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ABSTRACT

The effect of introducing garden egg (*Solanum aethiopicum*) to fluted pumpkin (*Telfairia occidentalis*) in a relay intercrop on the growth of crop mixture under rainfed conditions (September to November, 2014) was investigated at the Faculty of Agriculture University of Benin, Benin City Nigeria.

Garden egg and a local variety of fluted pumpkin were sown sole and intercrop. Garden egg and fluted pumpkin were planted sole and intercropped to evaluate their interaction effect on growth parameters such as plant height, stem girth, leaf number, and leaf area. Data obtained were subjected to analysis of variance (ANOVA).

The study reveals that intercropping of garden egg with fluted pumpkin significantly increased the growth of garden egg, as intercropped garden egg had significant increase as against sole garden egg. The same was not found to be true for fluted pumpkin as sole fluted pumpkin had significant growth increase but when intercropped, there was significant reduction in growth.

CHAPTER ONE

1.0 INTRODUCTION

Self-sustaining, low-input, and energy-efficient agricultural systems in the context of sustainable agriculture have always been in the centre of attention of many farmers, researchers, and policy makers worldwide (Altieri et al., 1983; Altieri, 1999). However, most practices of modern agriculture, e.g. mechanization, monocultures, improved crop varieties, and heavy use of agrochemicals for fertilization and pest management, led to a simplification of the components of agricultural systems and to a loss of biodiversity. Restoring on-farm biodiversity through diversified farming systems that mimic nature is considered to be a key strategy for sustainable agriculture (Jackson et al., 2007; Scherr and McNeely, 2008). On-farm biodiversity, if correctly assembled in time and space, can lead to agroecosystems capable of maintaining their own soil fertility, regulating natural protection against pests, and sustaining productivity (Thrupp, 2002; Scherr and McNeely, 2008). Biodiversity in agroecosystems can be enhanced in time through crop rotations and sequences in space through cover crops, intercropping, and agroforestry (Altieri, 1999; Malézieux et al., 2009). While modern agriculture has brought vast increases in productivity to the world's farming systems, it is widely recognized that much of this may have come at the price of sustainability (Tilman et al., 2002; Lichtfouse et al., 2009). This is because modern farming systems imply the simplification of the structure of the environment over vast areas, replacing natural plant diversity with only a limited number of cultivated plants in extensive areas of arable monocultures (Vandermeer et al., 1998). By contrast, on-farm biodiversity is familiar to traditional farmers mainly in developing countries, where traditional farming systems are characterized by their great degree of genetic diversity in the form of mixed cropping and agroforestry patterns, based on numerous varieties of domesticated crop species as well as their wild relatives (Altieri, 1999). These farming systems offer a means of promoting diversity of diet and income, stability of production, reduced insect and disease incidence, efficient use of labor, intensification of production with limited resources, and also maximization of returns under low levels of technology (Anil et al., 1998; Malézieux et al., 2009). Intercropping, also referred to as mixed cropping or polyculture, is the agricultural practice of cultivating two or more crops in the same space at the same time (Andrews and Kassam, 1976; Ofori and Stern, 1987; Anil et al., 1998). The component crops of an intercropping system do not necessarily have to be sown at the same time nor they have to be harvested at the same time, but they

should be grown simultaneously for a great part of their growth periods. In intercropping, there is normally one main crop and one or more added crop(s), with the main crop being of primary importance for economic or food production reasons. The two or more crops in an intercrop normally are from different species and different plant families, or less commonly they may be simply different varieties or cultivars of the same crop, such as mixing two or more kinds of wheat seed in the same field. The most common advantage of intercropping is to produce a greater yield on a given piece of land by achieving more efficient use of the available growth resources that would otherwise not be utilized by each single crop grown alone. There are many different kinds of species that can be used for intercropping such as annuals, e.g. cereals and legumes, perennials, including shrubs and trees, or a mixture of the two (annuals and perennials). In the case of shrubs and trees the term mostly used is agroforestry. The objective of this paper is to provide an overall view and evaluation of annual intercropping, summarizing its main advantages supported by a number of key examples from the published literature which point out its great value in the context of sustainable agriculture. This paper focuses on relay intercropping and not on agroforestry using garden egg and fluted pumpkin intercrop as case study.

The objective of this study is to evaluate the influence of intercropped telfairia and its time of intercropping on the growth yield of garden egg.

Meaning of Intercropping

Intercropping is the practice of growing two or more crops in close proximity and it is practiced by majority of farmers in the tropical and subtropical regions of the world. The system is widely practiced because it suppresses weeds and reduces pest disease infestation. (Ibeawuchi, 2007).

The degree of spatial and temporal overlap in the crop or more crops can be varied. As a result, numerous types of intercropping in which the temporal and spatial mixture have been varied to some degree have been identified (Andrews and Kassam, 1975).

Types of intercropping (spatial and temporal patterns)

Several types of intercropping, all of which vary the temporal and spatial mixture to some degree, have been described (Andrews and Kassam, 1976). The degree of spatial and temporal overlap in the component crops can vary somewhat, but both requirements must be met for a cropping system to be an intercrop. Thus, there are several different modes of component crops (Willey, 1985). Yield advantage occurs because growth resources such as light, water, and nutrients are more completely absorbed and converted to crop biomass by the intercrop over time and space as a result of differences in competitive ability for growth resources between the component crops, which exploit the variation of the mixed crops in characteristics such as rates of canopy development, final canopy size (width and height), photosynthetic adaptation of canopies to irradiance conditions, and rooting depth (Midmore, 1993; Morris and Garrity, 1993; Tsubo et al., 2001). Regularly intercropped pigeon pea or cowpea can help to maintain maize yield to some extent when maize is grown without mineral fertilizer on sandy soils in sub-humid zones of Zimbabwe (Waddington et al., 2007). Intercropping maize with cowpea has been reported to increase light interception in the intercrops, reduce water evaporation, and improve conservation of the soil moisture compared with maize alone (Ghanbari et al., 2010). This yield advantage occurs when the component crops do not compete for the same ecological niches and the interspecific competition for a given resource is weaker than the intraspecific competition. Normally, complementary use of resources occurs when the component species of an intercrop use qualitatively different resources or they use the same resources at different places or at different times

(Tofinga et al., 1993). In ecological terms, resource complementarity minimizes the niche overlap and the competition between crop species, and permits crops to capture a greater range and quantity of resources than the sole crops. Improved resource use gives in most cases a significant yield advantage, increases the uptake of other nutrients such as P, K, and micronutrients, and provides better rooting ability and better ground cover as well as higher water use efficiency (Midmore, 1993; Morris and Garrity, 1993). Thus, selection of crops that differ in competitive ability in time or space is essential for an efficient intercropping system as well as decisions on when to plant, at what density, and in what arrangement. Although in this way cropping management decisions specify the design of intercropping systems, intercrop performance is governed largely by the availability of and the competition for the environmental resources. Research has shown that intercrops are most productive when component crops differ greatly in growth duration (Wien and Smithson, 1981; Smith and Francis, 1986; Fukai and Trenbath, 1993; Keating and Carberry, 1993). For example, when a long duration pigeon pea cultivar was grown in mixture with three cereal crops of different growth durations, i.e. setaria, pearl millet, and sorghum, the Land Equivalent Ratio was highest with the quick-maturing setaria and lowest with the slow-maturing sorghum (Rao and Willey, 1980). It must be noted here that Land Equivalent Ratio shows the efficiency of intercropping for using the environmental resources compared with monocropping with the value of unity to be the critical value. When the Land Equivalent Ratio is greater than one (unity) the intercropping favours the growth and yield of the species, whereas when the Land Equivalent Ratio is lower than one the intercropping negatively affects the growth and yield of the plants grown in mixtures (Willey, 1979; Willey and Rao, 1980). Asynchrony in resource demand ensures that the late maturing crop can recover from possible damage caused by a quick-maturing crop component and the available resources, e.g. radiation capture over time, are used thoroughly until the end of the growing season (Keating and Carberry, 1993). By contrast, when the component crops have similar growth duration their peak requirements for growth resources normally occur about the same time and the competition for the limiting growth resources is intense (Fukai and Trenbath, 1993).

In intercropping crops could be arranged in any of the following forms.

Mixed cropping – Here component crops are totally, mixed in the available space without any form of arrangement.

Row cropping– The component crops are arranged in alternate rows. A variation of row cropping includes multiple rows of another.

Relay cropping– Here the second crop is sown at the onset of reproductive development or fruiting of the first crop such that when the first is harvested it gives room for the full development of the second.

Strip cropping- This involves sowing more than one crop in different strips.

Intercropping as previously mentioned has an increased yield advantage thus useful in poverty and hunger alleviation as an insurance against crop failure and positive effect on soil properties (Ehigior and Ikhidero, 1999).

Garden Egg (*Solanum aethiopicum*)

The name “Garden egg plant” was derived from the shape of the fruits of some varieties which are white and shaped like chicken eggs (Chenet et al., 2001). The plant (*Solanum* spp) is a vegetable with increasing popularity in the world (Pessarakli and Dris, 2003), and it originated from Tropical Africa (Norman, 1992). It is an economic flowering plant belonging to the family Solanaceae, of which members of about

1,400 species found throughout the temperate and tropical regions of the world are mostly herbaceous plants. The fruit of the plant comes in a wide array of shapes and colours, some are yellow and small with green stripes; there are the big yellow ones with white colour and flat ribbed green types among others (Chen et al., 2001). The importance of the garden-egg cannot be overemphasized. It is consumed on daily basis by urban families and also represents the main source of income for producing households in West Africa (Danquah- Jones, 2000). Nutritionally, garden egg contains water (92.5%), protein (1%), fat (0.3%), and carbohydrates (6%). They contain between 30 and 50% of iron (Fe), fiber, potassium (K), manganese (Mn), copper (Cu) and vitamins; thiamin (vitamin B1), B6, folate, magnesium and niacin. Egg plant also contains phyto-nutrients such as nasunin and chlorogenic acid (Sabo and Dia, 2009). It is a very good source of dietary fiber, potassium, manganese, copper and vitamin B6, folate, magnesium and niacin. Egg plant also contains phyto-nutrients such as nasunin and chlorogenic acid. It is a valuable vegetable for canning industries for garden-egg paste, sautéed garden-egg and other products. The fruits are fried, stewed, marinated and prepared in other ways. The garden egg plant with its bitter taste and spongy texture could really make an amazing pot of stew with a nice aroma. When eaten with boiled yam or rice, it becomes a delicacy you do not want to miss at the slightest opportunity. Medicinally, they are processed and used in the preparation of condiments and products used in treating different diseases and health problems (Burkill, 1985). A meal of garden egg is proven to be of benefit to patients suffering from raised intraocular pressure (glaucoma) and convergence insufficiency, as well as in heart diseases and Arteriosclerosis (Harish et al., 2008). The plant can be regarded as a brain food because it houses the anthocyanin phytonutrient found in its skin, Nasunin, a potent antioxidant and free radical scavenger that has been shown to protect cell membranes from damage. Studies have shown that nasunin protects the fats in brain cell membranes. Nasunin is not only a potent free radical scavenger, but is also an iron chelator. Iron is an essential nutrient, necessary for oxygen transport, normal immune function and collagen synthesis, but when it becomes too much in the blood stream; it becomes a major concern. Excess iron increases free radical production and is associated with an increased risk of heart disease and cancer. Menstruating women, who lose iron every month in their menstrual flow, are unlikely to be at risk, but in post-menopausal women and men, iron, which is not easily excreted, can accumulate. By chelating iron, nasunin lessens free radical formation with numerous beneficial results including protecting the blood cholesterol from peroxidation, preventing cellular damage that can promote cancer, and lessening free radical damage in joints, which is a primary factor in rheumatoid arthritis. The predominant phenolic compound found in garden eggs is chlorogenic acid, which is one of the most potent free radical scavengers found in plant tissues. The chlorogenic acid performs antimutagenic (anticancer) activities in the body. It also performs anti- LDL (bad cholesterol) activities by increasing the levels of HDL (good cholesterol) in the body and at the same time has antiviral and antimicrobial properties. Consuming high amounts of garden eggs have been found to be beneficial for people with glaucoma because it lowers the eye pressure. Egg plant contains measurable amounts of oxalates which are naturally occurring substances found in plants, animals, and human beings. When oxalates become too concentrated in body fluids, they can crystallize and cause health problems. For this reason, individuals with already existing and untreated kidney or gallbladder problems may want to avoid eating egg plant. Chewing thoroughly while eating, can enable you get significant benefits, including absorption of calcium from calcium-rich foods plant foods that also contain oxalic acid. As such, eating garden eggs does not stop you from meeting your calcium requirements. Egg plant is low in calories

and high in fibre. The egg plant is good for carbohydrate counters and dieters can actually snack on garden eggs in-between meals.

Production of garden-egg is highly concentrated with 85% of the output coming from five (5) countries. Presently, China is the world largest producer (56% of garden-egg output), followed by India (26%), Egypt, Turkey and Indonesia. Meanwhile, more than 2,048,788ha are devoted to cultivation of garden egg (FAO, 2008). In the United State of America, Georgia is the largest producing State. African garden-egg is one of the most commonly consumed fruit vegetable in the Tropical Africa, in quantity and value and probably, the third after *Lycopersicum esculentum* (tomato) and *Allium cepa* (onions) and before Okra. According to Girth et al. (1989), a rough estimate for a few countries indicates an annual production of 8,000 tonnes in Senegal, 60,000 tonnes in Cote d' Ivoire and 4,500 tonnes in Burkina Faso.

In Nigeria, garden egg is a very important vegetable crop grown on commercial scale in some parts of the country. However, the small scale growers account for at least 86% of the total production. In the South-East of Nigeria, specifically, in Abia State, garden-egg popularly called "Mikimiki" (big sized green fruit with very deep and sweet "endocarp") is grown commercially while in the savannah zone of Nigeria; the yellow, white and thick green skinned varieties are grown on large scale.

Fluted Pumpkin (*Telfairia Occidentalis*)

This leafy vegetable belongs to family Cucurbitaceae. The term fluted is used in description of the female flower which has a flute like appearance. It is believed to be indigenous to East, central and west Africa between latitude 7°S and 5°N and longitude 20°E and 38°N (Howes 1950). In Nigeria, it is referred to as Ugu by Igbos, Iroko by the Yorubas, Ubon by the Efiks. Its largest diversity in plant population can currently be found in Imo State and other surrounding areas in South-East Nigeria. Pumpkins are largely grown for their leaves which are used as vegetables and its fruit which is boiled and eaten as desert (Attere 1984).

The fluted pumpkin is a perennial dioecious crop although monoecious forms also exist. The female plants have distinctly stronger shoots and stronger shoots and larger leaves than male plants. The male plants however, flowers about 5 months from sowing while it takes the female plants another 3 weeks before its first flower is open (Chigwe and Saka 1994).

Pumpkin seeds contain 20-55% oil rich in unsaturated fatty acid oleic and linoleic acid and 23-25% protein, rich in arginine, aspartate and glutamine but they are deficient in lysine and sulphur containing amino acids. Pumpkin seeds can be eaten in the dry season as snack after roasting or grinding into butter (Gwanan and Nitcherlein 1995).

Pumpkin also contains high levels of copper, Iron and Vitamin A. Chandarasckhar et al (2000) reported that pumpkin leaves had the highest amount of beta-carotene in a form that promoted its absorption in adults, among selected green vegetables. Despite the importance of pumpkin in the small holder sector in Southern Africa, little research has been done on this crop (Chigwe and Saka 1994).

According to a research carried out by Ehigior (1994) and Edo ADP crops grown in mixture by farmers in Edo State were in the order

Maize + cassava

Maize + egusi

Maize + egusi + cassava

Yam + maize + melon

Yam + maize + egusi mellon + vegetable

Maize + cassava + cowpea

Despite the growing of these crop mixtures by farmers, little is understood on the effect of various crop components in an intercrop. Due to the importance of okro as a staple food crop and of fluted pumpkin in the diet of people in Nigeria, hence this study on the intercropping effect of both crops on their productivity in an ultisol in Benin City, Nigeria.

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