TO DETERMINE AGRONOMIC AND ECONOMIC ADVANTAGES OF INTERCROPPING SUNFLOWER WITH COMMON BEANS

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ABSTRACT

A field research trial on intercropping sunflower (*Helianthusannuus*) and common beans (*Phaseolus vulgaries)* was first held at the Kaimosi Agricultural Training Centre (ATC) farm in Nandi County in the short season of 2016. The purpose of the research was to investigate the agronomic and economic potential of intercropping the two crops. Particularly, the field trial was done in randomized complete block design (RCBD) coupled with three imitations. Sunflower variety H8998 and Mwitemania common beans (GLP 92) were sown simultaneously. The treatments included sole beans B (45 x 10 cm), sole sunflower S_1 (75 x 30 cm), sole sunflower S_2 (90 x 30 cm), and the intercrops of sunflower/bean (single and double rows of beans with the two sunflower spacing S_1 and S_2). Clearly, the results exhibited that sunflower plant height, head diameter, 100 seed weight, and number of pods per plant in case common bean was not significantly affected while days to maturity for beans and the yields of these two food crops were massively effected by the intercropping systems. Land equivalent ratio (LER) ranged between 1.32 and1.54 for all the four intercropping systems. Monetary equivalent ratio (MER) varied between 0.99 and 1.20 with three out of the four intercrops combinations having MER > 1.0. Sunflower S_2 (90 x30 cm) intercropped with double rows of beans had highest LER (1.54) and MER (1.20). The results indicate there was land use advantage and economic efficiency where each LER and MER value exceeded 1.0. Therefore, the intercropping method needs to be intensively practiced to maximize total crop production per unit area.

Background Information

Sunflower, scientifically recognized as *Helianthus annuus*, is a critical oil seed crop classified under the family, compositae. It contains an edible oil content of about 40-70% that is suitable for providing vitamins A, D, E, and K (Saleem et al., 2003). With its ease of adaptation in different regions, sunflower is grown in the south west of Kenya as a major crop rich in vegetable oil. Indeed, it is regarded as a high quality edible vegetable oil due to its nutritious value to human body. Apart from that, sunflower is widely accepted as a substitute traditional crop rich in vegetable oil other than oil palm and groundnuts found in the tropical areas (Ogunremi, 2000). Nonetheless, this oil vegetable crop only ranks the second best in the world to soybeans in respect to its oil content. The ministry of Agriculture is promoting alternative cash crops in its efforts towards the commercialization of Agriculture in Kenya (MOA, 2005). Sunflower fits well in this scheme because it is easily adaptable into various farming systems, especially because of favorable climatic and soil conditions (Jaetzold et al., 2006). Also, it does well when intercropped with common crops, including beans. It also has great potential to reduce household savings on edible oil and contribute in the development of biofuels which is becoming increasingly important in view of the escalating costs of fossil fuels. However, the low production of sunflower in most parts of Kenya is characterized by deprived agronomics techniques and inappropriate pest control methods, especially for the birds (Okoko et al., 2008). Moreover, there is a lacking of high quality yielding diversities of sunflower seeds coupled with reduced soil fertility, thus leading to low market prices of the oil crop (Gureshi & Memon, 2008). Also, the low production has been further exacerbated by the insufficient connections conducted on research farming extensions among famers and similarly the inadequate applications of the advanced farming technologies (Okoko et al., 2008; Gureshi & Memon, 2008).

The common bean, scientifically known as *Phaseolus vulgaris* L., is recognized one of the chief staple foods in the parts of southern and eastern Africa. Accordingly, Wortmann et al posit that the common bean ranks the second best and third as significant sources of dietary proteins and calories respectively (1998). In Kenya, however, it is widely eaten as the third most key food crop since it contains a high content of proteins (GOK, 1998). In fact, the common bean is nutritious since it contains the right quantity of irons, complex carbohydrates, folic acid, as well as other dietary elements (Kornegay et al., 1996). In particular, the crop has suitably contributed to food security for its composition of nutrients, short-cycle of growth, and ability to adapt to varied cropping systems. According to Maobe et al. (1998), the common bean is widely classified as a substitute grain legume in enhancing soil fertility for the reason that it helps inject N in the soil. Of course, it significantly contributes to build up of the carbon-based matter in the soil, thus enhancing the structure of the soil (Maobe et al., 1998; Dyck, 1997). Therefore, the affixed nitrogen is in turned converted into useful nutrients for the utilization of another cereal crop, leading to increased yields (Carsky et al., 1997). Clearly, it is estimated that the levels of nitrogen fixed underneath the ground annually for a hectare of land by soybean and common bean equal to 49-540 kg and 3-57 kg respectively (Wani & Lee, 1992). Intercropping entails the growing of two and above crops concurrently in a similar land space, either in a structured or unstructured arrangement (Elemo et al., 1990). The combination of more than two plants brings about a specific inter competition during a common season (Zhang & Li, 2003). The research study has established the possibility of intercropping sunflower with various kinds of grain legumes. Also, it has posited that intercropping through the application of upgraded agronomic practices is still regarded as the most feasible method of cropping (Adetunji, 1993). The reason is that such cropping approach helps optimize the production as it maximizes on the land space.

In the contemporary agriculture, intercropping has emerged as an advanced agro-technique for its effectiveness and efficiency of raising the production output of crops per unit area, especially among the small-scale holdings (Ali et al., 2000). Clearly, intercropping is beneficial as it impacts higher production yields in the following way. Intercropping economizes on land space and growth resources because different crops have diverse root abilities in utilizing the underneath nutrients. More so, different crops have varied canopy structures and heights as important prerequisites for the utility of complementary resources. Although, research review by Fukai and Trenbath (1993) has argued otherwise that the benefits of intercropping vary from one season to another and coupled with the marking of different locations. Further, the research has recommended for the development of high intensity intercropping systems as a measure of raising the production output. However, the annual report by MOA (2003) has emphasized on the utilization of grains legumes which are highly stress resistant, possess high protein and oil content, and have high capacity to improve soil fertility.

Increased agricultural productivity would improve the standards of living and lower the levels of poverty in a society in case farmers have sufficient access to the most appropriate technologies (Okoko et al., 2008). With high levels in Kenya based on the reporting by Kenya Poverty Reduction Strategy Paper (2001), it is projected that almost half of the Kenyan populations live below the poverty index of KES 1,239 or U$15 monthly. Consequently, there is a need to implement the most productive as well as high sustainable intercropping systems, which are highly compatible with the constituent crops. For example, it is important to plant sunflower, cowpea, soybean, and other most edible grain legumes at a latter cropping season for the reason that they do well in a dry weather for harvesting and post-harvesting, hence obtaining better seeds in quality and richness.

The study was set up in Nandi County during the short rains of October to December 2012. The area falls under Agro-Ecological Zone (AEZ) UM_{2}-$_{3}$ (wheat or maize-barley zone). The soils are deep, moderately fertile, of medium texture, and well-draining. The area is both suitable for sunflower and legumes production. The type of field experiment was row intercropping where sunflower spacing was varied with different spatial arrangement of beans.

1.0: Statement of the Problem

Sunflower yields in North Rift and Western Kenya regions are still low, 4 to 6 bags (50 kg bags) per acre. Under recommended management practices, farmers can harvest 8 to 10 bags per acre (Okoko & Ojowi; KARI Kisii Brochure, 2008) which are considered still low. The prices offered to farmers in the market are low as well si it leads to low income for farmers. Farmers' low adoption on appropriate production technologies, poor agronomic practices, declining soil fertility, poor infrastructure, and linkages are some of the contributory factors to low yields and income (Okoko et al., 2008; Gureshi & Memon, 2008).

Imperatively, this low adoption by famers is uneconomical when planting pure stands, especially for small-scale farmers. With the right adoption of sunflower-beans intercropping combinations, therefore, it would lead to higher net incomes per unit area in comparison with when the sunflower is grown alone. The statement is in line with Kenya Vision 2030 that aims at growing the agriculture value by raising the production outputs of both the livestock and crops. The introduction of new land policies would help impact agriculture value positively in the following ways. First, farmers are encouraged to utilize high and medium land spaces. Second, farmers would need to prepare new land for the purposes of cultivation, and further initiate irrigation mechanism in both arid and semi-arid areas. Lastly, enhancing the access to the market for small-scale holders via better marketing techniques would raise agricultural productivity.

Specific Objectives

To establish the existence of yield advantage in intercropping of sunflower with common beans system as compared to the mono cropping.

LITERATURE REVIEW

General Introduction

Accordingly, Jackson et al. (2007) have stated that most modern agricultural practices have brought about a simplification of the elements of agriculture systems coupled with biodiversity loss. They include mechanization, monocultures, better crop varieties, substantial application of agrochemicals for improving soil nutrients, and effective management of pests (Scherr & McNeely, 2008). Restoration of on-farm biodiversity via expanded farming systems which have mimicked nature is reflected as a key approach for impacting sustainable agriculture. Sustainable agriculture is a little more proficient in the utilization of resources for human benefits by bringing forth balance with the environment (Jackson et al., 2007). Similarly, sustainable agriculture needs to be environmentally suitable, economically acceptable, and socially desirable in a bid to impact a positive change. The goals of sustainable agriculture are attached to the following definitions. First, there is a need to promote food security coupled with sufficient quality and supply while seeing the needs and demands of the posterity (Eskandari, 2012a). Second, there is the conservation of water, soil, and natural resources. Third, it entails preservation of sources of energy whether inside or outside the farm. Next, there is the need to maintain and improve farmers' profitability index (Gruhn et al., 2000; Earles, 2005). Lastly, the objective centrally focuses on maintaining the liveliness of rural groups while undertaking biodiversity conservation.

According to Thrupp (2002), on-farm biodiversity may result in high capacity agro-ecosystem in terms of preserving soil fertility, initiating natural safety against pests, and supporting high productivity, especially when done in good time and space. Biodiversity in agro-ecosystems might be improved over time via crop rotations and sequent spacing of cover crops, proper intercropping, and sustainable agro-forestry (Altieri, 1999). The initiation of mass productivity of the global farming systems through contemporary agriculture is highly attributed to sustainability (Lichtfouse et al., 2009). Therefore, it is important to acquire information concerning the prospective of intercropping sunflower with other crops of profitable importance with intention of advising prospective farmers on cropping systems.

2.0 Sunflower Production

Sunflower also recognized as *Helianthus annuus* scientifically is an annual crop having a large inflorescence (flowering head), which originally came from Central America. The name sunflower was inferred from its big sizzling blooms, whose shape mirrors the sun

(Scherr & McNeely, 2008). With an irregular hairy stem and extensive coarsely notched leaves, it has a circular head flower comprising of 1,000 to 2,000 constituent flowers enjoined to a single receptacle base (Malézieux et al., 2009). In maturity phase, sunflower reaches a height of 0.6 m to 4.5 m and its yellow outer ring petals measure up to a diameter of 30 cm based on its variety (Muok et al., 2010).

Sunflower is considered among the most prospective substitute source of the old-fashioned vegetable oil like oil palm as well as groundnut within the tropics (Ogunremi, 2000). The agro-climatic conditions inside the forests and the ecologies of savanna continue to offer a lucrative growth grounds for the cultivation of sunflower, either under sole or intercropping (Ogunremi, 1984 and 1986). Therefore, cowpea, sunflower, soybeans, and other most appetizing grain legumes are acceptably considered for sowing during the latter cropping season due to the fact that they grow well in dry weather, especially useful for harvesting and post-harvest handling, thus obtaining better quality seeds.

Sunflower is extensively adapted among the primary eatable oil crops, which are grown in Kenya. Specifically, it was first brought forth in Kenya as an eatable oil crop for its high value (Okok et al., 2008). With deep taproots, sunflower can effectively extract water underneath the soil, therefore regarded as a drought-resistant crop (Acland, 1971). Sunflower is mostly used for the purpose of extracting edible oil, whereas the seedcake is used for formulation of animal feed. According to Muok et al. (2010), since this type of oil has better drying feature which do not affect color, it makes paints and varnishes. Apart from that, sunflower seeds can be undertaken as snack.

Agronomy

While promulgated via a direct sowing technique, the planting of sunflower is done during the heavy rains in a bid to promote maximization of yields. Usually, the crop thrives well in a well-drained loam soil, especially in places where the yearly rainfall varies from 500 to 1200 mm (Drumnet, 2010). Therefore, the rainy season should be long enough to facilitate the completion of ample planting, thus offering the sunflower chance to flower, and further mature in a dry spell (Muok et al., 2010). The sowing of sunflower is recommended at 75 cm and 30 cm for inter-row and intra-row spacing respectively. Besides, the crop is weeded regularly at a point where the plant reaches a height of 90 cm, therefore suppressing threats of weeds. It is important to draw up soil closely towards the stem to avoid cases of lodging. Hence, sunflower is effectively intercropped with grain legumes, leading to a better ground cover which responds well to the applied fertilizers (IDRC, 1998).

Table 1

Agronomic Parameters for Sunflower

Agronomic parameters	**Overall range**
Yearly temperature in degree centigrade	20-28 ^{0}C
Yearly rainfall in millimeter	500-1,200 mm
Altitude in meter	0-2,600 m
Type of soil	Well drained loam soils
Maturity period in months	5-10

Note. This table was obtained from the source (Muok et al., 2010; GTZ, 2009a).

KARLO has continued to breed the sunflower, and therefore brought forth varieties that suit perfectly with dissimilar agro-ecological zones. For example, there exist early to late maturing variations which might take roughly 100 to 140 days after being developed at KARI Njoro Station. Drumnet, a research-based organization which deals collaboratively with Bidco Oil Refineries, has brought about a new variety of sunflower known as Pannar 7369 (2010). This variety of sunflower grows in Nyanza through many attempts of introducing varieties, which could grow to a height of 6 feet and head diameter of about 9-12 inches. Additionally, the crop produced a typical of 550 kilograms per acre in comparison with 150 to 200 kilograms per acre resulting from other varieties planted by farmers.

Agricultural prospective and aptness

Sunflower thrives suitably in agro-ecological regions, which are characterized by an average to high rainfall and coupled with a rich, deep loam soil type. Such regions in Kenya are some parts of Nyanza, Western, Eastern, Rift valley, Central, and the Coast. Concerning the suitability of environment, sunflower plantation in Kenya covers a square kilometer of 140,003, which is about 24.6% of the country. In accordance with Tilman et al. (2000), the suitable land area for the growth of sunflower approximates to 86,414 km^2 or 15.2% of Kenya in case there is removal of the endangered areas, wildlife zones, wetlands, slopes, and animal movement paths. Clearly, sunflower does not rival with the farming of cash crops in most arable lands in Kenya, except for some regions like the upper Eastern of Mt. Kenya, the Coastal areas, and small parts of Western Kenya.

Current status

The farming of sunflower is majorly intense in Western and Nyanza parts of Kenya with approximately 3,300 ha for the former province and 2,500 ha for the latter one in 2003. Presently, a large number of farmers practise this kind of crop farming in these regions, simply because they target the sale of their produces to Bidco Oil Refineries. More so, the vegetable oil refinery company has collaborated with other business organizations, thus amplifying the demand of raw materials (EPZA, 2005). As an example, the MOA (2009) released a report which stated that almost 107 tons of the sunflower seeds were generated locally, while the imported quantity just totaled to 200 kg. Therefore, a large percentage of the produced tons were taken by the Bidco Co. for processing of edible vegetable oil. Apart from that, most farming of sunflower is done on a small-scale basis, thereby attributing to high instances of intercropping with grain legumes. As a result, there are low production yields of about 150-200 kg per acre since most of these small land holders have access to poor varieties. In fact, this is the reason why most farmers have shied away from its venture in spite of constant promotions by some organizations (IDRC, 1998; Drumnet, 2010). In this regard, the production of sunflower has greatly contributed to the generation of biodiesel in Kenya. Unfortunately, the costs of generating biodiesel is quite high relative to the pricing of the final products like sunflower cooking oil retailing at US$2.3 for a litre, unlike its counterpart litre of diesel at US$1.2.

Table 2

Gross Margin Calculation for One Hectare of Sunflower in Kenya

Item	**Units**	**Quantity**	**Unit price in Ksh**	**Total Output (per ha)**
Income for (A)	Kg	2,000	30	60,000
Variable costs				
Seeds	Kg	5	300	1,500
Equipment (hoes, machete)	No			2,000
SSP fertilizer associated with planting	50 kg bags	2.5	2,500	6,250
CAN fertilizer associated with topdressing	50 kg bags	2.5	2,500	6,250
Sub-total				16,000
Labor in (Ksh/ha)				
Land preparation			2,250	4,500
Planting	Manning days	10	200	2,000
Fertilization	Manning days	5	200	1,000
Weeding	Manning days	15	200	3,000
Bird watching	Manning days	30	100	3,000
Harvesting	Manning days	10	200	2,000
Threshing, winnowing, and Packing	Manning days	10	200	2,000
Sub-total				17,500
Total variable costs for (B)				33,500
Seasonal Gross margin for (A-B)				26,500

Note. This table was obtained from the sources (Muok et al., 2010; GTZ, 2009b).

Common Beans Production

Common bean, scientifically known as *Phaseolus vulgaris*, is a crucial food crop that ranks the second best after maize in Kenya (GOK, 2006). It is a significant dietary element among both the rural as well as urban dwellers. Its retailing price is relatively high when compared to other optional sources of protein like animal and fish products (FAO, 2008). Characteristically, common bean makes an almost perfect dietary meal, simply because it is rich in contents of iron, folic acid, as well as complex carbohydrates (Kornegay et al., 1996).

In particular, the crop suitably contributes to food security due to its composition of nutrients, short-cycle of growth, and ease of adaptation to varied cropping systems. Besides, this food crop continuously contributes to the economy's Gross Domestic Product of a country as it helps farmers make incomes (Wortmann et al., 1998; Mwaniki, 2002). With the ease of growing this crop as it survives under the shade of intercropping and has a small growth-cycle of about 65 to 90 days, it is adapted to varied cropping system. Likewise, common bean has been proved to intensify the agricultural production system.

In Kenya, the production of common bean happens chiefly in highlands and midlands with approximately 70% of the yearly farming occurring in three major parts of Kenya, namely Eastern, Rift Valley, and Nyanza. With regards to national productivity output, the Rift Valley undertakes the largest share at 33% followed by Western and Nyanza regions, each at 22% (Spilsbury et al., 2004). Unfortunately, a lot of farmers grow bean once a year in spite of the country having two planting seasons. Indeed, this contributed by unfavorable climate conditions. Therefore, the production outputs from regions like the Eastern and Coastal parts of the nation are relatively low due to constrained weather conditions. As an example, the rift valley and western part of Kenya with a total output of 33% and 22% correspondingly has planned for planning of bean only once a year, especially throughout the long rains from March to May. Contrastingly, the central as well as the Eastern part of the country practise it twice a year with more than three-thirds of farmers sowing during the long rains. Likewise, most farmers in the latter regions farm the common bean during the short rains between October and December.

Imperatively, there exists an impressive variety of common bean seed types in Kenya. In the late 1970s, more than 80 various seed types were sorted out throughout the country with six types turning out to be the most popular (Njungunah et al., 1980). Among the six popular types, there are red and reddish purple mottled, which reverie with diverse local names, such as Rosecoco, Nyayo, Wairimu, and Kitui), Purple greyish speckled, which is locally known as Mwezi mwoja, and Pinto sugars locally referred as Mwitemania. Besides, Rosecoco has been the most widely grown after the Canadian wonder type. Apart from that, Rosecoco and Canadian wonder type yield higher than other bean types, they need heavy rains coupled with high soil fertility.

Table 3

Calculation of a Gross Margin for an Hectare of the Common Bean in Kenya

Item	**Units**	**Quantity**	**Unit price(Ksh)**	**Total (per ha)**
Income for (A)	kg	10	6,500	65,000
Variable costs				
Seeds	kg	50	150	7,500
Equipment (machete, hoes)	No			2,000
SSP fertilizer for planting	50 kg bags	2.5	2,500	6,250
Storage dust	50 gm bags	3	300	900
Sub-total				16,650
Labor (Ksh/ha)				
Land preparation			2,250	4,500
Planting	Manning days	10	200	2,000
Fertilization	Manning days	5	200	1,000
Weeding	Manning days	15	200	3,000
Bird watching	Manning days	30	100	3,000
Harvesting	Manning days	10	200	2,000
Threshing, winnowing and Packing	Manning days	10	200	2,000
Sub-total				17,500
Total variable costs for (B)				34,150
Seasonal Gross margin for (A-B)				30,850

Note. The table was obtained from the sources (Muok et al., 2010; GTZ, 2009b).

2.1 Intercropping Systems

Intercropping is a shared agricultural method being presumed to raise the total production output per unit area. However, there are research studies which have confirmed the results of intercropping otherwise – Fukai and Trenbath (1993) have stated that the yields from one season to another vary greatly based on specific locations. In this way, they have viewed it important the need to generate the most prolific and sustainable intercropping systems together with their companionable intercrops. Andrews & Kassam (1976), several types of intercropping have varied both the sequential and spatial mixture to some extent as follows. Intercropping entails the planting of two or more crops together as compared to pure cropping where one species is sowed. Indeed, intercropping might comprise of annual plants which are sowed yearly, such as the perennial plants. Further, intercropping entails sowing fast-growing crop together with slow-growing ones to increase the chance of harvesting the first crop before the second advances maturity (Andrews & Kassam, 1976). Consequently, it is divided into the following groups as follow.

(i) Row intercropping

This is the act of growing two or more crops concurrently in a farm where they are sown in regular rows or rather the first crop is grown randomly with the second one.

(ii) Mixed intercropping

This is the act of growing of two or more crops simultaneously in no particular row arrangement. The plants are entirely mixed on the ready space without any unique row arrangement. Notably, this method of intercropping is suitable for grass-legume combined with pastures.

(ii) Strip intercropping

This is the growing of two or more crops concurrently in diverse strips, which are wide enough to allow self-regulating farming, but rather narrower for the interaction of crops ergonomically. Various rows of a species of the first plant are interchangeably used with several rows of a species of the second plant.

(iv) Relay intercropping

This is the growing of two or more plant crops concurrently, where a second crop is sown after the first crop has attained the propagative stage, but before reaching the harvest phase. This kind of intercropping is done in this way so that the second crop has ample time to mature immediately after the first one is harvested.

Sunflower (*Helianthus annuus L.*) is well renowned among the prospective substitutes readily available for the extraction of traditional vegetable oil like Palm oil and Ground nut found in the tropics (Ogunremi, 2000). As a second best source of vegetable oil, research studies on sunflower have established the potential possibility of intercropping it with varied kinds of legumes (Shivaramu & Shivashankar, 1992; Kandel et al., 1997). According to Agele et al. (2002) and Olowe et al. (2003), the full benefits of intercropping sunflower are attained, especially when it is done under the agro-climatic potential of the forest as well as the achieved savanna ecologies.

With the predominant intercropping of cowpea in the West African regions, the total yields output has been lower at 25-100 kg ha^{-1} in comparison with the expected total yields of about 300-520 kg ha^{-1} from the IITA research station report that was done in Kano state, Nigeria. However, the report did not make recommendations for the application of insecticide protection, thus leading to severe attacks by insects.

Soybean is productively fruitful when intercropped alongside the corn in the transitional zone of savanna forests (Olowe et al., 2003). Most importantly, the planting of sunflower, soybean, cowpeas, and other most edible grain legumes is normally done during the late cropping phase for the reason that they necessitate a dry weather. Such kind of dry weather facilitates ample harvesting and post-harvesting handling to obtain better quality seeds.

There exist fewer reports on the intercropping of sunflower with the most productive and edible grain legumes in tropics of Africa. Baker (1978) has recently observed that cereals benefits a lot when intercropped with legumes since they derive the N-fixed nutrient from the soil. Apart from that, there are many other advantages of intercropping plant crops, including the maximization of resource utilization and increased total returns resulting from higher earned incomes (Elemo et al., 1990). Thus, the rate of seedling for each food crop is slightly adjusted down its actual rate to augment the plant density. In case the intercrops existed in their full rates when sowed, however, neither the crops would yield normally due to extreme overcrowding. Advantages of Intercropping

There exist numerous agricultural reports which have confirmed the progressive effects of intercropping coupled with its superiority over a pure cropping method as indicated below.

2.0.1 Increasing production

Among the chief benefits of intercropping, there is an efficient utilization of the ready resources, leading to higher productivity than the planning of a sole crop from the mixture (Jannasch & Martin, 1999). Attaining higher total output is the main reason why intercropping is extensively practised across the world (Caballero & Goicoechea, 1995). Likewise, Ghanbari and Lee have recounted that the generated dry matter from intercropping wheat and beans are larger as compared to other intercrops (2002). Also, it has been confirmed that the intercropping of maize and beans in different ratios have impacted production positively due to abridged struggle between species as compared to rivalry within similar species (Odhiambo & Ariga, 2001). Further, they has regarded intercropping as an economic method of obtaining higher production output via the use of lower external inputs (Altieri, 1995). In fact, the entire technique of cropping optimizes efficiency as an important factor for small-scale land holders practicing crop farming during short season.

Furthermore, production output has significantly increased due to the complementary effects of intercropping, leading to reduced rivalry between plants (Mahapatra, 2011; Zhang & Li, 2003). The constant intercropping of either pigeon pea or cowpea would aid in sustaining the yields of maize, especially when sowed in the sandy soils found in the humid zones lacking mineral fertilizers (Waddington et al., 2007). Imperatively, production yield advantage arises since the growth resources, ranging from light, water, to nutrients are adequately taken in, and therefore changed into biomass over time. Notably, benefit comes forth when the component intercrops do not struggle for similar ecological niche (Cenpukdee & Fukai 1992a). Instead, the inter-specific competition arising from resource utilization is weaker in comparison with its intra-specific counterpart.

Francis and Decoteau have equally reported that production yields from sweet corn increase when intercropped with pea for they utilize better the environmental resources (1993). Therefore, amplified production arising from intercropping is attached to higher growth rates, reduced weeds, lessening the effects of pests as well as diseases (Eskandari, 2012b; Eskandari et al., 2009b). Further, it has facilitated more effective exploitation of resources arising from changes in resource consumption (Willey, 1985)

2.0.2 Better utility of environmental resources

---Tofinga et al have confirmed that the complementary utilization of resources is more effective when the constituent intercrop species make use of dissimilar resources rather than utilizing the same resources at diverse places or at varying times (1993). In ecological, however, complementarity in resource utilization aids a lot in lessening the niche overlay, thus sustaining a favorable competition between crop species. Further, it lets the constituent intercrops secure a large collection and amount of resources, unlike the mono crops. Indeed, enhanced resource use mostly offers a substantial yield advantage, such as the increase of the absorption of nutrients P, and K (Watiki et al., 1993; Willey, 1990). As a result, it provides better rooting ability, rich ground cover, and high efficiency in water use (Midmore, 1993; Morris & Garrity, 1993). Though critical decisions on cropping management have specified the pattern of intercropping systems, performance outcomes of intercropping are fundamentally depended on the readiness and competition for the environmental resources. In this way, research study by Fukai and Trenbath (1993) has indicated that intercropping is highly fruitful, especially when the constituent crops differentiate momentously in growth durations.

Besides, asynchrony as expressed in resource demand has always ensured that the late-maturing food crop convalesces from likely damage occasioned by a constituent of a quick-yielding crop (Keating & Carberry, 1993). Of course, this may not be limited to the readiness of resources like captured radiation over time, which is useful throughout the growing season. Contrastingly, when the constituent intercrops have alike growth durations, their peak prerequisites for limited growth resources would happen simultaneously with intense competition for the limited resources (Keating & Carberry, 1993).

2.0.3 Control of pests, diseases, as well as weeds

The most critical part of intercropping entails the need to control pests and diseases. As much as this part comprises of many advantages, there exist its detrimental effects, too. Clearly, the constituent intercrops are less harmed by varied pests and diseases in comparison with the practice of growing sole crops unpredictably (Trenbath, 1993). Nonetheless, the effectiveness of this method of curbing pests and diseases frequently varies randomly. Imperatively, a review on more than 150 published research studies has indicated that 53% of the species of pests are less harmful in the intercropping system of farming (Anil et al., 1998). More so, 18% of the pests were considered more adequate in posing threats. Whereas 9% of the pests exhibited no considerable differences, only 20% of them depicted a variable response (Risch, 1983). Therefore, a large number of pests are occasioned in the sense that the second crop is always susceptible to the infestation by pests. Such happens particularly when there is a lot of canopy to host the pests and diseases by offering favorable conditions (Risch, 1983). Therefore, plant residues provide suitable conditions for the infestation of pathogens.

Furthermore, the worsening of insect infestation in farms has been exacerbated by the extensive practice of monocultures, which deplete natural vegetation. As a result, many researchers have viewed it vital to decrease the diversity of the local habitat for the pests (Andow, 1991). Unlike in monocultures, the number of pests is low in the application of intercropping. Similarly, intercropping system has usually raised the biodiversity by impacting the natural ecosystems positively, thus preventing damages by pests (Watiki et al., 1993). Fundamentally, the mixing of crops lie cowpea and maize would considerably lower the population density and activities of legumes in terms of disbudding the flower strips, scientifically recognized as *Megalurothrips sjostedti* (Kyamanywa & Ampofo, 1988). Equally, the same results were confirmed with the intercropping of bean, cowpea, as well as maize in which the incidences of pest infestation is gradually reduced. For example, the infestation of black aphid (*Aphis fabae*) in beans has been confirmed to be significantly reduced when intercropped inside older and taller maize plantation. The reason is that canopy size of maize plantation would interfere with the occurrence of aphid, and therefore only a small percentage of the beans would be infested (Ogenga-Latigo et al., 1993). Thus, the intercropping of cowpea with maize lowers the chance of insects growing into a large population density.

Most importantly, weeds are recognized to inhibit the normal growth of crops, thus occasioning serious adverse effects due to the struggle for similar growth resources, including nutrients, light, land space, and water. Indeed, the application of intercropping is more impactful than mono-cropping in terms weeds control, but the efficacy differ critically based on the type of utilized intercrop system (Girjesh & Patil, 1991). Hence, intercropping is considered a better approach than pure cropping, simply because there are higher crop yields and limited growth of weeds.

2.0.4 Improvement of soil fertility and conservation

Legumes have a way of enriching the soil by fitting the atmospheric nitrogen, and therefore converting into an organic form, which is ready for the uptake by plants. According to Fujita et al. (1992), microbial fixed nitrogen would be a source of nutrients for the grain legume and cereal mixed cropping systems with limited nitrogen-embedded fertilizer. In this regard, the use of inorganic fertilizers, which would have greatly contributed to environmental hazards like nitrate pollution, is henceforth discouraged. Of course, the combination of legumes in the intercrops is considered an optional and sustainable measure of incorporating N-fertilizer into agro-systems inputs (Fustec et al., 2010). Additionally, the leaves and roots of the grain legume would properly decompose to produce nitrogen into the soil ready to be absorbed by the other plant crop. Rahman et al. (2009) has stated that the chief pathway to conserving other nutrients entails the returning coupled with decomposing of crop residues. Definitely, crop residues are signified as a key resource of impacting fertilization for the small-scale land-holders who manipulate the outcome of the nutrients produced via the decay of crop residues. Thus, this measure improves the efficiency of nutrients in the soil.

Intercropping through the use of grain legumes is indeed an excellent way of regulating soil erosion, thus supporting crop production (El-Swaify et al., 1988). In regions characterized with excessive rainfall, there are severe soil run-offs resulting from the actions of cropping management systems. In the event, the nutrients are washed away from the soil, hence leaving ground cover with poor fertility for ample crop production. Moreover, shallow rooting system aids a lot in aerating the soil. On the contrary, controlled soil run-off is recorded in the intercropping system of farming involving legumes together with cassava (El-Swaify et al., 1988). For example, the intercropping of sorghum and cowpea has been observed to reduce soil run-off by 20-30% as compared to 45-55% for the sole growth of sorghum or cowpea monoculture (Zougmore et al., 2000). All in all, the loss of soil loss in intercropping of sorghum and cowpea is significantly decreased.

2.0.5 Lodging resistance of weaker crops

Intercropping usually offers a high lodging resistance against crops, which have previously been regarded extremely susceptible to lodging (Assefa & Ledin, 2001). Enhanced stability of plants increases the harvestable yields, crop quality, as well as efficiency of harvest. The plants which are susceptible to lodging - tipping over during strong winds or heavy rains – would be offered structural support by the companion counterpart intercrop (Trenbath, 1976). Apart from that, the implementation of legumes intercrop with non-legumes has brought about attention to the way farmers increase cash returns by enhancing land use efficiency. As an example, most farmers have undertaken canola or mustard as a major intercrop aimed at raising lodging resistance of grain legumes (Waterer et al., 1994). In the end, such a method increases production yield, quality, and the efficiency of harvest.

Promoting biodiversity

Intercropping brings forth biodiversity in agro-ecosystems. In particular, the study results on intercropping have concluded that enlarged crop diversity might amplify the number of service delivery by the ecosystem. In accordance with Russell (2002), higher richness in species might be attributed to the cycling characteristics of nutrients, which often impact soil fertility. In this regard, curbing nutrient leaching losses is significantly important for the reason that it reduces the adverse effects of pests (Bannon & Cooke, 1998; Liebman & Dyck, 1993; Boudreau &Mundt, 1992). Moreover, such richness attached to a species may also compose of resistance to weeds (Fininsa, 1996). Thus, on-farm biodiversity is expected to impact the capacity of agro-ecosystems in sustaining fertilities of the soil, natural protection against pests, and yield.

2.0.6 Stability and uniformity of yields

The chief reason why intercropping is considered the most popular agricultural farming system globally is due to its higher stability as compared to mono-cropping (Horwith, 1985). For small-scale farmers having limited sources, they regard income and unvarying yields as an important aspect of farming. Undeniably, there are reduced instances of risks of incurring losses since a single crop in the intercrop might offer the needed yields, thus substituting the productivity of a failed crop (Eskandari et al., 2009a). Thus, the possibilities of agronomy letdown in multi-cropping systems are not higher than in pure cropping ones.

Clearly, intercropping has the capacity to offer high insurance against crop failure, specifically in regions that are prone to austere weather conditions like frost, drought, as well as flood (Clawson, 1985). In overall, it offers farmers chance to record enhanced financial stability, therefore implementing the system on labor-intensive farms. Really, this implies that the failure of a particular intercrop resulting from adverse conditions like frost, drought, as well as attacks from pests would not necessarily affect the total crop yield (Clawson, 1985). Of course, intercropping maize together with common bean would safeguard farmers from recording decline in nutrients, therefore the total household incomes would be higher as compared to mono-cropping of either of the food crops in Mbeere District (Fustec et al., 2010). Subsequently, the implementation of intercropping has come up to safeguard the environment from hazards, simply because the use of inorganic fertilizers are avoided, which would have possibly harmed major soil microbes (Onduru & Du Preez, 2007). Otherwise, the alternative coupled with sustainable application of organic nutrients via the fixation of the atmospheric nitrogen has reviewed down the farm inputs of the agro-ecosystems.

2.0 Performances of Sunflower and Intercrops

According to studies done by Rashid, Ibrar, Shahbaz, Ahmed, and Malik (2002), the production efficiency of sunflower when intercropped with summer grain legume like Soybean, Mung bean, and Urd bean under well rain-fed conditions have revealed the following. First, the sunflower plants per square meter, height, and harvest have stayed unaffected, while the stem girths, head diameter, and number of yielded seeds and weight have been greatly impacted in respect to their economic and biological factors. Next, the legumes plant height; primary branches for only Mung bean, seed weight, and harvest index have not depicted any major differences. On the contrary, the numbers of plants per square meter, number of pods per plant for the case of Soybean and Urd bean, and pod length have greatly reduced. More so, numbers of seeds per pod coupled with economic and biological yields have equally decreased. Therefore, the loss arising from yielding of sunflower in the intercrop has been compensated more by the summer legumes.

The research field attempts were organized at the Teaching and Research Farm of University of Agriculture in Abeokuta, Nigeria to determine the agronomic prospective of intercropping soybeans and cow peas together with sunflower at three growth phases. They included simultaneous SS at sowing, the tenth true leaf (V10) phase, and the eighteenth true leaf (V18) phase of transferring seedlings in 2002 and 2003. Therefore, the attained outcomes included a land equivalent ratio (LER > 1.00) ranging from 1.04 to 1.40 in 2002 and 1.05 to 1.24 in 2003 respectively, which were however attached to the intercropping systems. Besides, the marginal intercropping compatibility regarding the land equivalent coefficient (LEC > 0.25) consistently varied between 0.29 to 0.48 for sunflower or soybeans at SS, V10, as well as V18 in the year 2002. However, sunflower or cow pea only recorded the SS in the year 2003. Sunflower or cowpea SS in 2002 and sunflower or soybeans V10 in 2003 documented small monetary benefits over the most productive mono-crop with monetary equivalent ratio (MER) of about 1.12 to 1.04 with sunflower's yields equivalent at 1,349.2 and 1,421.6 kg ha^{-1} respectively.

Other research studies conducted by Aye Thaw at the Institute of Graduate Studies in Central Luzon State University, Philippines have documented the benefits for cultural practices for sunflower (*Helianthus annus*) when grown after the harvesting of wet land rice. The results have indicated that intercropping field legumes like mung beans, cowpea, and soybean do not affect the total yield performance of sunflower. Instead, the yields of these field legumes were however decreased significantly in an intercrop system when compared with its mono-crop counterpart. Therefore, the seed yield drop was at 93.79% for mung bean, 107.48 % for cowpea, and 139.41% for soybean.

Moreover, research studies that have promoted the relative productive efficiency together with the feasibility of a variety of intercropping systems involving sunflower were conducted by Saleem et al. (2006) at the Agronomic Research area of University of Agriculture, Faisalbad. Indeed, the outcomes of intercropping systems comprised of sunflower alone and a combination of sunflower and mash bean or sunflower and mung bean. The sowing of sunflower was done at a spacing of 90 cm apart for both the single and double-row strips arrangement. Saleem et al have confirmed that the attained outcomes showed that the growing of sunflower alone offered a optimal yield of about 2.41 to 2.24 t ha^{-1} (2006). Imperatively, intercropping is more beneficial than mono cropping in spite of the adverse effects of the main crop. Additionally, the loss is reimbursed by the harvesting of intercrops regarding the MA. Among many intercropping arrangements, the combination of sunflower and mash bean has been confirmed to be highly profitable, thus giving rise to the highest incomes of Rs 37,995.51 coupled with the highest benefit cost ratio (BCR) of 3.72 (Saleem et al., 2006). On the other hand, the case of sunflower and mash bean combination recorded a maximum income of Rs. 27,618.75 with a BCR of 3.02 for sunflower alone, especially when sowed at a spacing of 90 cm in double-row strips arrangement (Saleem et al., 2006). Overall, intercropping is widely practiced to optimize the production yields of intercrop from a given unit area under anticipated conditions.

3.0 Experimental Design

The objective of the research test was to measure the potential of intercropping Mwitemania common beans with sunflower. Evaluation of the productive efficiency of sunflower and common beans intercropping systems was the main objective. The research test was done in RCBD coupled with three replicas.

3.1 Data collection

Data on yield and other growth components were taken for sunflower and Mwitemania common beans.

(i) Plant height (cm)

The sunflower plant heights were measured every two weeks using a black board ruler up to day 120 days after sowing. The average height per plot was determined.

(i) Head diameter (cm)

It involved measuring the diameter of each plant at maturity using a ruler and the average per plot calculated.

(ii) Weight of 100 seeds sunflower per plot (kg/plot)

100 seeds were selected from the plants in a plot and weighed. The average per plot was then computed.

(iii) Total yield of sunflower (kg/ha)

All the plants were harvested for each plot, dried, and weighed using a spring weighing machine. The plot weights were extrapolated to determine yield/Ha.

(v) Number of days for bean in respect to harvest maturity

This was determined after all the bean plants and pods had turned brown. This was determined for each plot.

(vi) Number of pods per bean plant

The number of pods per plant was counted in a plot after 60 days. Definitely, the average number of pods for each plot was then established.

(vii) Total bean seed weight (kg/ha)

All the bean plants were harvested for each plot at maturity, dried and weighed using a spring weighing machine. The plot weights were extrapolated to determine yield per hectare.

3.2 Data Analysis

The data was summarized in excel package, and further evaluated through the employment of SPSS version 20. Specifically, the ANOVA was obtained at 95% confidence level and where necessary. Also, the post hoc analysis (LSD) was done to separate the mean.

Furthermore, the land equivalent ratio (LER) was equally applied to assess whether there was yield advantage or not in the intercrop in comparison with the growth of sole crop (Mead & Wiley, 1980). It estimates the land use benefits by the intercrop over the mono crop. It is useful measuring the sum of the yields of the intercropped constituent divided by the sole crop yield.

According to Vandermeer (1989), the LER is derived as a function of the indicated comparative land necessities associated with intercrops vs. monocultures. Indeed, the LER is the sum of comparative yields of the constituent species as expressed below.

$$\text{LER} = \sum_{i=1}^{m} \frac{yi}{yii}$$

Where;

yi is the production yield of the "i"th constituent from a unit area of the intercrop;
yii is the production yield of the same constituent growing as a mono crop over the a similar land space area; and
yi/*yii* is the comparative production yield of component *i*.

For the case of sunflower and common beans, LER will be calculated through use of the formula below as follows.

$$LER = La + Lb = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where;

La and *Lb* are the LERs for the specific intercrop of the system;
Yab is the intercrop production yield of crop ‘a’ for sunflower;
Yba is the intercrop production yield of crop ‘b’ for common beans;
Yaa is the pure stand crop production yield of ‘a’ for sunflower and;
Ybb is the pure stand crop production yield of ‘b’ for common beans.

There is a calculation of its ratio to help establish the incomplete LER for that specific crop for each mentioned crop (Darish et al., 2006). Further, the incomplete LERs for each crop are summed to result in the overall LER for the intercrop. Besides, Mazaheri and Moveysi (2004) have proved that LER value of 1.0 has indicated that the non-existence of differential yields in production, especially among the intercrops and gathering of the monocultures. Consequently, any value exceeding 1.0 has indicated that there would be a yield advantage from the intercrop.

Clearly, the Monetary Equivalent Ratio (MER) is helpful in the description of the economic efficiency of a cropping system. Adetiloye and Adekunle (1989) have confirmed that the sum of ratios of the comparative MR came from the individual constituent intercrops regarding the highest MR of a mono crop rather than the from whole land area covered by both sunflower and beans per unit time. Therefore, the MER is mathematically expressed as follows.

Monetary equivalent ratio (MER) = (ra + rb)/Ra

Where,

ra and *rb* are monetary returns from *a* and *b* and;

ra is the greatest mono crop monetary return and expressed as follows.

ra = Pa x Ya

rb = Pb x Yb

Where,

Pa, *Pb* are prices of unit weight of crop *a* and *b* and;

Ya, *Yb* are yield of *a* and *b*.

RESULTS AND DISCUSSION

The collected data was analyzed using SPSS version 20. The yields for sunflower coupled with the yields for constituent intercrops, including the height of a plant, diameter of the head, 100 grain weight, and the production yield per hectare. The yields for common bean and yield for the constituent crops range from the number of pods per plant and days, harvesting maturity, as well as the yield of grain per hectare.

4.0 The Effect of Cropping System on the Height of Sunflower Plant

The plant height for sunflower was measured every two weeks starting from the fourth week after sowing. The graphs for the days after sowing against plant height are shown below.

Figure 1

The Effect of Number of Days on the Height of Sunflower Plant after Sowing

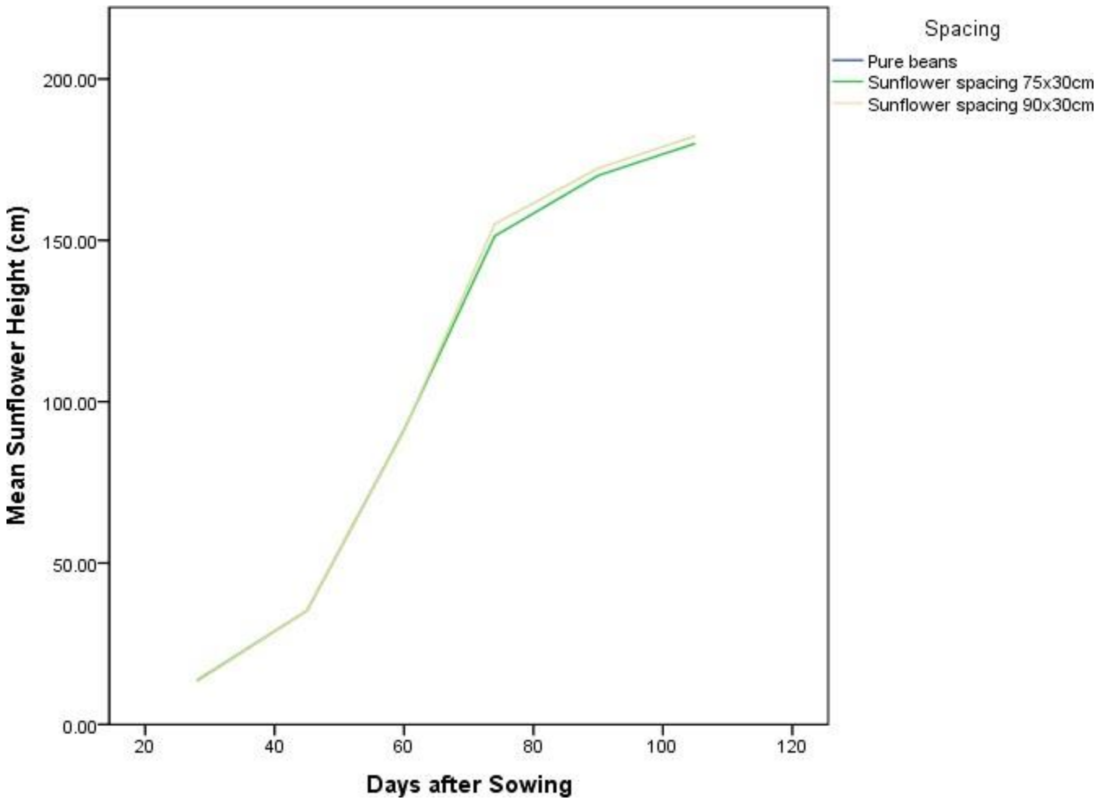
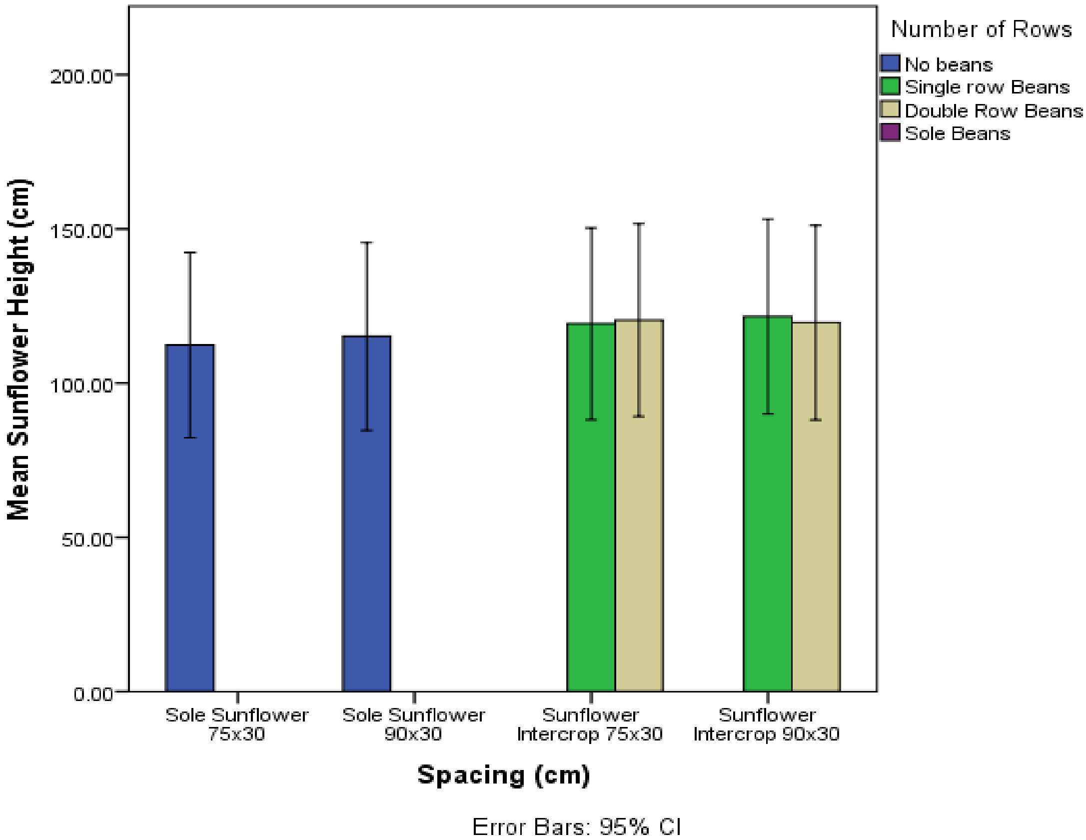


Fig 2
Effect of Spacing and Spatial Arrangement on the Height of Sunflower Plant



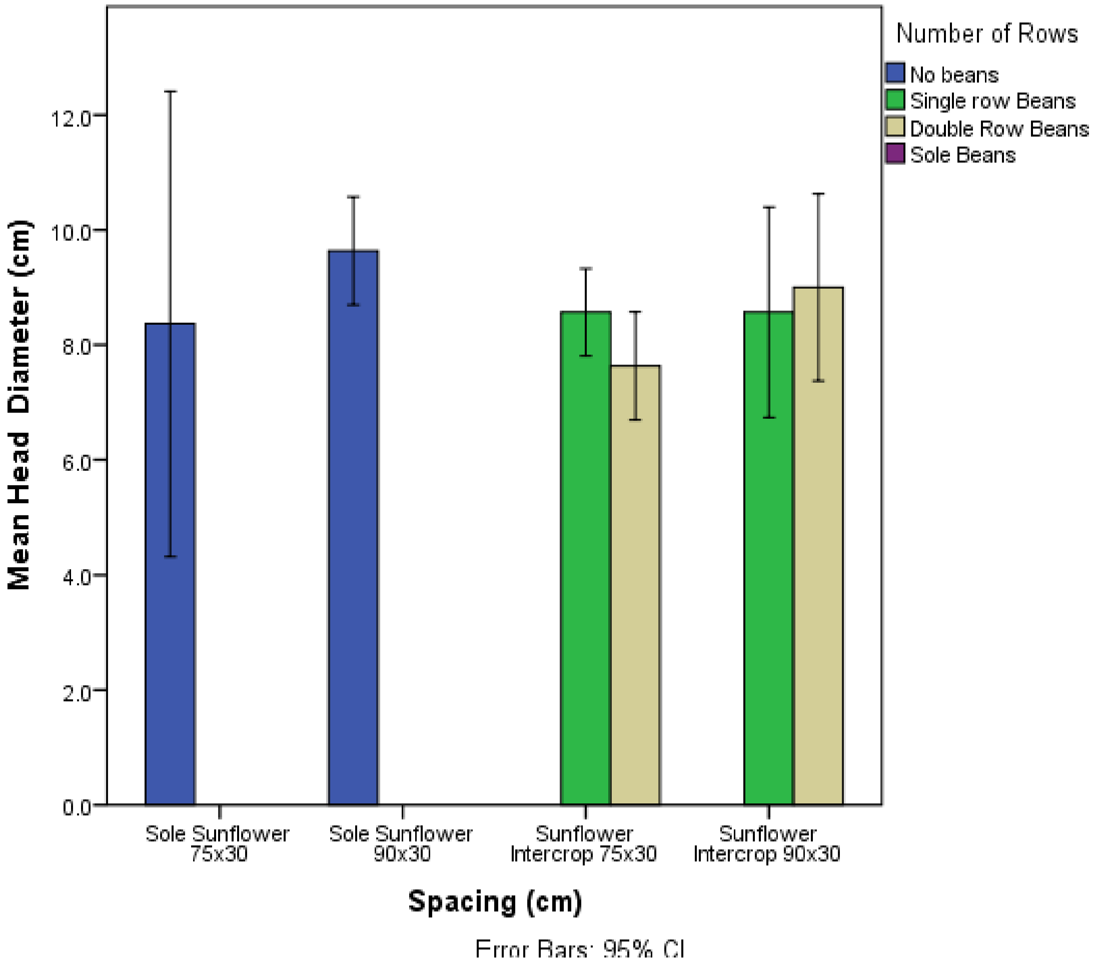
The analysis of variance (ANOVA) showed no meaningful differences ($p > 0.05$) between the treatment means for the height of the plant. Varying the spacing of sunflower and spatial arrangement of beans did not substantially impact the plant of sunflower. However, intercropped sunflower grew slightly taller than sole sunflower crops (figure 4.1 and 4.2) perhaps due to competition for resources with beans, especially for light.

4.1 The Effect Cropping System on Head Diameter

Sunflower head diameter was measured at maturity i.e. 120 days after sowing. The diameter was measured using a string and ruler.

Fig 3

The Effect of Spacing and Spatial Arrangement on Head Diameter



The analysis of variance (ANOVA) did not show meaningful differences ($p > 0.05$) between the treatment means for head diameter. The spacing as well as spatial arrangements did not substantially impact the size of the sunflower head. However, small differences were observed in head diameter as in figure 4.4 above with sole sunflower at 90 x 30 cm having the biggest head diameter. This could be due to wider spacing allowing bigger head formation because of less competition for resources.

4.2 The Effect of Cropping System on the Weight of 100 Sunflower Seeds

The results for analysis of 100 seeds per ha were established at maturity and the data used for analysis. The results are shown in the graph below.

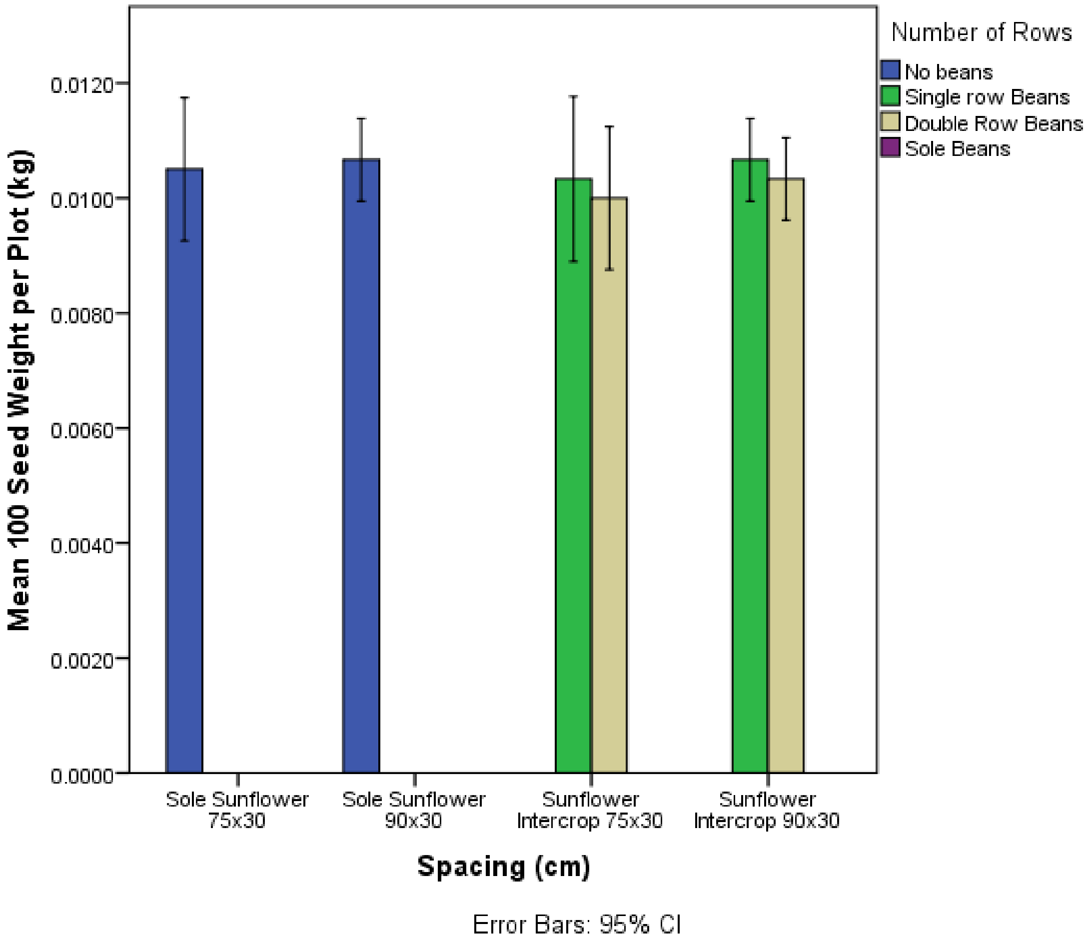


Fig 4: Effect of spacing and spatial arrangement on 100 seed weight

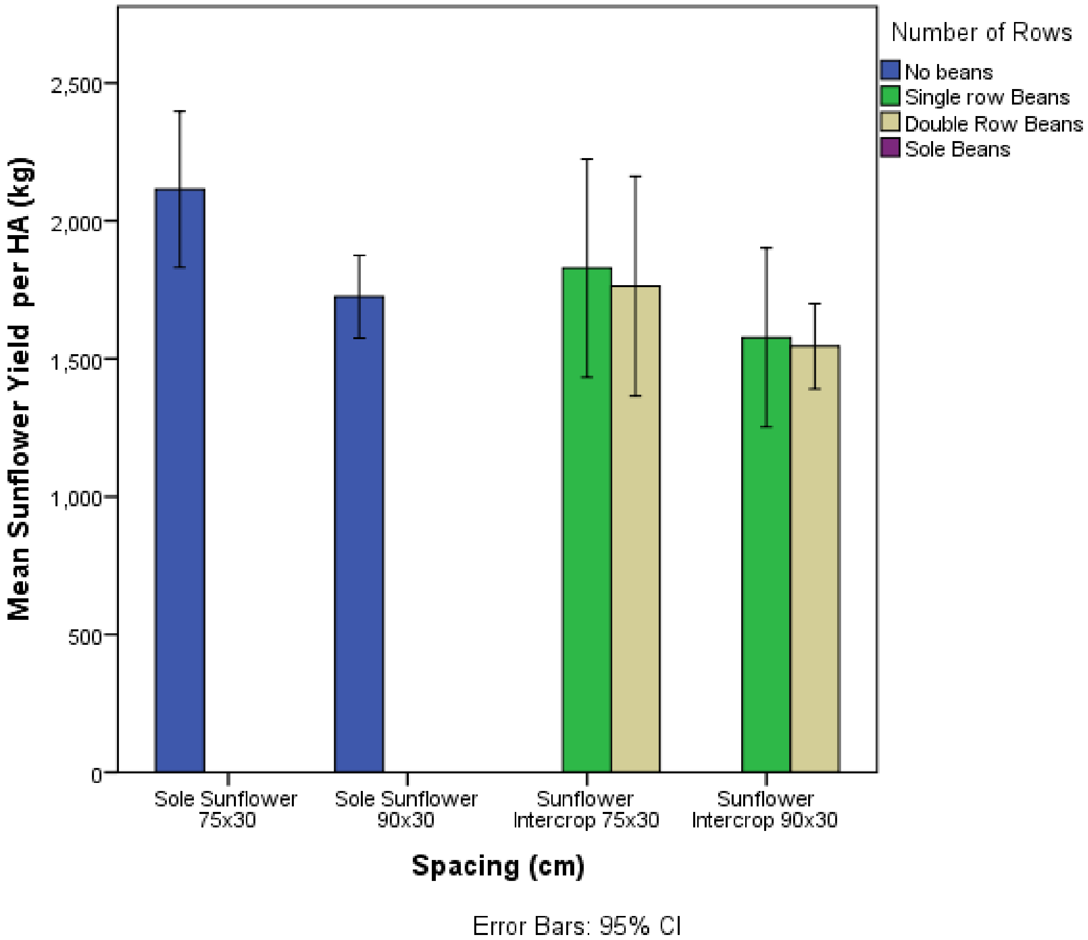
The analysis of variance (ANOVA) exhibited no significant differences ($p > 0.05$) between the treatment means for the 100 sunflower seed weight. Varying the spacing and spatial arrangements did not significantly affect the weight of 100 seeds. However, sunflower with the wider spacing of about 90 x 30 cm was slightly heavier than that of 75 x 30 cm. In fact, this resulted from more spacing and less competition for resources among sunflower plants in the case of the wider spacing.

4.3 The Effect of Cropping System on the Production of Yield Sunflower

Sunflower data on yield per ha was determined and the results of the analysis were as indicated in figure 4.5 below.

Figure 5

The Effect of Spacing and Spatial Arrangement on the Production Yield of Sunflower



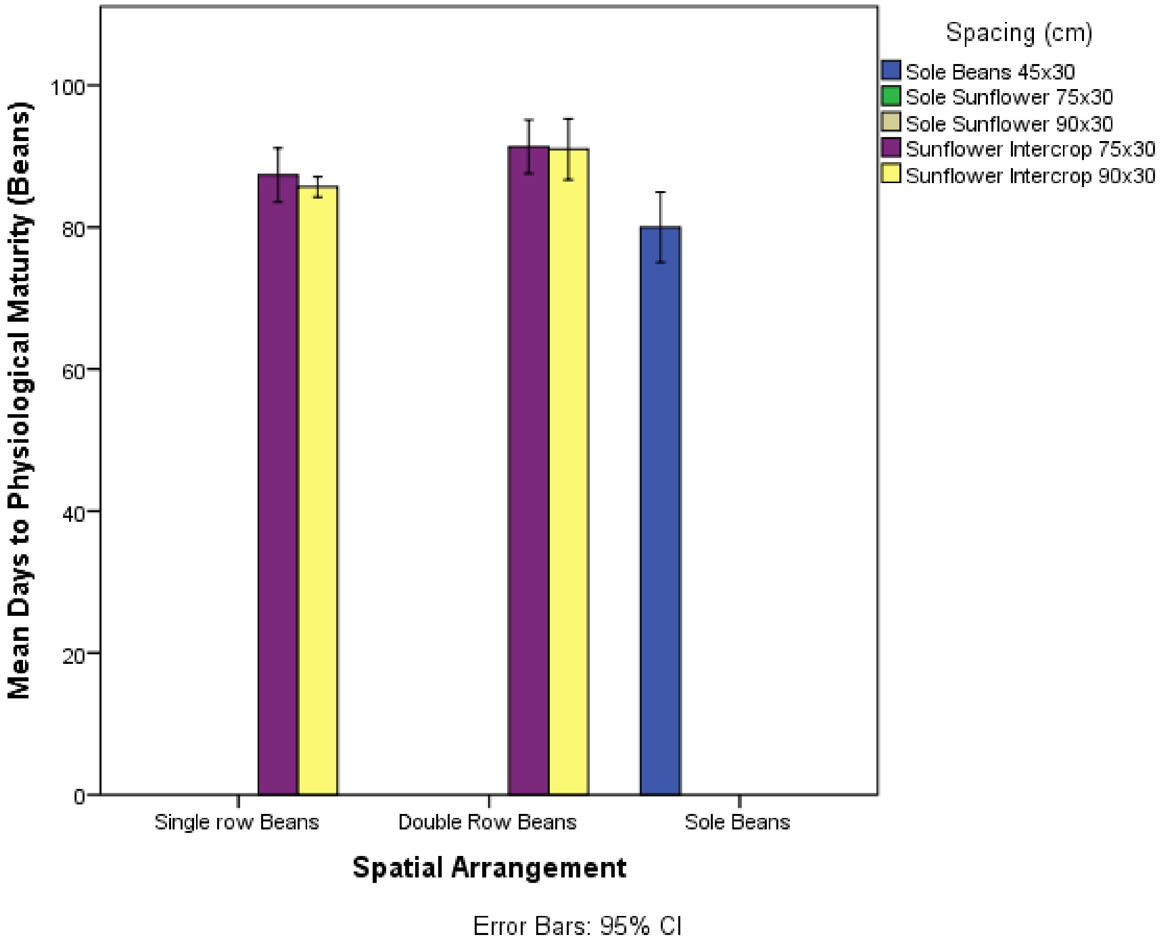
The analysis of variance (ANOVA) showed some meaningful differences ($p < 0.05$) between the treatment means for the sunflower yield. In fact, the yield of sunflower was meaningfully affected by spacing. The mean yield of sunflower per ha for spacing S_1 (75 x 30 cm) were substantially greater than that for spacing S_2 (90 x30 cm) regardless of spatial arrangement of beans. This was due to higher population of plants per ha (44,400 against 37,000). The results confirmed the findings of Gill (1990) who inferred significant differences for biological yield of sunflower in pure stand and intercropping system.

4.4 The Effect of cropping pattern on number of days of physiological maturity

Imperatively, the effect was established when the bean pods changed color from green to yellow, and further to straw yellow.

Fig 6

The Effect of Spacing and Spatial Pattern on Days in Respect to Physiological Maturity



The ANOVA) showed meaningful differences ($p < 0.05$) between the treatment means for the number of days in respect to the physiological maturity. The employment of Post hoc analysis was aimed at finding out where the differences lied precisely.

Table 4

LSD Multiple Comparisons on Spatial Arrangement for the Number of Days in Respect to the Physiological Maturity (Beans)

	Single row Beans	Double Row Beans	Sole Beans
Single row Beans		-4.67*	6.50*
Double Row Beans	4.67*		11.17*
Sole Beans	-6.50*	-11.17*	

Note. The difference in the mean is meaningful at level 0.05.

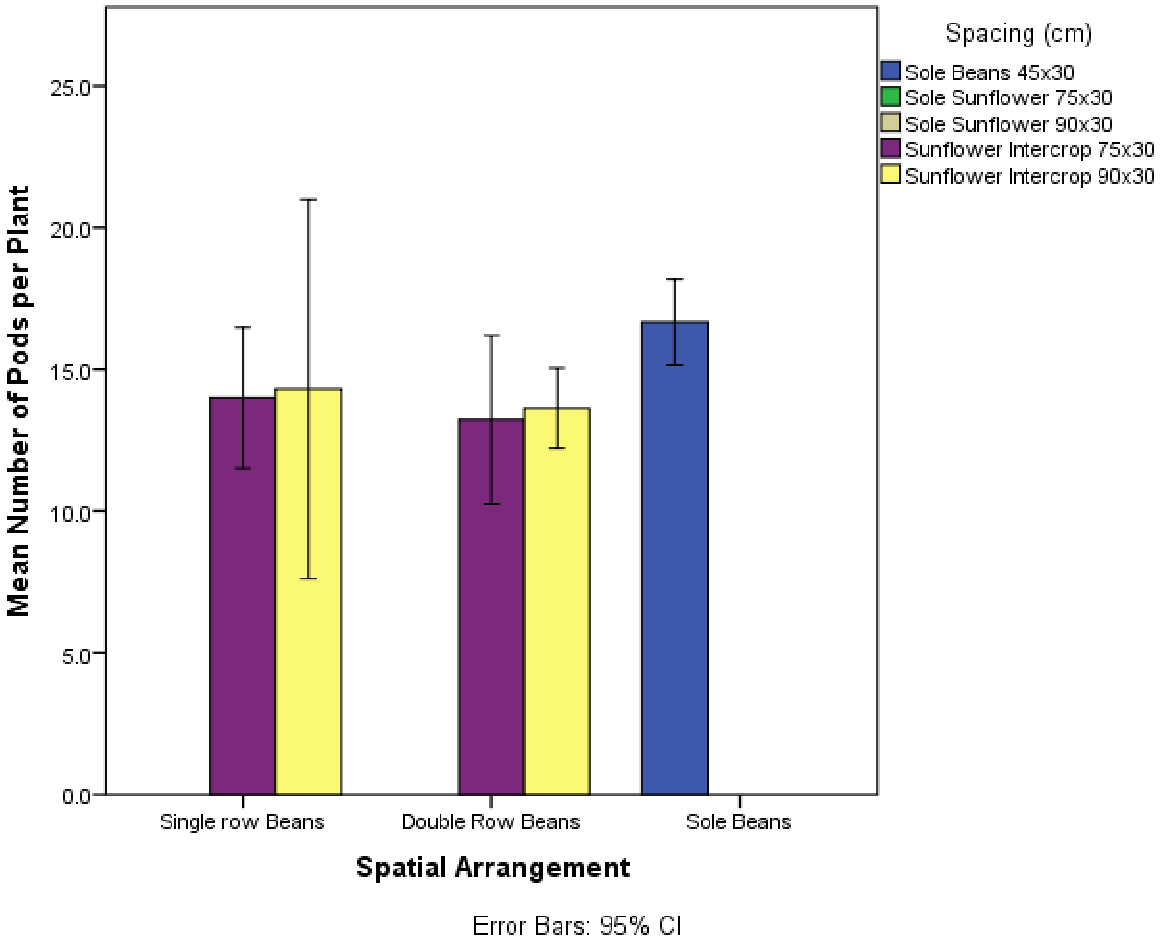
From post hoc analysis, double row beans took the longest number of days to physiological maturity compared to sole beans and single row beans. Sole beans took the shortest time to harvesting. The sole beans took the shortest time probably because of less shading effect and less competition for resources. There was more shading effect and competition in the double row beans and that could be the reason why it took longer to mature.

4.5 The Effect of Cropping System on the number of Pods

The average number of pods per plant was categorically estimated for each treatment (plot) and the data analyzed.

Fig 7

The Effect of Spatial Arrangement and Spacing on Number of Pods Per Plant

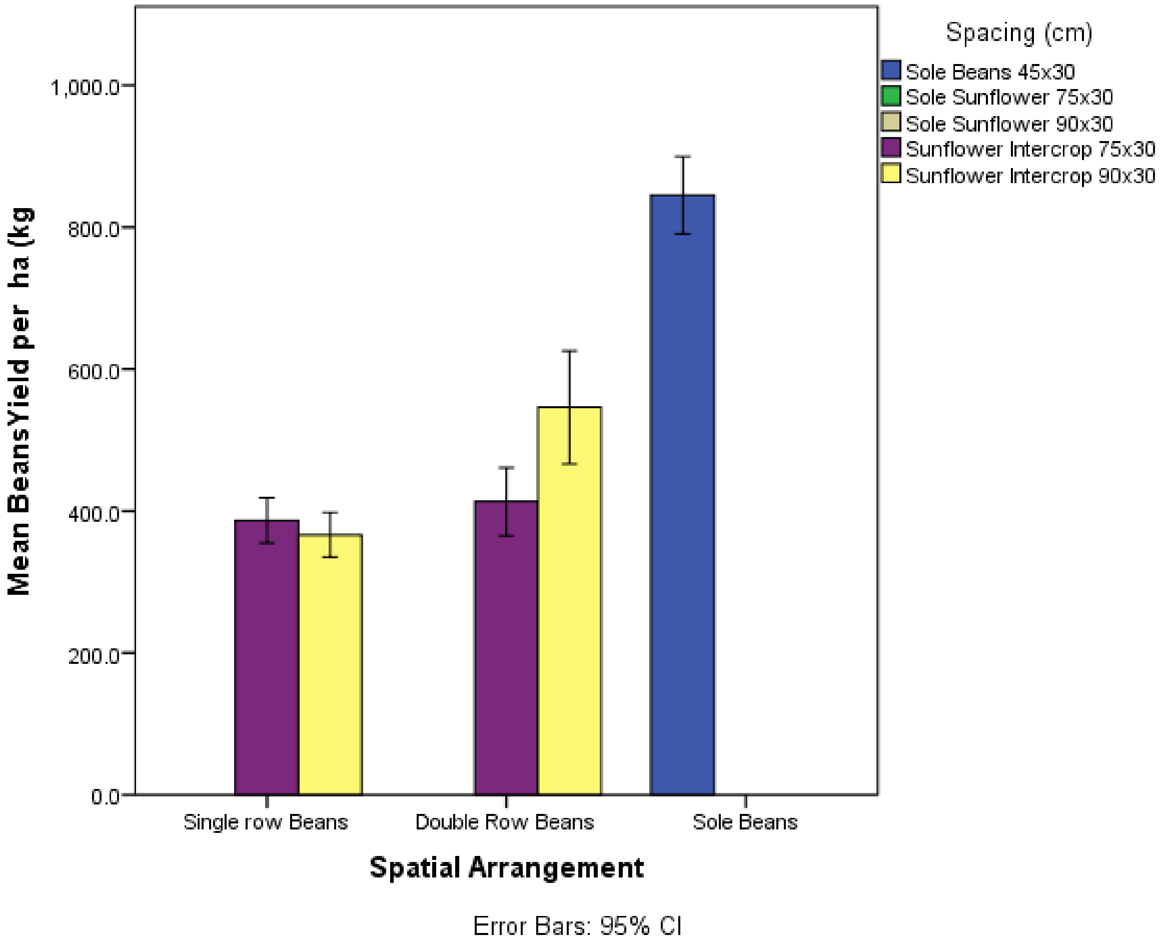


The ANOVA indicated no substantial differences ($p > 0.05$) between the treatment means for varied numbers of pods per plant. The spacing and spatial arrangement did not meaningfully affect the number of pods per plant based on the genetic reasons.

The Effect of Cropping System on Yield of Beans

Bean data on yield per ha was determined and the results of the analysis were as shown below.

Fig 8
Effect of Spacing and Spatial Arrangement on Yield of Beans



The analysis of variance (ANOVA) has also exhibited some significant differences ($p < 0.05$) between the treatment means for bean yields. The yield of common bean per hectare was substantially affected by both the spacing and number of rows (spatial arrangement). Sole beans had the highest yield, followed by double row beans and lastly single row bean spatial arrangement. Post hoc analysis was conducted to assess where the differences were found. The outcomes are shown in the table below.

Table 5

LSD Multiple Comparisons for Spacing on Bean Yields

	Sole Beans	Bean Sunflower Intercrop Spacing 75 x 30 cm	Bean Sunflower intercrop Spacing 90 x3 0 cm
Sole Beans		444.867*	388.567*
Bean Sunflower Intercrop Spacing 75 x 30 cm	-444.867*		-56.300*
Bean Sunflower intercrop Spacing 90 x 30 cm	-388.567*	56.300*	

Note. The difference in the mean is substantial at the level, 0.05.

The yield for sole beans was significantly higher than for both intercrop beans. This was because sole beans had a higher population and had less competition for resources such as light compared to intercrops. Yield of bean intercrop for spacing 90 x 30 cm was suggestively higher than for bean intercrop at spacing 75 x 30 cm. This is because bean intercrop at spacing 90 x 30 cm had more space hence less competition for resources.

Table 6

LSD Multiple Comparisons on Spatial Arrangement for Bean Yields

	Single Row Beans	Double Row Beans	Sole Beans
Single Row Beans		-102.900*	-468.167*
Double Row Beans	102.900*		-365.267*
Sole Beans	468.167*	365.267*	

Note. The difference in the mean is substantial at the level, 0.05.

Yield for sole beans was significantly higher than for both single and double row spaced intercropped beans. This was because sole beans had higher population and less competition for resources such as light in the absence of sunflower. Yield for a double row bean was higher than for single row beans because of higher beans population.

5.0 Conclusions

In overall, the total output from the intercropping recorded to be greater than that of sole cropping as depicted by total land equivalent ratios (LER_T) of sunflower and beans. Indeed, the agronomic benefit (LER > 1.00) extended between 1.32-1.54 in respect to the mono crops. The recorded LER values were greater than unity (1.0), therefore signifying that it would be more productive to intercrop sunflower and common bean than growing separately.

Based on the LER values, sunflower and bean crops produced between 32% and 54% more in the intercropping systems. The high values of LER presented by sunflower (0.83-0.91) exhibited that it was indeed the dominant crop in the intercropping, therefore this confirmation being in line with what was stated in the study by Muhammad et al. (2007). Notably, the intercropping of sunflower and canola (*Brassica campestris*) recorded significant results, where sunflower showed a LER value of 0.95 and 0.75 for canola. In another research study, Sarandón and Chamorro (2003) established that the possibility of attaining a LER of 1.99 in the case of intercropping sunflower and maize.

Furthermore, a maximum value of LER at 1.54 was attained, especially when sunflower was sown at 90 x 30 cm in double-row, whereas the common bean exhibited yield advantage at 54%. In other words, it is likely to harvest the production yields from sunflower at one hectare of intercropping as compared to the cultivation of sole sunflower at1.54 hectare. Therefore, the minimum LER value of 1.32 was achieved, especially when sunflower was sown at 75 x 30 cm with intercropping of double-row beans. The highest MER was attained at 1.20 for sunflower or double-rows of beans S_2B_2 – 90 x 30 cm, and the lowest value was at 0.99 for sunflower or single-row of common bean, S_2B_2 – 90 x 30 cm.

5.1 Recommendations

Results have indicated that there is a possibility of raising the total productivity of the intercropping systems provided that the production yields of both sunflower and beans would be enhanced. The following are the recommendations towards the need to improve the intercropping system of sunflower or bean.

i) Carrying more research to find the most compatible sunflower or bean variety combination that can give higher yields and economic returns. Future research should therefore focus centrally on screening grain legume varieties to classify high yielding ones. Seed bulking of the beans which perform properly in intercropping should be reinforced so that all farmers in the area have access to clean and quality seeds.

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