produced from high fertilizer inputs to sole cropped maize rotated with legumes or maze produced with integration of maize produced with organic and inorganic inputs (Mafongonya et al., 2003).

They reported that maize intercropping systems are very common in large areas of East and Southern Africa. They reported that maize and beans (Phaseolus vulgaris) are predominant in East Africa while in Southern Africa maize is intercropped with cowpea (Vigna unguiculata), groundnuts and bambara nuts to a less extent. Furthermore, they reported that, the low plant densities of legumes found in most intercrops mean that they can input modest amounts of N and organic matter each year to maintain soil fertility.

According to Okigbo (1977) maize is intercropped with vegetables and other crops in traditional agriculture mainly to satisfy dietary requirements. In Nigeria, maize is often found severally intercropped with assorted crops thereby forming an integral component of various cropping systems. Ikeorgu (1983) reported that maize compatibility in mixtures was attributed to the fact that it is a C4 plant, and giving reasons why C4 plants are successful in most cropping systems. Crookston and Kent (1975) upheld that they have higher temperature requirements for optimum growth and more so, respond to higher light intensities and they remove carbon dioxide from the atmosphere than the C3 plants.

Agboola and Fayemi (1971) reported that in maize/cowpea intercrop, yields of maize were improved with associated cowpea crop, which provided about 25 kg N per hectare to maize crop through nodulation but noted that the intercrop yield of cowpea was lower than the sole crop. Researchers in RRIM (1975) reported that the intercrop yield of maize was within the range of 2.2–4 t/ha in maize-rubber mixture. They also observed that root and stem lodging of intercropped maize was less in maize/melon than in sole maize or even maize/cassava. Also, researchers in IITA (1975) stated that maize grain yield was hardly reduced by intercropping maize with cow pea. However, Wahua et al. (1981) and Eriksen and Whitney (1984) reported that in maize/cowpea mixture, maize is the dominant crop and its shading effects on cowpea have been established to reduce cowpea grain yield

A cropping system or a crop production system consists of the cropping pattern in terms of crop combination, spatial arrangement and sequences of cropping in addition to the resources and input management and technology involved in the production of the desired products (Okigbo, 1978).

For centuries in the tropics, farmers have taken the advantage of the year round favourable temperature and solar radiation when water is available, to produce a number of crops simultaneously on the same piece of land (Ikeorgu, 1983). This system, which involves the practice of growing several crops on the same piece of land, is referred to as multiple cropping (Gomez and Gomez 1986). It is an ancient strategy for crop production among farmers in the tropics. Traditionally, subsistence farmers primarily to increase the diversity of their products and to achieve stability and sustainable agriculture use this method. Since nature consistently integrates her plants and animals into a diverse landscape, a major tenet of sustainable agriculture is to create and maintain diversity (ATTRA 1998). Nature is efficient; there is no waste product since outputs from one organism become inputs for another. The principles by which nature functions explains that the death of one organism becomes food for other organisms and since we are modeling nature, we must understand and utilize these principles to reduce costs and increase profitability, while at the same time sustaining our land resources.

In Nigeria, the traditional farmer finds it more satisfactory to plant a diversity of crops than planting sole. It is cheaper for farmers to grow many of their own requirements than to buy them (Kurt, 1984, Gomez and Gomez 1986). The human environment changed tremendously, when the early human replaced hunting and gathering of food with domestication of crops and animals. By producing a limited selection of crop plants and animals, human kind has greatly reduced the level of biological diversity over much of the earth. Annual crop monocultures represent a classic example and in response to this biological simplification, nature has struggled to restore diversity to these landscapes – that is her tendency (ATTRA, 1998). Our "war" with nature over the tendency towards diversity is what we call "weed control" and "pest management". We could hardly produce any crops if we simply allow our fields to be covered by natural vegetation (weeds) but with the benefit of diversity we can realize some reasonable yields by planting mixture of different crops that help to suppress weeds.

In crop mixtures, cooperation is more apparent than competition and there is far more cooperation in nature than competition. Cooperation is typified by naturally beneficial relationships that occur between species within communities. An example is the relationship that exists among squirrels, fungi and trees in the redesigned forest (Maser, 1990). However, stability tends to increase with increasing diversity because if a crop field is abandoned, it will first be colonized by just a few species of plants, insects, bacteria and fungi. After several years, a complex community made up of many wild species develops and once wild plant and animal community has reached a high level of diversity, it appears to remain stable for many years (ATTRA, 1998). Also, the more complex and diverse communities become, the fewer the fluctuations in numbers of a given species, and the more stable communities tend to be. As the number of species increases, so does the web of interdependencies, in both lower and higher rainfall years. There are fewer increases in any one species and fewer fluctuations in the community as a whole (Savory, 1998). ATTRA (1998) explained that in pursuing diversity on the farm, we could begin to model them after some natural principles. Some pioneering farmers were able to utilize nature's principle of diversity to their advantage. Some results of their efforts include lower cost of production and higher profits, which is the main target of any farmer.

Most recently, the urban agriculture sprang up and is fast expanding and helping to feed the teeming urban population in Nigeria and West African sub region.. Uncompleted buildings, road sides and fallow lands within the urban areas are seriously being used for intensive farming ranging from rearing of animals to horticultural productions such as ornamentals and vegetable crop production. This system is now feeding a lot of indigenes who at the establishment of the township were displaced and other urban inhabitants who find farming very interesting and economic as an avenue to create wealth and sustain their families.

Intercrop Productivity

One of the most important reasons to grow two or more crops together is the increase in productivity per unit of land. Researchers have designed several methods for assessing intercrop performance as compared to pure stand yield (ATTRA, 1998) but the use of the land equivalent ratio (LER) has become common practice in intercropping studies, because of its relatively simple concept (Kurt, 1984). The land equivalent ratio (LER) may be defined as the relative land area under sole crops that is required to produce the yields achieved by intercropping (Kurt 1984). It is usually stipulated that the "level of management" must be the same for intercropping and sole cropping. In this regard, intercrop and sole crop have to be at their optimum populations as differences in population affects yield responses (Huxley and Maingu 1978).

Kurt, (1984) noted that an important concept inherent in the use of LER is that, whatever be their type or level of yield, different crops are placed on a relative and directly comparable basis. He further explained that based on land areas, LER also reflects relative yields (the numerical yield total is numerical to LER) i.e. the LER can be taken as a measure of relative yield advantage.

The LER is calculated as follows:

$$LER = L_A + L_B + \ldots\ldots + L_N = \frac{Y_A}{S_A} + \frac{Y_B}{S_B} + \ldots\ldots + \frac{Y_N}{S_N} = \sum_{I=1}^{N} \frac{Y_N}{S_N}$$

Where L_A, L_B… L_N is the LER for the individual crops

Y_A, Y_B… Y_N are the individual crop yields in intercropping.

S_A, S_B… S_N is their yields as sole crops

When LER is greater than 1 or more, it signals yield advantage and a ratio of less than 1, is yield disadvantage (ATTRA, 1998, Kurt, 1984).

Soil fertility maintenance: Soil losses and run-off is limited because the practice of intercropping, more especially multi-storey cropping provides a nearly continuous soil cover thus preventing it from the direct impact of the rains (Kurt, 1984; Gomez and Gomez, 1986). They pointed out that intercropping produces a dense and diversified root system and this reduces leaching of nutrients. Okigbo and Lal (1979) reported that relatively simple intercropping system as maize/cassava can increase of CEC (cation exchange capacity), and pH as well as increase Mn content in the soil. According to Ibeawuchi and Ofoh,(2003) in an intercropping of cassava /maize/food legumes the decaying litter form humus and organic acids that form complexes with Iron(Fe) and Aluminum (Al) thus reducing considerably the ability of soil to tie up Phosphorus (P) hence making it available in the soil. Furthermore, the integration of trees into cropping systems in the form of alley cropping is another means of maintaining soil fertility. It reduces soil erosion and leaching with the help of the root systems by "pumping up" nutrients to the surface from layers beyond the root systems of annual crops (NRC, 1984). In a farmer-oriented research, IITA Ibadan Nigeria has for several years developed a method for planting giant leucaena as an intercrop with corn, yam and rice. In the growing season the trees are kept cut and pruned so that they do not shade the nearby crops. The resulting leaves and twigs are used as nitrogen rich mulch while the larger branches serve as poles or firewood. In the dry season, the tree intercrops are allowed to re-grow and draw nutrients from deep soil levels (IITA, 1979).

Soil Nutrient uptake: Several scientists have compared nutrient uptake in crop mixtures and in pure stands and showed that crops extract more nutrients from the soil when grown in mixture than when grown in pure stands Dalal (1974) compared maize and pigeon pea mixture with maize, and observed that the differences in growth duration of the components crops tend to minimize competition. Kassam and Stockinger (1973) shared the same view in reporting that intercropping systems were most rewarding in terms of yield of the component crops when there was a competition gap between the periods the components crops made maximum demand on the micro-environment (soil nutrient, soil moisture, light etc). Agboola and Fayemi (1972) reported the need for intercropping with legume as the tropical legumes were capable of fixing large amounts of nitrogen when grown in mixture with maize. They concluded that the maize component received an equivalent of about 25 kg N/ha from the associated legume.

Water use efficiency: According to (Okigbo, 1978) and Kurt (1984), intercrops have better water use efficiency than sole crops. They explained that this is of special importance for farmers in the semi arid tropics where water is the main limiting factor of production. They reported that one of the reasons for increased water use efficiency of intercrops is the windbreak effect. Okigbo (1978) observed that when low growing crops are interplanted with tall growing ones, this leads to reduced evapotranspiration. Again, there is a low population for the residual moisture at the end of the growing season which is another means of using available soil moisture more efficiently by intercropping (Rao and Willey, 1980; Okigbo, 1978).

Yield Advantage

Intercropping has been reported to have yield advantage over sole cropping. These advantages can occur as a result of complementary use of growth resources such as nutrients, water and light by the component crops (Enyi, 1973). The yield advantage may be in terms of higher yield or higher net income. He further explained that the yield can be quantified in terms of dry matter production, grain or root yields, nutrient uptake, energy or protein production and market value. According to Kurt (1984) and Gomez and Gomez (1986) the yield advantage is measured using land equivalent ratio (LER) or Relative yield totals (RYT). LER is defined as the relative land area under sole crop that is required to produce the yield achieved by intercropping at the same management level. While RYT is the sum of the ratios obtained from the relative yields (intercropping yields divided by respective sole crop yields) of the component crops in a mixture using the above calculations, yield advantage have been reported for cassava/maize and cassava/beans mixtures (CIAT 1979). According to Ikeorgu et al. (1983), cassava/maize intercrop gives higher amount of calories per hectare of land than the pure stands. Also, land equivalent ratio of 1.71 has been reported for cassava/maize intercrop (CATIE, 1977)

Stable yield: Another major advantage of intercropping is yield stability. That means a reliable food production over years that provides a high income for the farmer and enhances diversity of farm products (Rao et al., 1979). Gomez and Gomez (1986) felt that intercropping does not only enhance diversity of farm products but also provides insurance against crop failure. They reported that with diversified crops, intercropping stabilizes yield through the principle of compensation. They explained that when one crop component suffers from pests, diseases, draught etc, the loss of this crop is compensated at least partially by the other component crop(s) since there is now less competition for growth resources, and stated that there would be no compensation if it were to be only a sole crop system.

Pest: Intercropping can play a significant role in integrated pest management. There are many cases where pests and especially weeds are suppressed by certain crop combinations like maize/soybean, maize/black gram, maize/velvet bean (Chaud and Sharma, 1977). They reported that in all the crop combinations there were pest (stem borer) reduction in all intercropping involving maize and another crop when compared to maize grown sole.

According to Moreno (1979) intercropping cassava and maize significantly delayed the onset of the cassava scab (Spaceloma spp) epidemic. Also, when cassava is planted in association with maize and common bean, there is less rust (Uromyces manihotis) on cassava. Arene (1976) and Ene (1977) reported that there was significant reduction of cassava bacteria blight (CBB) (Xanthomonas manihotis) by intercropping with maize, melon or other crops in Nigeria. They concluded that this reduction in CBB could be ascribed to the earlier and better soil cover provided by the intercrops, which at least to a significant level prevented splashing of the bacteria from the soil onto cassava leaves and stems.

Wolfe (2000) reported that farmers in Yemen province of China under the direction of international team of scientists made some simple changes in their rice production methods. They changed from planting their typically pure stand of single rice variety to planting a mixture of two different rice varieties. This technique helped in reducing blast disease and the farmers were able to abandon using chemical fungicides, which they had been using.

Weed and intercropping systems

Onwueme and Sinha (1991) reported that a weed is plant growing where man does not want it to be. They explained that any kind of plant can be a weed as long as it exists in a location or situation where it is considered undesirable. Fadayomi (1979) pointed out that weeds constitute a major limiting factor in food production in Nigeria. After a long research, FDA (1994) reported that one of the major tasks facing Nigerian farmers in their effort to feed the nation is the absence of adequate technologies to control weeds. They stressed that until adequate attention is paid to the weed problems confronting different categories of farmers, real progress cannot be made in agricultural development in Nigeria. The total land area a farmer can cultivate is determined to a great extent by how much labour is available to him for weed control. Also in many cases only a farmer and his wife are available to face this great task because their children of school age are generally away from home.

Akobundu (1987) reported that weeds determine the farm size and limit of crop production potential of peasant farmers and indirectly affect the well being of farm families. According to Lavabre (1991), weeds to some extent affect all crops but how serious this is depends on the species and circumstances. He explained that average crop losses due to weeds are estimated at 25% but may be as high as 50% or over 80% with certain food crops. Also, Reminson (1978), and Nangju (1980) reported on the reductive effect of weed on crop production and indicated that 51% reduction in cowpea yield was due to weed infestation, 65% in cassava, 73% in yam and 80% in maize. Akobundu and Poku (1987) reported that in Nigeria, yield reductions have also been attributed to poor crop establishment and stand reduction in growth, pest and disease infestation.

Kurt (1984) explained that yield losses due to weeds are considerable in the tropics and can exceed 50%. He reported that weed infestation increases with time from clearance onward and after three years the farmers are often forced to abandon a field and clear a new one, because the time needed for weeding is greater than time needed for clearing forest or bush. In Western Nigeria, at least 50% of a farmer's working time is spent on weeding (Moody, 1975), and the situation is similar in other regions.

Most crop combinations suppress weed growth by providing an early ground cover, due to high plant population or fast growing component crop e.g. melon. Even though, the yields of the domesticated crops are often considerably reduced, this is still more than weed would produce in the same place (Evans, 1960). In many intercropping systems, only one weeding is required to produce optimum yields instead of three or more in sole crops. Often times, this weeding is combined planting another intercrop thus further reducing the time required solely for weeding (Kurt, 1984).

Moody (1977) found that in Asia crop associations of maize and groundnut, mung bean or sweet potato were excellent for reducing weed growth, yield losses and weeding time. He explained further that in a maize/sweet potato and maize/groundnut crop combination, weed growth was less than in sole cropped groundnut or sweet potato but higher than in sole maize. Researchers in CIAT (1979) reported that in intercropping systems involving cassava/beans, weed growth was reduced in Central America. They explained that with this result, frequent weeding of pure cassava was no more efficient in weed control than intercropping cassava with beans. Hart (1975) concluded that the success of an intercropping system in suppressing weed growth does of course; depend on soil fertility and climate as well. His result showed that suppression of weed is often higher with low fertility than with high fertility soil and the same was valid for low and high rainfall areas.

Conclusion

Due to the nature of our soils, early weeding should be done to reduce completion for nutrients by the component crops and also weeds in intercropping systems.. Row intercropping is encouraged to give room for mechanization which most medium and large-scale farmers advocate. Timely harvest is also advocated to give room to other component crops with longer harvest period. Intercropping helps the resource poor farmers to produce food in excess of what is required by the family and these surpluses are used to feed the ever-increasing world population. By this, intercropping plays a wonderful role in reducing the hunger gap between the haves and have not. It is therefore by its nature a sustainable way of food production and a strategy for resource poor farmers who produce majority of our foods.

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