

# Potentials of Intercropping Systems to Soil - Water - Plant- Atmosphere

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## Abstract

A well planned intercropping system can efficiently serve as alternative to input such as fertilizer, herbicides, pesticides and pathogenicides. The interaction between the intercrop species, soil and environmental factors have positive effects on crop nutrition and photosynthesis and these have improved the nutrient content of the soil and different intercrop components. The high percentage ability of the intercrop species to suppress weeds especially when legume crops are involved in the plan, improves the physicochemical properties of the soil, contributes to the health of the intercrop species as the intercrop promotes the synthesis of allelopathic compounds and phenolic compounds such as anthocyanins and flavonoids which may serve as a deterrent to diseases and pests and improve the quality of the intercrop plants. Due to its inherent biological, biochemical and physiochemical properties intercropping system may be used to promote sustainable crop production and for safe management and cost-effective agricultural activities.

**Keywords:** allelopathic, disease, intercrop, pests, pathogens, nutrient recycle, socioeconomic

## 1. Introduction

Intercropping system is a traditional cropping system more pronounced in Africa, Asia and Latin America were poverty is on the higher percentage. The intention of the farmers being the quantitative advantage of the intercrop over the sole crop most often time the system involve growing the main crop together with the sub-crop or secondary crop (less desired crop). Some of the objectives of the sub-crop in the intercrop are to provide nutrients, suppress weeds, pests and disease check through their allelopathic effect, adequate utilization of environmental factors and their interactions with the crop species. In such a situation the yield advantage of the intercropping is the yield accruing from the additional crop (the sub-crops). In most cases especially where it is the main objective of the farmer to grow both crops, the joined intercrop result is greater than the joined sole crop output. Though in some cases combined intercrop yield does not necessary exceed the yield of the higher yielding sole crop. Cereal-legume intercrop in countries like south America, Africa, and Asia has being found by Vandermeer (1989) to be common practice and their advantages relative to sole cropping are affected by soil water content and nutrients, species and varieties of the crop plant. Intercropping ensures yield stability efficient utilization of sunshine and land and in maintaining the fertility of the soil (Onwueme and Sinha, 1991, Nweke et al., 2013, Nweke, 2015). In brinjal- groundnut intercropping Prashaanth et al. (2009) observed that pod weight of brinjal in mono cropping was low due to absence of intercrop which leads to high water evaporation from soil surface. Yield successes were recorded by Jiao et al. (2008) in maize-groundnut intercropping they observed that the intercrop system increased the effective utilization of light by maize and groundnut that led to the yield enhancement. Ogindo and Walker (2008) have identified that due to higher leaf area and leaf area index inter crop has being able to minimize soil water loss. On low nitrogen soils the amount of nitrogen fixed was closely correlated with legumes dried-matter production (Vallis et al., 2012). Bhegat et al. (2006) reported yield increases under intercrop conditions of groundnut/sweet corn of which they attributed it to none availability of symbolically fixed N by the groundnut crop of which they observed to increase with increasing proportion of groundnut. Intercropping studies with *calapogonum mucunoides*, groundnut, pigeon pea and cowpea, Agboola and Fayemi (2001) indicated that the cover crops fixed 370kgN/ha when intercropped with maize. Viljoen and Allamaon (1996) found out that income generation, adaptability, and weed control, reduction in crop failure, adequate nutrient, soil conservation and maintenance are major factors for famers to intercrop their crops. Potentials for increase gains due to the growth of another crop on the same land are some other advantages of intercropping system. Time as well as farm instruments and labour are easily managed (McCoy et al., 2001, Vandermeer 1989).

Crop parasitic nematodes are one of the main soil-borne plant pests that can be effectively reduced when food crops and legumes are intercrop. Legume crops are susceptible to nematodes of various ranges of species. Some of these legumes when used in intercrop system whether as live mulch or in situ creates an unsuitable environment for the nematodes of which drastically reduced their population in soil. The number of nematode specie, *meloidogyne incognita* which is not thought as a maize pest can rise under pigeon pea, bambara groundnut *psophocarpuspalustris*. When any of these legumes is intercropped with maize the population of *Helicotylenchus psendorobustus* the spiral specie of nematode which is injurious to maize plant is likely to decrease. Poor resource farmers due to none availability of farm land and efficient utilization of inputs by intercrop species engage in the practice of intercropping. Single crops require more chemicals to control diseases, pest and insects and these chemicals may not be available. Such beneficial interactions between food crops and legumes justify the intercropping systems effect on certain plant parasites and pest. Thus the review tends to report on the potentials of intercropping on efficient utilization of soil resources and environmental factors, yield and economic returns, pests, diseases and weed control.

## **2. Effect of Intercropping on the Soil Pathogens, Pests, Diseases, Weeds and Allelopathic Compound on Soil-Water-Crop Environment**

Intercropping system has been indicated to be more ideal to use instead of herbicide in controlling growth of weeds in farm land (Liebman and Davis 2000). The total quantity of weed on maize plant can decrease by means of intercropping of which are influenced by climate condition and maize culture. The study of Gomez (2007) showed that for most variables evaluated in Brazil intercropping system decreased the quantity of herbicides used in weed control and there was no interaction recorded among the maize culture and weed control method. Crops from hand weeding recorded higher values relative to crops obtained from intercropped plots that are not weeded. Hence cowpea was inefficient in controlling weed in the intercropped plots. According to Liebman and Dyck (1993) intercropping system is competitively advantageous to mono cropping with regard to utilization of soil nutrients, allelopathic impact on weeds and the ability to exploit those nutrients not used by weeds for the good of the crop plant than would have done by mono cropping.

Maize intercropping, with different kinds of leguminous and other crops is an extensively used practice across the world and the assessment of weed control in maize production using intercropping system is of great concern. The ability of the different crop varieties such as maize, soybean, cotton and potatoes, to reduce weed biomass have been reported by Callaway (1992). The yield losses observed in the old one were indicated to be due to less LAI (leaf area index), less photosynthetic density and its less nitrogen use efficiency. Sinoquet and Cardwell (1995) have argued that plants involved in competition for light possess some major attributes of which are the rate of leaf area expansion, height of plant and distribution short leaf areas. These are some of the features that can make intercrop plants to have competitive advantage over weeds. These characteristics however may be increased by changes in plant management systems like plant spacing, crop population or through crop breeding (Linguist and Motesium 1998). The plan can cause maize plant to compete more favourable than the weed thereby reduce quantity of chemicals required for the control of weed. Forage legumes especially the prostrate type like bambara groundnut, mucuna pruneus, melon, cowpea, groundnut, *centrosema pubescens* *pueraria phaseoloides* etc, when use in an intercropping system compete with and smother weeds successfully when well established. Jurium and Henerary (2009) in Zaire used cover crops like *pueraria javanica*, *stylosenthes guianensis* and *calapogonum mucunoides* to get rid of *imperata cylindrica* completely in the savannah region.

In southwest Nigerian, at international institute of tropical agriculture (IITA) main station Ibadan, Akobundu and Okigbo (2005) investigated maize yield with several ground-cover weed competition. Maize seed was sown in already established legumes. Weed population was observed to be greatest in *dsemondium triflorum* *indigofera spicata* and in non-tillage control plots, was moderate in groundnut and maize – stover plots and very small in *centrosema*, *pubescens*, cow pea, pigeon pea, and *psophocarpuspalustris* plots. Higher maize yield was obtained from where weed competition was minimized by the legume cover crop. Akobundu (2010) noted that after five years of intensive cropping maize yield obtained from plots with live mulch (intercrop) under minimum or conventional tillage were found to be greater than maize yield obtained from sole crop (bare). Maize in non-tillage system responded to application of 60kg nitrogen/ha but no nitrogen response were observed by maize in the live mulch plots. This meant that intercrop contributed to the need of the maize crop. Although good results were obtained from alfisol, disappointing results were recorded on strongly acid ultisol in south-east Nigerian by Faulkner (2004) of which he attributed mainly to poor establishment of cover crop. The system of intercropping of cereals with legumes are been enjoyed by farmers in the tropical environment and rain fed areas of the world due to its advantage for weed control and yield increment (Tsubo et al., 2005, Gosh et al., 2004, Poggio 2005).

Srikrishanh et al. (2008) found weed population was reduced in brinjal- groundnut intercropping. Intercropping maize and legumes - soybean considerably reduces weed density compared with mono-cropping soybeans.

Growing crops in a mixture reduce weed occurrence (Zuofia et al., 1992). Intercropping with cover crop reduced the structure of weed community, an alternative weed growth reduction and reproductive potential mainly to maintain productivity. Using cover cropping as a tool for weed control, especially for farming activities with small inputs weeds were drastically reduced and yield increased (Itulya and Aguyoh, 1998, Liebman and Davis 2000, Schoofs and Ebtz, 2000). The suppression of weed occurrence was observed in maize/groundnut intercrops, sweet potato/mung beans intercrop and in all weed biomass were drastically reduced. This could be due to the shading effect as was reported by Oswald et al. (1998) it was equally observed that single weeding is merely required to achieve the same yield value obtained from several weeding required of sole maize. Soybean intercropping was noted to decrease weed population to the tune of 39% as relative to sole maize (Ayemi et al., 1984). However in another study by Ayemi et al. (1984) weed biomass was not reduced by maize/cowpea intercrop, it was concluded that weed population must be controlled initially to enable the leaves to develop sufficiently enough for weed reduction in inter cropping of maize and cowpea. Obilana and Ramaiah (1998) explained that striga control practices can be achieved through intercropping systems which requires small manipulation in the farming methods without any conditional inputs though he opined that this should be accompanied by additional land weeding of which could be made easier by striga plants.

The term allelopathy referred to the release of chemical substances directly or indirectly into the soil medium by one plant to harmfully affect another plant. Ferguson and Rathinasabapathi (2003) found out that in both natural and agricultural systems dangerous chemical which is allelopathy is released from one part of plant by leaching, root exudates, volatilization, residue decomposition and other process. Allelopathy been root exudates has potential effect on many parts of the plant communities, dominance, diversity and productivity. According to the work of Florentine and Fox (2003), the degree of allelopathic effect is determined by the magnitude or extent of disease and insect infestation during the plant growing period. Allelopathy as well play major role in reducing weed growth. Thus intercropping legumes with cereals can take advantage of allelopathic potential to reduce the growth of weeds. The reduction of weed population through allelopathy is weed sensitive. Hence weed control in larger form will involve the growing of different species of crop together and each releasing harmful chemical (allelopathy) to a particular weed type.

The popularly known allelopathic impacts according to Ferguson and Rathinasabapathi (2003) will include decrease in the germination of seed and growth. There is no physiological target site or common mode of action for all allelochemicals. However, enzyme functions, photosynthesis, cell division, pollen germination etc are some known sites of action for allelochemicals. Allelopathic suppression becomes complex with mixture of different compounds when its activities interact with chemicals such as alkaloids, amino acids, flavonoids, phenolic compounds, carbohydrates and terpenoids. Many of these chemical substances noted to be inhibiting are produced from living plants that release phytotoxic chemicals into the soil medium through plant residue decomposition, leaching, root exudation and volatilization. Swain (1977) found most of the phototoxic chemicals as secondary metabolites which are not important in primary metabolism necessary for plant establishment. Some notable allelochemicals usually cause suppression of seed germination and growth. Weed species often possess much higher levels of allelochemicals than the crop plants (Gupta 2007). In organism communities the work of Adie and Chase, (2007) showed that many plants tend to regulate one another through the production and release of chemical stimulators, inhibitors or attractants. Akinsanmi, (1998) however, reported that certain weeds produce chemical substances which are detrimental to crop plants, some are poisonous to animals while yet others may harbour insects and pathogenic organisms harmful to crop planted. Weeds can cause greater reduction in yield of vegetables. Awogbade et al. (2003) investigated the effects of aqueous extracts of *phyllanthus amarus* on germination rate of some vegetables. They found out that allelopathic effect of *phyllanthus amarus* on celosia, solanum and amaranthus germination were inhibited at 50% extract concentration while corchorus and okra had lowest germination rate 75% and 100% extract concentration respectively. Manonmani (2012) reported similar inhibition of root and shoot elongation with increased extract concentration of *tridax procumbens* on some leguminous plants. The plumule of solanum experienced stimulatory effect of extract at 100% concentration of which they found to be significantly higher than other treatments, both plumule and radicle of okra were mostly inhibited at 100% extra concentration.

Allelopathic weed inhibition can be influenced by such factors as or parameters like; pest and disease infestation, amount of nutrients, herbicides, solar radiation, water content, temperature as well as environmental and physiological stress. Plant parts such as roots, stems/bark, leaves and flower, soils and their chemical compound can produce allelopathic effect of which changes over a growing period. Ferguson and Rathinasabapathi, (2003) noted that these chemicals can persist long in the soil affecting member plants and those planted in succession.

Crop yields and residues as noted by Stanford and Haris, (1984) are equally affected by allelopathic and phytotoxic chemicals. El –Ehawas and Shehata (2005) reported that kidney pea and maize seedling emergence decreased with treatment of *Acacia Nilotic* and *Eucalyptis rostrate* on biological and morphological criteria. The authors found out that yield reduction in cropping system was due to allelopathic effect. These allelopathic problems however can be observed in both intercropping systems and mono cropping systems. For instance, continuous monoculture system can cause the accumulation of photo-toxins and injurious soil organisms that can give rise to phototoxicity and reduction in fertility of soil. A good number of species of weed also have some growth inhibiting effects on crops. Many physiological processes and activities of crop plant are influenced by allelo compound that stop growth of plant. In the root rhizosphere the concentration of ion uptake and hydraulic conductivity determine the level of growth suppression by the allelochemical. Nonetheless some plant may be able to escape allelopathic chemicals due to their hypersensitivity of which the implication is that some crop root become strongly affected by allelo chemicals which can inhibit their growth.

Intercropping help in pest and disease control maize for example is susceptible to many insects and diseases. Therefore intercropping will be promising cultural practice for this purpose based on the fact that one member crop of an intercropping method may be check against pest or disease spread. In maize/chilli intercrop Gutierrez, (1999) found the activities of *anthonomus eugenii* to be less and yield obtained higher relative to sole chilli. The leaf hopper and white fly infestation were observed by Srikrishanh et al. (2008) to be less in the intercrop of groundnut and brinjal relative to mono cropping. Trenbath, (1993) noted that diseases and pests that cause destructive effect in sole crop show very less harmful effect in intercrop unlike in mono culture. For instance, maize is susceptible to many insect species as pest such as weevils, boll warms, beetles, stalk borers, leafhoppers, aphids etc and diseases like stalk rot and leaf streak (which are bacterial diseases), cob and tassel (fungal diseases) dwarf mosaic and streak diseases (viral diseases) and root knot disease cause by nematodes (Flett et al., 1996). Also for example cowpea are usually influenced by insect like aphids, foliage beetle, thrips and pod borers, diseases such as rust virus (e.g. anthracnose) and scab and bacterial diseases such as blight (Adipola et al., 1999, Edema 1995). So growing these crops in intercropping system have the capacity of bringing down the incidence of these diseases and pest to the barest minimum where it will have no remarkable effect on the yield of crops and the return on investment to the farmer. Vandermeer (1973) opined that intercropping effect on these pest and diseases may be associated to micro environment effects of related crops in intercropping compared to sole cropping. Intercropping methods have been observed to cause low survival of pests due to the consequences of landing on none host plant as well as their visual disturbance and distributive effect. Even the existence of weed as reported by Altien (1990) can affect pest search for their hosts. Power, (1990) used intercrop method to decrease the level of *Dalbusmoundi* (Maize leafhopper) in different maize cultivars. Anyisi and Mposi (2001) intercropping cowpea cultivar PAN 311 found that the incidence of stalk borer *chiloparellus* (swine hoe) infestation was significantly reduced in sorghum intercrop relative to mono culture. The yield of bean and aphid attack was observed by Oganga-Latigo et al. (1992) to decrease following intercropping system. Anyisi and Mposi, (2001) where of the opinion that factors such as crop species, variety of cultivars, crop density, soil water content and fertility as well as row management have made yield increases in intercrop relative to mono crop and pest control inconsistent in research results. Individual crops as reported by Nwanze and Mueller (1989) may not have the same effect or response. With maize/*Lablab purpureus* L. (*Lablab*) intercrop Maluleke et al. (2005) observed significant reduction in maize stem borer of which was severe in mono culture. Increased crop densities were equally noted by Oganga-Latigo et al. (1992) to have decreased the impact of aphid following intercropping method. There was reason or chance that less visual diseases under this situations were merely due to unfavourable micro climate for the aphid intercrops.

### **3. Influence of Intercropping on Soil Nutrient, Crop Yield and Economic Returns to The Farmer and Ills of Intercropping System**

Cash advantage due to intercropping (CAI) investigated in cassava and water melon intercrop in south-west Nigerian, Kintomo, (2001) observed that CAI increased with increase in water melon proportion indicating higher contribution of water melon to mixture productivity. The CAI value showed that the alternative cropping system could generate additional income for farmers of which such income could be used to maintain cassava plots the following year when farmer may be cash trapped. Gosh et al. (2006) in intercropping test found out that intercropping was beneficiary for the soil microbial community of sorghum but not for soybeans an indication that the two crops competed with each other. According to Ecoport (2004) and Ikeh et al. (2013) growing conditions affect yield of intercrop even with proper management. In as much as agricultural systems are been affected by the growing conditions of crops intercrop systems can as well make the conditions vulnerable to the environmental factors coupled with management systems in operation thereby creating inconsistency in yield of which cause a

drawback in the adoption of the intercrop method. Intercropping of cereal with legumes have been found to be a protection against yield failure, less cost of production and increase monetary return to poor resource farmers, improving yield stability and socioeconomic enhancement (Ofor and Stern 1987, Nweke and Anene 2019). Intercropping economic benefit according to the work of Seran and Brintha (2009) is that it occupied greater land uses thereby provide higher net returns. Vegetable cowpea intercropped with capsicum gave more money than mono culture. Therefore intercropping gives high income per unit area than sole cropping. John et al. (1943) reported 43% profit in intercrop over sole culture in a 3- year study of ground/pigeon pea intercrop prepared in 8:1 proportion. Veeraswamy et al. (1974) showed that the arrangement of 6 groundnuts:1 pigeon pea was more economical than 8:1 their result showed that groundnut gave 99% of the sole crop yield and pigeon pea 37% of its sole crop yield, totaling an advantage of 36%. Bhagat et al. (2005) in two –year study involving different maize varieties under intercropping system with groundnut recorded lowest net returns under sole groundnut compared to intercrop in a study of groundnut/sweet corn intercropping at different fertility levels and row proportions. Alom et al. (2009) summed up the findings of their studies that farmers of the maize growing areas should grow intercropped hybrid maize with groundnut as the intercrop was found to be more profitable than either sole hybrid maize or sole groundnut.

The main factor responsible for yield gains in intercropping is the ability to use early resources by the legume that complements the use of late resources by the longer season crops of which were made possible by the general growth arrangement of crops in intercropping. In rubber based cropping system, intercropping cassava during the immature phase of rubber was found to be profitable. The profitability index 0.75 was recorded by Esekade et al. (2013) for rubber + cassava intercropping system, indicating that 75% of the total amount invested in the farm was recovered in four years compared with zero returns recorded for sole rubber cropping. Also Esekade and Ojiekpon (1997) reported high economic benefit of intercropping rubber with arable crop during the immaturity period of rubber. Intercropping may pose a certain problem like increased labour requirement and difficulty in mechanization. Problems like competition for water, light and nutrients that may result in low yield of component crops but this depend on the crop intercropped. Water needs competition can be reduced if the crops are planted at a larger distance. The major disadvantage of intercropping system according to Ghaffarzadeh, (1997) is that intercropping is not adapted to very dry, poorly drained and heavy clay soils and this implies difficult in seed planting, harvesting and fertilizer application and weeding in mechanization are made for uniform fields. Hence the use of implements in intercropping system in large scale could be herculean task, though presently some modern implements have been found useful in some intercropping methods.

#### 4. Conclusion

Intercropping system have shown to have significant effect on the yield and yield components of intercrop species due to its better use of environmental resources and soil moisture compared to mono crop. An alternative to the use of herbicides as it suppressed weed growth, decrease the preponderance of pests and diseases and increase the fertility of soil through nitrogen increase to the system. Therefore it is of interest that if farmers explore the use of intercropping effectively in their limited land resources cum non-availability of farm inputs in most cases, agricultural sustainability can be achieved with ease in south eastern soils of Nigerian.

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