INFLUENCE OF PLANT DENSITY AND INTERCROPPING ON THE PERFORMANCE OF ELITE COWPEA VARIETIES IN EASTERN UGANDA

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DECLARATION

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

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This thesis has been submitted with our approval as University supervisors.

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DEDICATION

This piece of work is dedicated to my dear parents; Mr. Mpoza Emmanuel and the Late Nakitende Sumini, my lovely wife Nsengiyunva Maria and son Kawooya Victor Raamiah, all my brothers and sisters, and the entire Engeye Clan.

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ABSTRACT

Cowpea (*Vigna unguiculata*) is of major importance to the livelihoods of millions of relatively poor people in less developed countries of the tropics. In Uganda, cowpea occupies an economically important place among grain legumes especially in the eastern and northern regions where it is an important source of protein and household income. Two experiments were conducted at the National Semi-Arid Resources Research Institute (NaSARRI) Serere in Eastern Uganda during the first and second rains of 2011. Experiments were conducted to determine the influence of plant density and intercropping on the performance of elite cowpea varieties in eastern Uganda. Experiment 1 examined the effect of inter-row distance on the performance of elite cowpea varieties namely; IT85F-2841 (Spreading), MU-93 (Spreading), MU-93 (Semi erect), IT82D-889 (Erect) and two local cowpea varieties namely: Ichirikukwai (Spreading) and Ebelat (Erect). The treatments comprised of three inter-row distances; 45×30 cm, 60×30 cm and 75×30 cm. The treatments were arranged in a Randomized Complete Block Design (RCBD) with three replications. Experiment 2 investigated the effect of intercropping the elite cowpea varieties with maize in Eastern Uganda. This experiment was planted out in a split plot design of a Randomized Complete Block Design (RCBD) where maize row spacing was varied at two levels; 60×30 cm and 120×30 cm with three replicates. This gave rise to one inter-row and two inter-row treatments of cowpea between maize. Data were collected on cowpea growth parameters including; plant height, number of branches, number of leaves, days to 50 % flowering, and cowpea yield parameters including; number of pods per plant, seeds per pod, 100 seed weight (g), pod mass (g) and cowpea grain yield (t ha^{-1}).

The results obtained indicated a significant ($p = 0.05$) difference in growth attributes observed among the cowpea cultivars. Plant population had no significant ($p = 0.05$) effect on most of the cowpea growth and yield parameters in this study. Elite cowpea varieties, MU-93 (spreading) and IT85F-2841 produced higher leaf yield than MU-93 (erect) and IT82D-889. Cowpea elite variety IT82D-889 flowered and reached physiological maturity earlier than all other cowpea cultivars. Cowpea row spacing of 60×30 cm at a plant population of 55,555 plants/ha gave consistently higher grain yield. Cowpea elite variety, IT82D-889 gave significantly ($p = 0.05$) the highest grain yield across the two seasons. Cowpea elite varieties IT85F-2841 and MU-93 (spreading), gave both higher cowpea leaf yields and high cowpea grain yields. Elite cowpea varieties, IT85F-2841 and MU-93 (spreading) with spreading growth habit were more significantly ($p = 0.05$) productive under intercropping than cowpea varieties IT82D-889 and MU-93 (erect) with erect growth habit. Land Equivalent Ratios showed that the best intercropping advantage occurred in 1 row maize : 2rows Cowpea intercropping. Maize planting pattern of 120×30 cm gave the highest maize grain yield than 60×30 cm planting pattern in the March to July 2011 rain season, yet the contrary happened in the September to December 2011 rain season. Cowpea elite variety, IT82D-889, should be recommended to Ugandan farmers for its early maturity and higher cowpea grain yield. However, further research should be conducted to test the yield performance of this variety on-farm and under different Agro ecological zones before it can be forwarded to the Uganda National Variety Release Committee. Cowpea varieties, IT85F-2841 and MU-93 (spreading), should be recommended as dual purpose cowpea cultivars to Ugandan farmers for their higher leaf yields and high grain yield. Farmers should also adopt the intercropping pattern preferably the 1 row maize : 2 rows Cowpea technique for yield advantage. However, more research is needed to further understand the associated additional benefits to enhance the benefits of intercropping achieved in this study.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Taxonomy, Origin and Growth habit of cowpea

Cowpea belongs to the botanical species *Vigna unguiculata* (L) Walp. (Singh and Rachie, 1985). *Vigna unguiculata* is a member of the Order Leguminosales, Family Fabaceae and Tribe Phaseolae (Kochhar, 1981; Singh and Rachie, 1985). It consists of one subspecies *Vigna unguiculata* with three cultivated cultigroups: unguiculata, Biflora and Sesquipedalis and two wild varieties (Maréchal *et al*., 1978). Cultigroup unguiculata is the most diverse of the cultivated subspecies unguiculata and has the widest distribution (Singh and Rachie, 1985). It is commonly called cowpea and is widely grown in Africa, India and Brazil (Singh and Rachie, 1985).

All evidence points to cowpea originating in Africa, although where the crop was first domesticated is uncertain (Singh and Rachie, 1985). Cowpea was thought to have originated in West Africa (Rawal, 1975) in an area encompassing the savannah region of Nigeria, Southern Niger, part of Burkina Faso, Northern Benin, Togo and the North-Western part of Cameroon (Ng and Maréchal, 1985). Padulosi *et al*. (1990) reported that Southern Africa is the centre of genetic diversity because the most primitive of the wild cowpea occurs in Namibia from the west, across Botswana, Zambia, Zimbabwe and Mozambique to the East, and the Republic of South Africa and Swaziland to the South. The former Transvaal (Northern Provience) in South Africa is depicted as the most probable centre of speciation of cowpea due to the presence of wild varieties such as var. rhomboidea, var. protracta, var. tenuis and var. stenophylla, all of which occur from the Northern Province to Cape Town, Swaziland, Zimbabwe and Mozambique (Singh *et al*., 1997).

Cowpea is a single crop species, but the varietal requirements in terms of plant type, maturity, seed type, colour preference and use pattern are extremely diverse from region to region (Singh *et al*., 1997). The growth-habit traits of cowpea are moderately heritable (Singh *et al*., 1997) and the life cycle depends on the cultivar (Singh and Rachie, 1985). It can be an annual or perennial crop, erect, trailing or climbing with striate smooth or slightly hairy stems (Singh and Rachie, 1985; Fox and Young, 1982). The leaves are trifoliate and the leaflets are ovate or lanceolate with entire margins or 3-lobed at the base (Fox and Young, 1982). Both flower size and style length are heritable (Emebiri, 1989) and the inflorescence is axillary with some white and mauve flowers measuring 15-22mm long; the fruit is an erect, linear-cylindrical, smooth or slightly warty pod measuring 5-15cm, depending on the cultivar. The seed colour ranges from white to dark red or black, often mottled, oblong or reniform (Fox and Young, 1982). The optimum temperature for cowpea seed germination range from 20 to 30^0 C (Quass, 1995). Most cowpea cultivars in the tropics and subtropical regions of Africa are grown in humid regions with an annual rainfall varying from 1500-2000 mm (Tindal, 1983). The future developmental plant vigour depends on the cultivar and Ogunbodede (1988) reported considerable genetic variability in cowpea for several seedling traits.

1.2 Cowpea production in the world

The major producers of cowpea in the world include; Nigeria, Niger, Brazil, Burkina Faso, Ghana, Kenya, Uganda and Malawi (Singh and Rachie, 1985). Rapid progress in cowpea improvement has been made and the increase of cowpea production in the traditional growing regions has resulted in cowpea expansion into new areas (Singh and Rachie, 1985). Cowpea is widely distributed throughout the tropics and, the world cowpea production was estimated at 3 million tones grown on a global production area of 12.5 million hectares, with 64% (8 million hectares) of this total in West and

Central Africa followed by about 2.4 million hectares in Central and South America, 1.3 million hectares in Asia, and about 0.8 million hectares in East and southern Africa (Singh et al., 1997).

1.2.1 Cowpea production in Uganda

In Uganda, cowpea is grown for grain and leaves in the Northern and Eastern parts of the country. Although yields of 2500 $kgha^{-1}$ are achievable (Rusoke and Rubaihayo, 1994) yields at farm level average only 150-400 $kgha^{-1}$ (Sabiiti *et al*., 1994). Farmers in Eastern Uganda commonly grow cowpea as an intercrop with sorghum and greengram (Adipala *et al*., 1997). In Eastern Uganda, where nearly 90% of the country's crop is produced (Adipala *et al*., 1997), cowpea production is in transition. Table 1, represents the cultivated area of cowpea in Uganda between the years 1981 and 2001 (FAOSTAT, 2002). It was traditionally grown almost exclusively as a food crop for domestic consumption, however, with the demise of cotton as the main cash crop and the emergency of external markets, many farmers in the region now grow cowpea for cash markets (Sabiiti *et al*., 1994).

Table 1: Cultivated area of cowpea in Uganda ('000 ha)

Year	Cultivated area of cowpea in Uganda ('000 ha)
1981	40
1986	49
1989	46
1990	49
1992	49
1994	53
1996	56
1998	60
2000	64
2001	64

Source: FAOSTAT (2002)

1.3 Importance of cowpea

Cowpea is of major importance to the livelihoods of millions of relatively poor people in less developed countries of the tropics (Singh *et al*., 1997). Cowpea grain is widely traded out of the major production areas and provides a cheap and nutritious food for relatively poor urban communities (Singh *et al*., 1997). It is often called "meat for poor people" since its protein is the cheapest (Atachi *et al*., 1984). An animal production study showed that the average daily gain (ADG) of cows and sheep on cowpeas is more than on rye grass and compares favourably with that on clover pastures (Phillip *et al*., 1986). The main use of cowpea as a vegetable crop is as a legume, especially for small scale farmers in rural areas (Kay, 1979; Coetzee, 1995). It is very palatable, highly nutritious and relatively free of metabolites or other toxins (Kay, 1979; Quass, 1995). The chemical composition of cowpea seeds corresponds with that of most edible legumes (Coetzee, 1995). The seeds also contain small amounts of ß-carotene equivalents, thiamin, riboflavin, vitamin A, niacin, folic acid and ascorbic acid (Kay, 1979; Tindall, 1983). The use of cowpea seeds as a seed vegetable provides an inexpensive source of protein diet. The dried pulse may be cooked together with other vegetables to make a thick soup, or ground into a meal or paste, before preparation in a variety of ways (Allen, 1983; Kay, 1979; Quass, 1995). Similarly, fresh, immature pods may be boiled as vegetable. Fresh leaves and growing points are often picked and eaten in the same way as spinach (Coetzee, 1995; Quass, 1995). Dried leaves are preserved and eaten as a meat substitute (Fox and Young, 1982; Quass, 1995). According to Kay (1979), cowpeas are grown in some countries for example India as a dual purpose crop.

In Uganda, cowpea occupies an economically important place among grain legumes especially in the eastern and northern regions where it is an important source of protein and household income (Sabiiti *et al*., 1994; Adipala *et al*., 1997). The grain may be boiled whole, grounded or mixed with sweet potatoes or other plantain (Obuo, 1995). Relative to other grain legumes and vegetable crops, cowpea possesses multiple advantages for farmers, including high production on poor, sandy soils unsuitable for the production of other crops, higher rates of symbiotic nitrogen fixation and lower fertilizer requirements (Timko and Singh, 2008). Cowpea is also more tolerant to drought and high temperatures than other grain legumes (Hall *et al*., 2002).

1.4 Problem statement

Cowpea yields in Uganda are constantly very low averaging 200 to 400 kg ha^{-1} (Sabiiti *et al*., 1994). This has been attributed to a complex of insect pests and diseases (mostly viruses), poor agronomic practices, use of low yielding cultivars, which are susceptible to farmer conditions, poor market access and decline in soil fertility. A diagnostic survey conducted in 1993 by Makerere University Cowpea Improvement project revealed that some of the most important constraints to cowpea production in the country included low yield potential of landraces, narrow genetic base, lack of improved seed, pests and disease attacks, and poor agronomic practices (Adipala *et al*., 1997; Edema and Adipala 1996; Karungi *et al*., 2000). According to a recent survey report carried out in 2010 in Eastern and Northern Uganda under the McKnight Foundation funded cowpea project, cowpea production is constrained by the following factors in order of importance; low yielding local varieties, pests and diseases, poor agronomic practices, land shortage, seed scarcity, drought, poor soils and lack of market.

1.5 Justification of the study

The use of landraces with low yield potential has greatly curtailed cowpea production in Uganda (Adipala *et al*., 1997). To address this problem, a number of introductions were made from International Institute of Tropical Agriculture in Nigeria, Tanzania and Kenya (Rusoke and Rubaihayo, 1992). However, prior to recommending any improved genotype for farmers adoption there is need to understand the local and improved varieties in terms of growth patterns and yield attributes. Thus, it is essential to quantify the relationship between agronomic traits (Obisesan, 1985) and to establish their direct and indirect contribution to yield. In addition, breeding programs and research activities have mainly been focused on sole crop situations yet most of the end-users of the technologies generated are small-scale and resource poor farmers, who, most often practice mixed cropping (Owere, 2001). The small-scale farmer for instance in Uganda unlike his counterpart in the developed world relies on family labour, natural environment, limited inputs and simple tools and therefore, can only manage small farms, which must provide him with both his financial and dietary requirements (Beet, 1982) at the least cost. This therefore means that intercropping could provide the best alternative to him.

Therefore, to improve cowpea production, more research was needed, among other factors, on the selection of high yielding genotypes and assessing them under different agronomic practices such as plant densities and various cropping systems. There is need to investigate the effect of various agronomic practices on growth, grain yield and yield components of different elite cowpea varieties since there has been no yield data on these varieties in the last two decades in Uganda (McKnight cowpea project survey, 2010). This study was, therefore, intended to assess the influence of plant density and intercropping on the performance of elite cowpea varieties in eastern Uganda.

1.6 Objectives of the study

The main purpose of this study was to evaluate the yield performance of selected elite cowpea varieties under different plant densities and cropping systems.

The specific objectives of this study were to:

a) Determine the appropriate planting density that would maximize yield of selected elite cowpea varieties.
b) Evaluate growth and yield response of elite cowpea varieties and maize in an intercropping system.

1.7 Hypotheses tested

The hypotheses which guided the study were that;

a) Yields of elite cowpea varieties are higher than that of local varieties under optimum plant density.
b) Elite cowpea varieties give different yield performance under different cropping systems.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Cowpea varieties

Traditional varieties are often adapted to the environments in which they have evolved (Summerfield and Roberts, 1985). These local cultivars of cowpea have low yield potentials, long maturing periods and are susceptible to pests and diseases (Singh and Allen, 1980; Rusoke and Rubaihayo, 1992; Sabiiti *et al.,* 1994; Omongo *et al.,* 1995). They are usually grown in mixtures with other crops such as finger millet, sorghum, maize, greengram, and cassava (Sabiti *et al*., 1994; Adipala *et al*., 1997a). The majority of farmers in Uganda grow local varieties which include Ebelat, Ichirikukwai, Ekowo, Amul, Annul and Angondui (Obuo, 1995). These varieties differ considerably in their growth characteristics such as pod size, seed shape, size and colour (Anonymous, 1995). The local varieties are either determinate (elect), indeterminate (spreading) or semi-determinate, Ebelat is erect; Ichirikukwai is semi erect, while the spreading type includes Agondri, Ekowo and Amul (Obuo, 1995; Adipala *et al.*, 1997a).

Cowpea improvement work has largely been conducted at the International Institute of Tropical Agriculture (IITA), Ibadan Nigeria where a wide range of new and improved varieties have been developed (IITA, 1989; Singh, 1989). These varieties are high yielding (up to 2500 kg/ha), early maturing (less than 90 days) and reportedly have moderate to high host plant resistance to some key diseases and pests, nematodes, weeds and drought (IITA, 1978; Sing and Allen, 1979; Allen *et al*., 1981). Selection among locally adapted types is one process that has led to identification of improved varieties, which are high yielding, early maturing, pest and disease resistant (Pandey, 1987; Singh, 1989). Singh and Rachie (1985), commended these recent advances in genetic improvement for transforming cowpea into practically a new crop that is attractive to small holders throughout the world. In Uganda, cowpea improvement work was first attempted at Makerere University in the late sixties and early seventies (Acland, 1987) but due to civil strife work could not continue (Bua and Adipala, 1995). About two decades ago some research on cowpea was revived at Makerere University and some varieties with yield of 2500 kg/ha under experimental plots were selected (Rusoke and Rubaihayo, 1994). These include: IT82D-522-1, IT85F-1987, IT82D-716, TVX3236, and TVX274-02. However, none of these varieties was taken up by farmers and thus, the majority of Ugandan farmers still grow the local varieties (Asio, 2004).

2.2 Cowpea growth and developmental phases

A cowpea plant goes through a number of growth stages from seed germination to maturity. These include seedling, flowering, pod formation and pod filling stages (Asio, 2004). The vegetative phase in cowpea lasts from germination and establishment until the first flower appears, about 40 days after planting depending on the variety (Pandey,1987). Adverse growing conditions during the vegetative period such as severe moisture stress or reduced irradiance may stunt plants sufficiently to prevent recovery during the reproductive period and so yields will be low (IITA, 1975; Summerfield *et al.*, 1976). Soil moisture is essential for germination and seedling growth; roots grow poorly in dry soils and cannot absorb nutrients for the plant ((Pandey, 1987).

The reproductive phase in cowpea shows extreme variation, some cultivars flower within 30 days from sowing and are ready for dry seed harvest 25 days later; others take more than 100 days to flower and take up to 240 days to mature (Singh and Rachie, 1985). However, genotypes that flower early have shorter blooming periods than later flowering ones (Wien and Summerfield, 1984). Time to flowering is determined exclusively by either mean temperature or photoperiod. Photoperiod sensitive genotypes may flower later than expected in short days if it is relatively insensitive to temperature. In those circumstances plants would be less strongly induced to flower in short days (Singh and Rachie, 1985). Indeterminate cowpeas that have been discovered begin flowering early, but have delayed leaf senescence after producing the first flush of pods, which enables them to produce a second flush of pods (Gwathmey *et al*., 1992). On the contrary, in the determinate cultivars, once the reproductive phase begins very little vegetative growth occurs. Early erect determinate cowpea cultivars which start flowering about 30 days after sowing in the tropics, have proved to be useful in some dry environments and years because of their ability to escape drought (Hall and Patell, 1985). Grain yield of cowpea is more sensitive to soil water deficits during flowering and pod filling than during the vegetative stage (Turk *et al*., 1980; Ziska and Hall, 1983; Ziska *et al*., 1985).

2.3 Cowpea growth traits

Growth traits of cowpea include; branch number, plant height, node number, stem diameter, leaf number, leaf area and root length and these traits to some extent are moderately heritable (Singh *et al*., 1997). The number of branches established at the vegetative stage, decides the plant skeleton; it limits both the number of leaves, which produce photosynthates (source) and number of pods which become the sink. The size of the plant at flowering and hence the number of nodes produced, greatly influence economic yield in determinate genotypes, which have a limited capacity to continue growth and leaf production once the first flush of fruits has been set. However, in the indeterminate cowpea varieties, plant size at flowering has relatively little effect on economic yield (Porter, 1974).

2.4 Yield and yield components of cowpea

Cowpea grain yield depends upon other component traits such as number of pods per plant, pod length, number of seeds per pod and seed weight (Nakawuka and Adipala, 1999). Each yield component contributes to the total yield, thus effect on any component will affect yield. Some yield components are determined more by variety than by environment (Pandey, 1987). The magnitude and direction of correlation coefficients between yield and yield contributing agronomical characters indicate that yield is a function of the number of pods per plant, number of seeds per plant, pod length and 100 seed weight (Bapna *et al*., 1972). Experiments conducted at Samau, Nigeria during 1965 and 1966 showed that the number of pods per plant and the 100 seed weight were independent of one another and were significantly associated with the grain yield. Ebong (1972) found that grain yield of cowpea depended mainly on number of pods per plant. Asssefa *et al*. (2001) working on green gram in India similarly showed that pods per plant is the principal yield contributing trait. Its correlations, both direct and indirect effects were positive and high for seed yield. In Uganda, Nakawuka and Adipala (1999) reported that branch number, pod number and seeds per pod significantly contributed to grain yield. In another study conducted by Asio (2004), pods per plant, pod length and seeds per pod significantly contributed to yield and were considered during selection of high yielding cowpea genotypes.

2.5 Intercropping as a practice

Joint cultivation of two or more crops at the same time on the same piece of land is referred to as intercropping (Sullivan, 2003), and is an age-old, widespread practice in the warmer climates of the world (Searle *et al*., 1981), especially the tropics (Willey, 1979). Vandermeer (1989) proposed that intercropping be divided into three general categories; full, relay and sequential intercropping and that preference depends on the extent of physical association between the crops. However, Grossman and Quarles (1993) divided intercropping into four basic spatial arrangements which include; Row intercropping where two or more crops are planted simultaneously with both crops planted at distinct rows; Strip intercropping where two or more crops are planted together in strips wide enough to permit separate crop production practices using machines but close enough for the crops to interact; Mixed intercropping where two or more crops are planted together without any distinct row arrangement; Relay intercropping where a second crop is planted into an already standing crop at a time when the standing crop is at its reproductive stage or has completed its development but before harvesting.

Intercropping as a practice allows maximum benefit to be made of natural resources available for production. The interest of growing two or more crops at the same time on the same piece of land is increasing because of the potential to increase an area's productivity (Fortin and Pierce, 1996). Resource poor farmers mostly practice intercropping because of limited land but also for the beneficial interaction regarding chemical application. Sole crops require more chemicals to control insect pests and diseases, and these chemicals may not be available even if financial resources are available (Singh and Adjeigbe, 2002). In addition, farmers with limited resources have limited capacity to tolerate production failure and, therefore are compelled to practice intercropping where a legume is combined with a cereal as a nutritious food and fodder source (Henriet *et al*., 1997).

2.5.1 Significance of intercropping

Among the various combinations of cereals and legumes used by small-scale farmers, cowpea and maize is one of the most widely used (Mpangane *et al*., 2004). The principal reasons for farmers to intercrop are flexibility, profit maximization against crop failure, soil conservation and maintenance, weed control and balanced nutrition (Shetty *et al*., 1995). Other advantages of intercropping include potential for increased profitability and low fixed costs for land as a result of a second crop in the same field. Time, labour management, and equipment are also better utilized (McCoy *et al*., 2001). According to Viljoen and Allemann (1996), some of intercropping advantages include: higher yield than sole crop yields, probably due to less intra-specific competition, greater yield stability, more efficient use of environmental resources, better weed control, provision of insurance against crop failure and improved quality by variety. The major disadvantage of intercropping is not well adapted to very dry, poorly drained and heavy clay soils and also implies difficulty in harvesting, using machinery (Prochaska, 2001). Difficulty in mechanization such as sowing, weeding, fertilizing and harvesting are made for uniform field, therefore, intercropping on large scale using machinery is generally believed to be impossible although there are intercropping examples using modern machines that exists (Baumann, 2001).

2.5.2 Variety selection for intercropping

Crop varieties used in an intercrop should be highly plastic, that is, they should give fairly stable yields over a wide range of plant populations (Beet, 1982). This allows for flexibility for varying of crop proportions. When crops are grown in association, interactions between the component species occur which is a response of one species modified by the presence of the other species. Competition in mixed communities is therefore, two fold that is inter and intra specific Trenbath (1976) hence the success of an intercrop will depend on the choice of the right cultivars.

2.6 Plant population density and intercropping

Plant populations are important in determining yield and competition for the available resources (Holliday, 1960). Some crop varieties, however, have a high degree of plasticity and such varieties give fairly stable yield over a wide range of populations and on intercropping such varieties, the population effect on yield is low compared to its sole stand (Beet, 1982). Trenbath (1976) reported that two plants no matter how close do not compete with each other as long as the water content, the nutrient material, light and space are in excess of the needs of both. In addition, Tanimu (1997) reported that the level of competition depended on the level of supply of resources, the nature of the plant community in particular the resource requirements of the individual plants, the number of plants per unit area (plant population) and the spatial arrangements. Holliday (1960) suggested that as population of monocultures are increased, competition is likely to begin earlier than for different species because in a monoculture all the plants require the same resources at the same time. Willey and Osiru (1972), Obuo (1996) and Hegewald and Lihner (1980) suggested that intercrops required different resources and competition was less likely and optimum population for intercrops was higher since the intercrops had the ability to make better use of environmental resources. This was further supported by the report of Obuo *et al*. (1997) who pointed out that cowpea in pure stand yielded best at 60 cm x 30 cm spacing, but under intercropping, the best yield was obtained at 60 cm x20 cm spacing in a cowpea-sorghum intercrop, it therefore follows that the extent to which the population must be increased should be related to the magnitude of the yield advantages (Ochaya, 1998).

2.7 Spatial arrangements and crop mixtures

Spatial arrangement defines the pattern of distribution of plants over the ground, which determines the shape of the ground area available to the plant (Willey, 1979). Crop arrangement is important because it determines the efficiency with which solar radiation and space is utilized (Nayak *et at*.. 1996) When plants are grown together in a community, they will affect each other and the degree of influence depends on the planting pattern which results in interference that affect the extent to which the population must be increased to have a yield advantage (Willey, 1979). The way the plants are laid in the field also influences the growth, development and yield of the individual plants as well as the crop as a whole (Beet, 1982).

2.8 Higher yields per unit area

Intercropping has been reported to give higher yields per unit area compared to sole crops (Ssekabembe, 1983). Yield advantages from intercropping as compared to sole cropping are often attributed to mutual complementary effects of component crops, such as better total use of available resources. Generally, monoculture legumes have higher yield compared to an intercropping system. However, in most cases, land productivity, measured by Land Equivalent Ratio (LER), clearly shows the advantage of mixed cropping of cereals and legumes (Mandal *et al*., 1990). Depending on component crops, yield advantages may vary considerably due to several factors, including differences in plant architecture, rooting patterns, competitive advantages and potential nitrogen fixing capacity of the legume. These, in turn, determine the optimum density, time of sowing and amount of nitrogen fertilizer. The need for simultaneous production of different food crops and or cash crops can also encourage intercropping.

2.9 Assessment of intercropping productivity

2.9.1 Land Equivalent Ratio (LER)

Assessment of land return is made from the yield of pure stands and from each separate crop within the mixture. The calculated figure is called the Land Equivalent Ratio (LER), intercrop yields are divided into pure stand yields for each crop in the intercropping system and the two figures added together (Mead and Willey, 1980; Sullivan, 2003). Yield advantages from intercropping, as compared to sole cropping are often attributed to mutual complementary effects of component crops, such as better use of available resources. Land Equivalent Ratio gives an indication of magnitude of sole cropping required to produce the same yield on a unit of intercropped land.

Land Equivalent Ratio concept has got some short comings, particularly when used to compare the productivity of an intercrop and sole crop (Thobatsi, 2009). The major problem is that the computation of Land Equivalent Ratio needs maximum yields of sole crop obtained at optimum plant densities (Willey, 1979). When yields of sole crops at recommended plant densities are compared with those of intercrops it will be likely that the advantage of intercropping is overestimated since the plant density may be altered as an experimental variable to determine optimum plant density (Ifenkwe *et al*., 1989). This is most likely to occur in an "additive" experiment where intercropping of two component crops do have twice the plant density of individual sole crops (Ofori and Stern, 1986). A similar problem occurs when cultivars are tested for their suitability to intercropping. Sole crop yields of different cultivars may be obtained and partial Land Equivalent Ratio (pLER) values of the component crop be calculated by dividing the yield of a specific cultivar in sole and intercropping production and added together to give total LER. The partial Land Equivalent Ratio gives an indication of the relative competitive ability of the components of an intercropping system. Therefore the species with a higher partial Land Equivalent Ratio is considered to be more competitive for growth limiting factors than the species with lower partial Land Equivalent Ratio (Willey, 1979). However, when sole crop yields differ among cultivars, a higher LER may be obtained compared to cultivars with low sole crop yields (Thobatsi, 2009). Therefore, for computation of LER the highest yield of a cultivar in sole cropping should be used. This is an illustration that productivity of different cropping systems should be made using treatments, which produce maximum yields for different cropping systems (Fukai, 1993). Another short coming is that LER does not give the production of biomass or the exact value of yields, instead it represents the yield advantage and disadvantages of intercrops compared to sole crops and the time factor is less considered for the crop maturities (Thobatsi, 2009).

2.9.2 Methods of determining Land Equivalent Ratio (LER)

Computation of Land Equivalent Ratio can be achieved by use of several methods, most of which have been suggested in literature. The choice of a sole crop yield for standardizing a mixture yield in the estimation of the LER consists of averaging all the sole yields in each block (Fisher, 1977); averaging sole yields in the entire experiment (Mead and Stern, 1980; Oyejola and Mead, 1982); averaging sole crop yield at each treatment level in studies that involve graded levels of factor A and B (Mead and Willey, 1980) and using the yield of the best sole crop treatment of each crop (Huxely and Maingu, 1978; Mead and Willey, 1980). These methods cannot be generalized because the method to be used depend on the aim of the experiment (Thobatsi, 2009).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental site

The study was conducted on-station at the National Semi-Arid Resources Research Institute (NaSARRI) based at Serere, Eastern Uganda. NaSARRI (33º 22'E, 1º 31'N) is at an elevation of 1,000 metres above sea level (m.a.s.l) (Department of Lands and Survey, 1967). The annual rainfall was 1,197.9mm with two rainy seasons (Figure 1). The total rainfall was 486.0mm and 640.8mm during the 2011A (first season) and 2011B (second season) respectively. Maximum and minimum temperatures were 30.2ºC and 18.8ºC, respectively (Figure 2) during the year 2011.

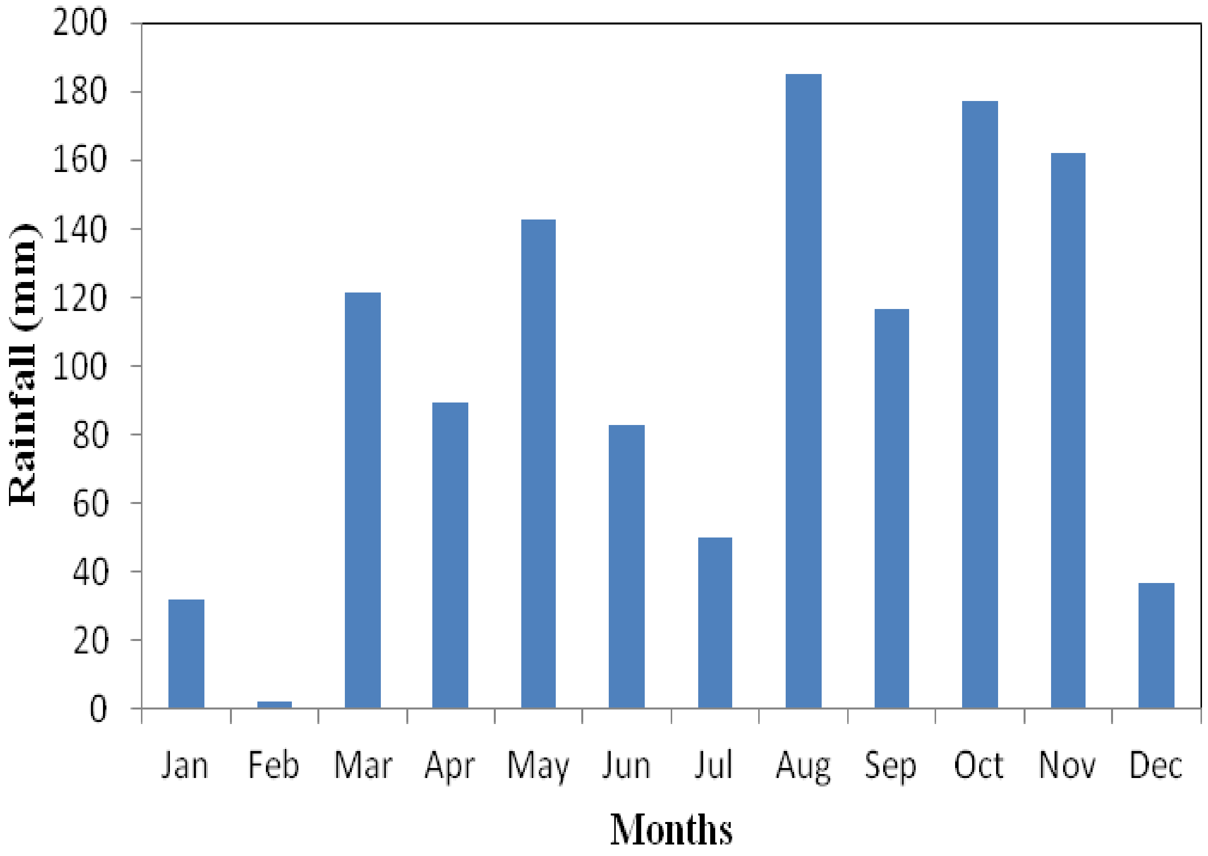

Figure 1: Monthly mean rainfall (mm) during 2011A and 2011B rainfall seasons at Serere.

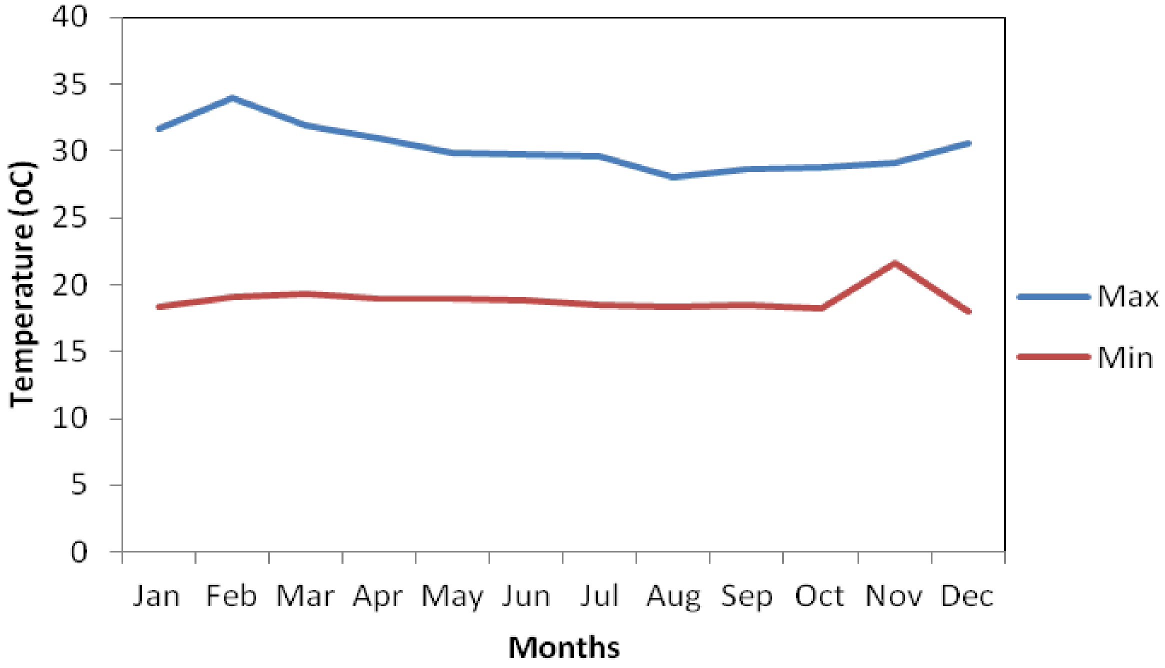

Figure 2: Monthly Maximum and Minimum temperatures (^{o}C) during 2011A and 2011B rainfall seasons at Serere.

3.2 Materials

According to a recent survey report carried out in 2010 in Eastern and Northern Uganda under the McKnight Foundation funded cowpea project (Bisikwa *et al*., 2013), Ichirikukwai (Spreading) and Ebelat (Erect) cowpea cultivars were local farmer preferred varieties and have been grown for long thus these two were used as local varieties in the study. The local varieties had seeds which were white in color and not resistant to Aphid Mosaic Virus. The four elite cowpea varieties used were obtained from the AGRA- funded project and these included; IT85F-2841 (Spreading), MU-93 (Spreading), MU-93 (Erect), and IT82D-889 (Erect). The seeds of these AGRA varieties were white in color except IT82D-889 variety which had brown seed color. The AGRA varieties are due for release to be adopted by farmers but their agronomic attributes need to be assessed first. Furthermore, all the above mentioned AGRA-varieties that were used in this study were resistant to Aphid Mosaic Virus.

3.3 Experiments

Two experiments were conducted in the first and second rainy seasons of 2011. The details of the experiments were as follows:

3.3.1 Experiment 1: Effect of plant density (planting pattern) on growth and yield of selected elite cowpea varieties in Eastern Uganda.

3.3.1.1 Experimental Layout

Three inter row distances were used (45×30 cm, 60×30 cm and 75×30 cm). These are referred to as high, medium, low plant densities respectively (Table 2). The plots measured 3m × 4m. The experiment consisted of two local cowpea varieties; Ichirikukwai (Spreading), Ebelat (Erect), and four elite cowpea varieties; IT85F-2841 (Spreading), MU-93 (Spreading), MU-93 (Erect), IT82D-889 (Erect) from AGRA funded project, were arranged in a randomized block design with three replications. There were a total of 54 experimental units. Table 3 shows the treatment details for experiment one.

Table 2: Experiment 1 expected plant population at three density levels

Density	Spacing (cm)	Plot Size (m^2)	Plants per hill	Expected plants (m^2)	Expected plants (ha)
Low (D1)	75×30	4×3	1	4.4	44444
Medium (D2)	60×30	4×3	1	5.5	55555
High (D3)	45×30	4×3	1	7.4	74074

Table 3: Experiment 1 Treatment Details

Treatment Code	Treatment Description
VID1	IT85F-2841 (Spreading) planted at 75×30 cm
VID2	IT85F-2841 (Spreading) planted at 60×30 cm
VID3	IT85F-2841 (Spreading) planted at 45×30 cm
V2D1	MU-93 (Spreading) planted at 75×30 cm
V2D2	MU-93 (Spreading) planted at 60×30 cm
V2D3	MU-93 (Spreading) planted at 45×30 cm
V3D1	IT82D-889 (Erect) planted at 75×30 cm
V3D2	IT82D-889 (Erect) planted at 60×30 cm
V3D3	IT82D-889 (Erect) planted at 45×30 cm
V4D1	MU-93 (Semi Erect) planted at 75×30 cm
V4D2	MU-93 (Semi Erect) planted at 60×30 cm
V4D3	MU-93 (Semi Erect) planted at 45×30 cm
V5D1	Ebelat (Erect) planted at 75×30 cm
V5D2	Ebelat (Erect) planted at 60×30 cm
V5D3	Ebelat (Erect) planted at 45×30 cm
V6D1	Ichirikukwai (Spreading) planted at 75×30 cm
V6D2	Ichirikukwai (Spreading) planted at 60×30 cm
V6D3	Ichirikukwai (Spreading) planted at 45×30 cm

Key for treatment codes: Cowpea varieties V1 = IT85F-2841, V2 = MU-93 (Spreading), V3 = IT82D-889, V4 = MU-93 (Erect), V5 = Ebelat and V6 = Ichirikukwai. Row spacings D1 = 75×30cm, D2 = 60×30cm and D3 = 45×30cm row spacing.

3.3.1.2 Data collection

3.3.2.1 Plant growth parameters

Five plants were tagged at random from each plot for recording observations on various growth parameters. Plant height was measured in centimeters from the base of the plant to the tip of the main stem in the five tagged plants and the mean plant height was worked out and expressed in centimeters. Cowpea branches were counted from the same five intact plants and mean number of branches per plant were determined. The number of days taken from sowing to blooming (first flower bud) 50 percent of the plants per plot was recorded as days to 50 percent flowering. Cowpea physiological maturity was determined by the change in pod colour from green to brown (Cisse and Hall, 2005).

3.3.2.2 Yield components

Plants selected from the net plot area for taking growth observations at the time of harvest were used for recording the following yield components. Number of pods per plant; Total filled pods present in five tagged plants were counted and the mean was calculated and expressed as number of pods per plant. Number of seeds per pod; The seeds from pods were separated, counted and mean number of seeds per pod calculated. Pod length (cm); Five pods were collected at random from the five selected plants and their length was measured in centimeters and the mean was calculated and expressed as the length of the pod. 100 Seed weight (gm); A random sample from the yield of net plot was taken out and one hundred seeds were counted and weighed.

Seed yield (kg ha^{-1}); Final Seed Yield was determined as follows:

$$\text{Seed yield (kg ha}^{-1}\text{)} = \frac{\text{Seed weight (kg) of plot} \times 10000}{\text{Harvested area (m}^{2}\text{)}}$$

3.3.2.3 Data analysis

All the recorded growth and yield parameters data were subjected to analysis of variance (ANOVA). Mean comparisons were made by Fisher's Protected LSD test at 5% level of significance.

3.3.2 Experiment 2: Evaluation of growth and yield response of elite cowpea varieties and maize in an intercropping system.

3.3.2.1 Experimental Layout

Experiment 2 investigated the effect of intercropping the elite cowpea varieties with maize in Eastern Uganda (Plate 1 and Plate 2). The main treatments were; i) sole cowpea, ii) sole maize, iii) intercrop 1 (one row of maize to one row of cowpeas) and iv) intercrop 2 (one row of maize to two rows of cowpea). The sub-treatments were four elite cowpea varieties IT85F-2841 [spreading], MU-93 [spreading], MU-93 [erect], IT82D-889 [erect] and one maize variety, Longe 5 which is an open pollinated variety with quality protein were used. Maize was used in thus study based on the findings of McKnight Cowpea project base line survey that was conducted in 2010, which revealed that trends have changed in Eastern Uganda and farmers intercrop cowpea with maize compared to sorghum. The experimental design was a split-plot and the treatments were replicated three times. The gross sub-plot sizes were 4m × 5m. There was 2-m path between replicates and 1-m path between sub-plots. Both crops were planted on the same day as indicated above. The maize planting patterns were at two spacings of 60 cm × 30 cm and 120 cm × 30 cm giving one and two rows of cowpea in between the maize rows, respectively. Cowpea varieties were planted at 60 cm × 30 cm in all plots where applicable.

3.3.2.2 Data collection

Data on elite cowpea varieties in experiment two (2) was collected on all parameters as described in experiment one (1), and the same procedures were used. In addition, maize cobs were collected on drying, from five plants per plot including those from sole maize plots. Data on number of cobs, weight of grain per cob and total grain weight as well as yield per hectare were computed from the samples.

3.3.2.3 Data analysis

All the data collected were subjected to ANOVA and analyzed as a split plot in a Randomized Complete Block Design (RCBD) to establish the yield variances under the intercrop using the Genstat statistical analysis programme. Likewise all other procedures of mean separation were done as described in experiment one. A correlation analysis was also done for this intercrop experiment. In addition, Land Equivalent Ratios which refer to the assessment of land return was made from the yield of pure stands and from each separate crop within the mixture. Land Equivalent Ratios (LERs) were computed for the intercrop experiment as follows:

$$\textbf{LER} = \frac{Y^*M_i}{Y^*M_m} + \frac{Y^*C_i}{Y^*C_m} + K\ldots.Xn$$

Where Y^* = yield of, M_i = Maize intercrop, M_m = Maize monocrop, C_i = Cowpea intercrop, C_m = Cowpea monocrop and K = Constant. *Source:* (Ibrahim Hamza, 2008). The LERs were analysed and any LER greater than one (>1) was interpreted as intercropping advantage.

Plate 1: 1 row Maize : 2rows Cowpea intercrop cropping Pattern system 2011A Season

Plate 2: IT82D-889 under sole crop cropping Pattern system 2011A Season

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Experiment 1: Effect of plant density (planting pattern) on growth and yield of selected elite cowpea varieties in Eastern Uganda.

Plant population is important in determining yield and competition for the available resources (Holliday, 1960). Some crop varieties, however, have a high degree of plasticity and such varieties give fairly stable yield over a wide range of plant populations (Beet, 1982). Trenbath (1976) reported that two plants no matter how close do not compete with each other as long as the water content, the nutrient material, light and space are in excess of the needs of both. In addition, Tanimu (1997) reported that the level of competition depended on the level of supply of resources, the nature of the plant community in particular the resource requirements of the individual plants, and the number of plants per unit area (plant population). Despite its immense importance, cowpea yields in farmers' fields are low. In a survey (Sabiiti *et al.* 1994, Annon., 1995), it was established that one of the main reasons for low yield of cowpea in Uganda was poor spacing. Farmers plant cowpea by broadcasting the seed, resulting in some parts of the field to have either very high or low plant population (Mye, 1940; Anonymous, 1995).

For any genotype to express its potential it should be tried under optimum population level. Variation in the population causes changes in the light intensities, humidity and temperature within canopies. Wider spacings plants tend to putforth a vigorous vegetative growth, while closer spacings tend to restrict the same (Shivananda, 2005). Optimum population level is the one, which provides the plant with the best environment to express its capacity fully under the given conditions (Shivananda, 2005). Therefore, there is a need to understand the relationship between plant density and yield so as to identify the optimum population. In Uganda, some experiments have been carried out to assess the effect of spacing on the grain yield of cowpea. Masefield (1946) reported that the spacing of 60 × 30 cm gave significantly better yields than the spacing of 30 × 30 cm. Mehta (1970) found out that close spacing (23 × 23 cm and 15 × 15 cm) depressed yields, but found no significant difference in grain yield with spacings of 30 × 30, 45 × 45, 60 × 30 and 60 × 60 cm. However, Mehta's experiments were performed in one season. Kayode and Odulaja (1985) working on inter and intra row spacing in Nigeria reported 60 × 20 cm spacing to be optimal for cowpea production, but this may not be applicable to Uganda's case because of differences in soil types and climatic conditions. With the introduction of high yielding cowpea varieties, there is need to determine the optimum inter-row spacing since spacing depends on the growth characteristics of the cultivar. The objective of this component of the study was to establish optimal inter row spacing for the four elite cowpea varieties due for release to farmers.

4.1.1 Effect of plant density (planting pattern) on growth parameters of selected elite cowpea varieties.

4.1.1.1 Plant height

Results presented in Table 4 indicate that during the March to July rain season (2011A), there were significant differences ($p = 0.05$) in plant heights among cowpea varieties (Table 4). Overall, the cowpea varieties were taller in the September to December rain season (2011B) compared to the March to July rain season (Table 4). The study also indicated a 7.8% increase in plant height in the September to December rain season. This was probably because of the higher rainfall amounts received in the September to December rain season than the March to July rain season with lower rainfall amounts (Figure 1).

During the March to July rain season, IT82D-889 and MU-93 (Erect) were significantly ($p = 0.05$) taller than all the other cowpea varieties. The mean plant heights during the March to July rain season ranged from 25.35 cm to 33.80 cm where by local variety Ebelat produced the shortest plants and elite cowpea variety IT82D-889 the tallest plants respectively. However, during the September to December, rain season cowpea varieties did not show a significant difference ($p = 0.05$) in plant height (Table 4). The mean plant height during the September to December, rain season ranged from 26.09 cm to 48.67 cm where by local variety Ichirikukwai produced the shortest and Ebelat the tallest plants respectively.

Spacing patterns did not show significant ($p = 0.05$) differences in plant heights during the March to July rain season, though 60×30cm produced taller plants than 45×30cm and 75×30cm spacing (Table 4). Similar results were obtained by Mohamed (2002) who reported that plant density (plant population) had no significant effect on plant height. However, spacing pattern 75×30cm produced significantly ($p = 0.05$) taller plants during the September to December rain season. This finding can still be attributed to a combination of more rain in the September to December rain season and the significant ($p = 0.05$) effect of the season and plant density interaction effect on the performance of the cowpea varieties tested in this study. The interaction effect due to genotype and row spacings on plant height per plant was not significant ($p = 0.05$) during the growth stages (Table 4). Similar results were obtained by Shivananda (2005) who reported that the interaction between genotype and row spacings had no significant effect on the plant height of cowpea.

Table 4: Effect of spacing pattern on plant heights of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Spacing pattern (cm)				Spacing pattern (cm)			
Variety	**45 × 30**	**60 × 30**	**75 × 30**	**Variety mean**	**45 × 30**	**60 × 30**	**75 × 30**	**Variety mean**
	Plant height (cm)				Plant height (cm)			
IT85F-2841	29.28	31.67	31.59	**30.85**^{a}	30.87	29.13	43.73	**34.58**^{a}
MU-93 (Spreading)	25.98	27.76	30.71	**28.15**^{a}	34.37	28.87	35.20	**32.81**^{a}
IT82D-889	29.99	33.80	33.15	**32.31**^{b}	33.93	33.57	36.85	**34.78**^{a}
MU-93 (Erect)	28.58	30.57	29.59	**32.31**^{b}	32.03	27.87	37.43	**32.44**^{a}
Ebelat	25.35	31.62	27.35	**28.10**^{a}	32.37	31.49	48.67	**37.51**^{a}
Ichirikukwai	25.53	31.87	26.27	**27.89**^{a}	26.09	32.77	42.43	**33.76**^{a}
Spacing Mean	**27.45**^{d}	**31.21**^{d}	**29.77**^{d}	**29.48**	**31.61**^{c}	**30.61**^{c}	**40.72**^{d}	**34.31**
				CV % = 14.4				**CV % = 20.2**
				Variety LSD: = 4.05				**Variety LSD: = 6.61**
				s.e = 4.24				**s.e = 6.92**
				Genotype x Spacing = NS				**Genotype x Spacing = NS**
								Seasonality mean change = 7.8%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

4.1.1.2 Number of branches per plant

Generally, cowpea varieties grown in the March to July rain season had more branches compared to those grown in the September to December rain season, as portrayed by a 5% decrease in number of branches in the September to December rain season (Table 5).

Results presented in Table 5 indicate that in the March to July rain season, there were significantly (p = 0.05) more branches produced by local variety Ichirikukwai than all the other varieties. The mean branch number per plant ranged from 4.13 to 9.40 with MU-93 (Spreading) and Ichirikukwa (local variety) producing the lowest and highest number of branches respectively during the March to July rain season. However, in the September to December rain season there was no significant difference (p = 0.05) in number of branches among all cowpea varieties (Table 5). The mean branch number per plant ranged from 4.07 to 6.87 with IT82D-889 and Ebelat (local variety) producing the lowest and highest number of branches respectively during the September to December rain season.

Spacing pattern did not show significant differences (p = 0.05) in number of branches per plant during both rain seasons. During the March to July rain season, spacing pattern 75×30cm produced more branches compared to other spacing patterns (Table 5). However, during the September to December rain season spacing pattern 45×30cm produced more branches than 60×30cm and 75×30cm. However, decrease in plant density increased the number of branches per plant. On the contrary, Alege *et al.,* (2007) reported that increased plant densities reduced the number of branches per plant. The interaction effect due to genotype and row spacings on number of branches per plant was not significant (p = 0.05) during the growth stages (Table 5). Similar results were obtained by

Table 5: Effect of spacing pattern on number of branches per plant of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Spacing pattern (cm)				Spacing pattern (cm)			
	45 × 30	**60 × 30**	**75 × 30**	**Variety Mean**	**45 × 30**	**60 × 30**	**75 × 30**	**Variety Mean**
	Number of branches per plant				Number of branches per plant			
IT85F-2841	6.13	5.00	5.13	**5.42^{a}**	6.07	5.40	4.60	**5.36^{a}**
MU-93 (Spreading)	5.60	4.13	5.53	**5.09^{a}**	4.27	5.27	6.13	**5.22^{a}**
IT82D-889	5.73	5.67	4.80	**5.40^{a}**	5.20	4.07	5.33	**4.87^{a}**
MU-93 (Erect)	5.87	4.60	6.60	**5.69^{a}**	5.60	5.40	4.67	**5.22^{a}**
Ebelat	5.53	5.07	6.60	**5.73^{a}**	6.87	5.07	5.27	**5.73^{a}**
Ichirikukwai	6.20	9.40	8.07	**7.89^{b}**	5.67	5.67	5.07	**5.47^{a}**
Spacing Mean	**5.84^{d}**	**5.64^{d}**	**6.12^{d}**	**5.87**	**5.61^{c}**	**5.14^{c}**	**5.18^{c}**	**5.31**
				CV % = 21.5				**CV % = 24.2**
				Variety LSD: = 1.20				**Variety LSD: = 1.28**
				s.e = 1.26				**s.e = 6.92**
				Genotype x Spacing = NS				**Genotype x Spacing = NS**
								Seasonality mean change = 5.0%

Means within the same row or column followed by same letter are not significantly different from each other at $P \leq 0.05$ according to the LSD test

Table 6: Effect of spacing pattern on number of leaves per plant of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Spacing pattern (cm)				Spacing pattern (cm)			
Variety	**45 × 30**	**60 × 30**	**75 × 30**	**Variety Mean**	**45 × 30**	**60 × 30**	**75 × 30**	**Variety Mean**
	Number of leaves per plant				Number of leaves per plant			
IT85F-2841	52.7	54.1	62.9	**56.6**^{b}	54.7	52.1	57.9	**54.9**^{c}
MU-93 (Spreading)	50.3	50.9	65.9	**55.7**^{b}	52.3	48.9	61.2	**54.2**^{c}
IT82D-889	40.8	32.7	54.5	**42.7**^{a}	42.8	30.7	49.5	**41.0**^{a}
MU-93 (Erect)	40.9	50.1	42.8	**44.6**^{a}	42.9	48.1	37.8	**42.9**^{ab}
Ebelat	59.8	53.5	57.1	**56.8**^{b}	61.8	51.1	52.1	**42.9**^{ab}
Ichirikukwai	48.1	53.9	44.9	**48.9**^{ab}	50.1	51.9	39.9	**47.3**^{ac}
Spacing Mean	**48.8**^{d}	**49.2**^{d}	**54.7**^{d}	**50.9**	**50.8**^{e}	**47.1**^{e}	**49.7**^{e}	**49.2**

March to July season, 2011A	September to December season, 2011B
CV % = 22.5	**CV % = 23.4**
Variety LSD: = 10.95	**Variety LSD: = 11.01**
s.e = 33.19	**s.e = 11.52**
Genotype x Spacing = NS	**Genotype x Spacing = NS**
	Seasonality mean change = 1.69%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

Shivananda (2005) who reported that the interaction between genotype and row spacings had no significant effect on the number of cowpea branches per plant.

4.1.1.3 Number of leaves per plant

During both rain seasons there were significant differences (p = 0.05) in number of leaves among the elite cowpea varieties (Table 6). Overall, the number of leaves per plant was higher in the March to July rain season compared to the September to December rain season.

Results presented in Table 6 also indicate that during the March to July rain season, IT85-2841, MU-93 (Spreading), Ebelat (local variety) and Ichirikukwai (Local variety) produced significantly (p = 0.05) more number of leaves than IT82D-889 and MU-93 (Erect). In contrast, during the September to December rain season, IT85-2841, MU-93 (Spreading) and Ichirikukwai (Local variety) produced significantly (p = 0.05) more number of leaves than IT82D-889, MU-93 (Erect) and Ebelat (Local variety).

Spacing patterns did not show significant differences (p = 0.05) in number of leaves per plant during both rain seasons (Table 6). However, increase in plant density decreased the number of leaves per plant across the two seasons except for 45×30cm spacing under the September to December rain season. These results are in agreement with previous findings reported by Mohammad (1984) and Alege *et al.,* (2007).

4.1.1.4 Number of nodes per plant

There were significant differences (p = 0.05) in number of nodes per plant among the elite cowpea varieties (Table 7). Overall, cowpea number of node per plant were higher in the March to July rain season compared to the September to December rain season. Overall, there was a 6.5% decrease in cowpea number of nodes per plant during the September to December rain season.

Results presented in Table 7 indicate that during the March to July rain season, Ichirikukwa (local variety) significantly (p = 0.05) gave higher number of nodes per plant compared to other cowpea varieties. The mean number of nodes per plant during the March to July rain season ranged from 6.27 to 12.27 with MU-93 (Erect) and Ichirikukwa (local variety) producing the lowest and highest number of nodes per plant respectively. During the September to December rain season, among elite cowpea varieties, variety IT82D-889 significantly (p = 0.05) produced a lower number of nodes per plant compared to other cowpea varieties. The mean number of nodes per plant ranged from 5.60 to 8.33 with IT82D-889 and Ebelat (local variety) producing the lowest and highest number of nodes per plant respectively.

Spacing patterns did not show significant differences (p = 0.05) in number of nodes per plant during both rain seasons (Table 7). During the March to July rain season, spacing patterns of 60 × 30 cm and 45 × 30 cm produced the highest and lowest number of nodes per plant respectively. However, during the September to December rain season, cowpea number of nodes per plant increased with increase in plant density.

Table 7: Effect of spacing pattern on number of nodes per plant of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Spacing pattern (cm)				Spacing pattern (cm)			
	45 × 30	**60 × 30**	**75 × 30**	**Variety Mean**	**45 × 30**	**60 × 30**	**75 × 30**	**Variety Mean**
	Number of nodes per plant				Number of nodes per plant			
IT85F-2841	7.73	7.33	6.60	**7.22**^{a}	7.73	6.73	5.87	**6.78**^{ab}
MU-93 (Spreading)	6.67	8.00	7.73	**7.47**^{a}	6.13	7.00	7.47	**6.87**^{ab}
IT82D-889	7.13	7.33	6.93	**7.13**^{a}	6.27	5.60	6.87	**6.24**^{ac}
MU-93 (Erect)	7.67	6.27	8.20	**7.38**^{a}	7.40	7.60	6.40	**7.13**^{ab}
Ebelat	7.53	7.27	8.13	**7.64**^{a}	8.33	7.87	6.27	**7.49**^{bc}
Ichirikukwai	8.67	12.27	10.20	**10.38**^{b}	7.00	7.20	6.67	**6.96**^{ab}
Spacing Mean	**7.57**^{d}	**8.08**^{d}	**7.97**^{d}	**7.87**	**7.14**^{e}	**7.00**^{e}	**6.59**^{e}	**6.91**

2011A	2011B
CV % = 18.0	**CV % = 16.8**
Variety LSD: = 1.35	**Variety LSD: = 1.11**
s.e = 1.41	**s.e = 1.16**
Genotype x Spacing = NS	**Genotype x Spacing = NS**
	Seasonality mean change = 6.5%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

Table 8: Effect of spacing pattern on number of days to 50 percent flowering of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Spacing pattern (cm)				Spacing pattern (cm)			
Variety	**45 × 30**	**60 × 30**	**75 × 30**	**Variety Mean**	**45 × 30**	**60 × 30**	**75 × 30**	**Variety Mean**
	Days to 50% flowering				Days to 50% flowering			
IT85F-2841	49.66	49.33	48.33	**49.11^{bc}**	49.67	48.33	47.33	**48.44^{b}**
MU-93 (Spreading)	48.00	49.33	49.66	**49.00^{ab}**	49.33	49.00	47.67	**48.67^{bc}**
IT82D-889	48.66	48.33	49.66	**48.88^{ab}**	48.67	48.67	46.67	**48.00^{ab}**
MU-93 (Erect)	49.66	49.00	48.66	**49.11^{bc}**	49.00	50.00	50.00	**49.67^{c}**
Ebelat	48.66	48.00	48.66	**48.44^{a}**	48.33	47.33	45.67	**47.11^{a}**
Ichirikukwai	49.66	50.00	49.33	**49.66^{c}**	51.00	48.00	50.00	**49.67^{c}**
Spacing Mean	**49.05^{e}**	**49.00^{e}**	**49.05^{e}**	**49.03**	**49.33^{f}**	**48.56^{ef}**	**47.89^{e}**	**48.59**
				CV % = 1.3				**CV % = 2.6**
				Variety LSD: = 0.62				**Variety LSD: = 1.22**
				s.e = 0.65				**s.e = 1.28**
				Genotype x Spacing = NS				**Genotype x Spacing = NS**
								Seasonality mean change = 0.45%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

4.1.1.5 Days to 50 % flowering

Overall, cowpea varieties flowered earlier in the September to December rain season compared to the March to July rain season (Table 8). This was probably due to the relatively higher minimum temperatures (Figure 2) received during the September to December rain season compared to the March to July rain season, that might have induced the early flowering of the cowpea. Cowpea genotypes differed significantly ($p = 0.05$) in days taken to 50% flowering during both seasons (Table 8). Among elite cowpea varieties, IT82D-889 flowered significantly ($p = 0.05$) earlier than the rest of the elite cowpea varieties during both seasons. However, during both seasons local variety Ebelat flowered significantly earlier compared to the other varieties used in this study.

During the March to July rain season row spacing had no significant ($p = 0.05$) influence on days taken to 50% flowering (Table 8). However during the September to December rain season days to 50% flowering increased with increase in plant density with 75×30cm spacing giving the earliest days taken to 50% flowering. The interaction effects among cowpea genotypes and row spacings were significantly different with respect to days to 50% flowering. These results are in agreement with previous findings reported by Shivananda (2005).

4.1.1.6 Days to physiological maturity

Overall, cowpea varieties reached physiological maturity earlier in the March to July rain season compared to the September to December rain season (Table 9). This could still be attributed to the changes in the temperature regimes received during both seasons. This further shows that the high temperatures received in the March to July rain season (Figure 2) might have triggered faster cowpea growth reaching physiological maturity earlier than in the September to December rain season.

Cowpea genotypes differed significantly (p = 0.05) in days taken to physiological maturity (Table 9). Elite cowpea varieties IT82D-889 and IT85F-2841 were significantly (p = 0.05) earlier in reaching physiological maturity than the rest of the elite varieties during the March to July rain season. There were no significant differences (p = 0.05) among cowpea elite varieties as far as days to physiological maturity during the September to December rain season were concerned.

Spacing patterns 45×30cm, 60×30cm and 75×30cm, were not significantly different (p = 0.05) in terms of days to physiological maturity during both seasons. Similar results were obtained by Hamad (2004) and Elawad (2000), who reported that plant density had no significant effect on days taken to reach physiological maturity when cowpea was sown on low or high plant densities. The interaction effects among genotypes and row spacings were not significantly different (p = 0.05) with respect to days to physiological maturity.

Table 9: Effect of spacing pattern on number of days to physiological maturity of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Spacing pattern (cm)				Spacing pattern (cm)			
	45 × 30	**60 × 30**	**75 × 30**	**Variety Mean**	**45 × 30**	**60 × 30**	**75 × 30**	**Variety Mean**
	Days to physiological maturity				Days to physiological maturity			
IT85F-2841	76.00	76.33	75.00	**75.78**^{ab}	76.33	76.67	75.33	**76.11**^{a}
MU-93 (Spreading)	77.00	77.00	75.67	**76.56**^{b}	76.33	73.67	74.33	**74.78**^{a}
IT82D-889	73.67	74.33	75.00	**74.33**^{a}	75.00	75.67	75.00	**75.22**^{a}
MU-93 (Erect)	76.33	75.67	75.67	**75.89**^{b}	74.67	75.00	75.67	**75.11**^{a}
Ebelat	74.33	75.00	74.33	**74.56**^{a}	77.67	77.33	78.33	**77.78**^{b}
Ichirikukwai	75.67	76.33	75.67	**75.89**^{b}	77.67	77.33	77.33	**77.44**^{b}
Spacing Mean	**75.50**^{d}	**75.78**^{d}	**75.22**^{d}	**75.50**	**76.28**^{d}	**75.94**^{d}	**76.00**^{d}	**76.07**
				CV % = 2.1				**CV % = 1.7**
				Variety LSD: = 1.51				**Variety LSD: = 1.21**
				s.e = 1.58				**s.e = 1.26**
				Genotype x Spacing = NS				**Genotype x Spacing = NS**
								Seasonality mean change = 0.37%

Means within the same row or column followed by same letter are not significantly different from each other at $P \leq 0.05$ according to the LSD test

4.1.2 Effect of plant density (planting pattern) on yield and yield components of selected elite cowpea varieties in Eastern Uganda.

4.1.2.1 Number of pods per plant

Overall, cowpea varieties produced a higher number of pods per plant in the March to July rain season compared to the September to December rain season. The study also indicated a 9.8% decrease in number of pods per plant in the September to December rain season (Figure 3 and 4). This implies that although the latter season cowpea crop developed the highest vegetative attributes like plant height because of higher rainfall amounts, this was counter productive in terms of yield component responses to the different seasons. Excessive vegetative growth could have diverted assimilates to vegetative growth at the expense of proper partitioning to reproductive yield components like number of pods.

Cowpea genotypes differed significantly (p = 0.05) in number of pods per plant during the March to July rain season, Overall local cowpea variety Ichirikukwai produced significantly (p = 0.05) higher number of pods per plant (Figure 3). Among elite cowpea varieties MU-93 (Spreading) and IT82D-889 produced the highest and lowest number of pods respectively during the March to July rain season. During the September to December rain season, local cowpea variety Ebelat and elite cowpea variety MU-93 (Spreading) produced the highest and lowest number of pods per plant respectively.

Spacing patterns 45×30cm, 60×30cm and 75×30cm, were not significantly different (p = 0.05) in number of pods produced per plant during the March to July rain season (Figure 3). Spacing patterns 60×30cm and 45×30cm produced the lowest and highest number of pods per plant during the March

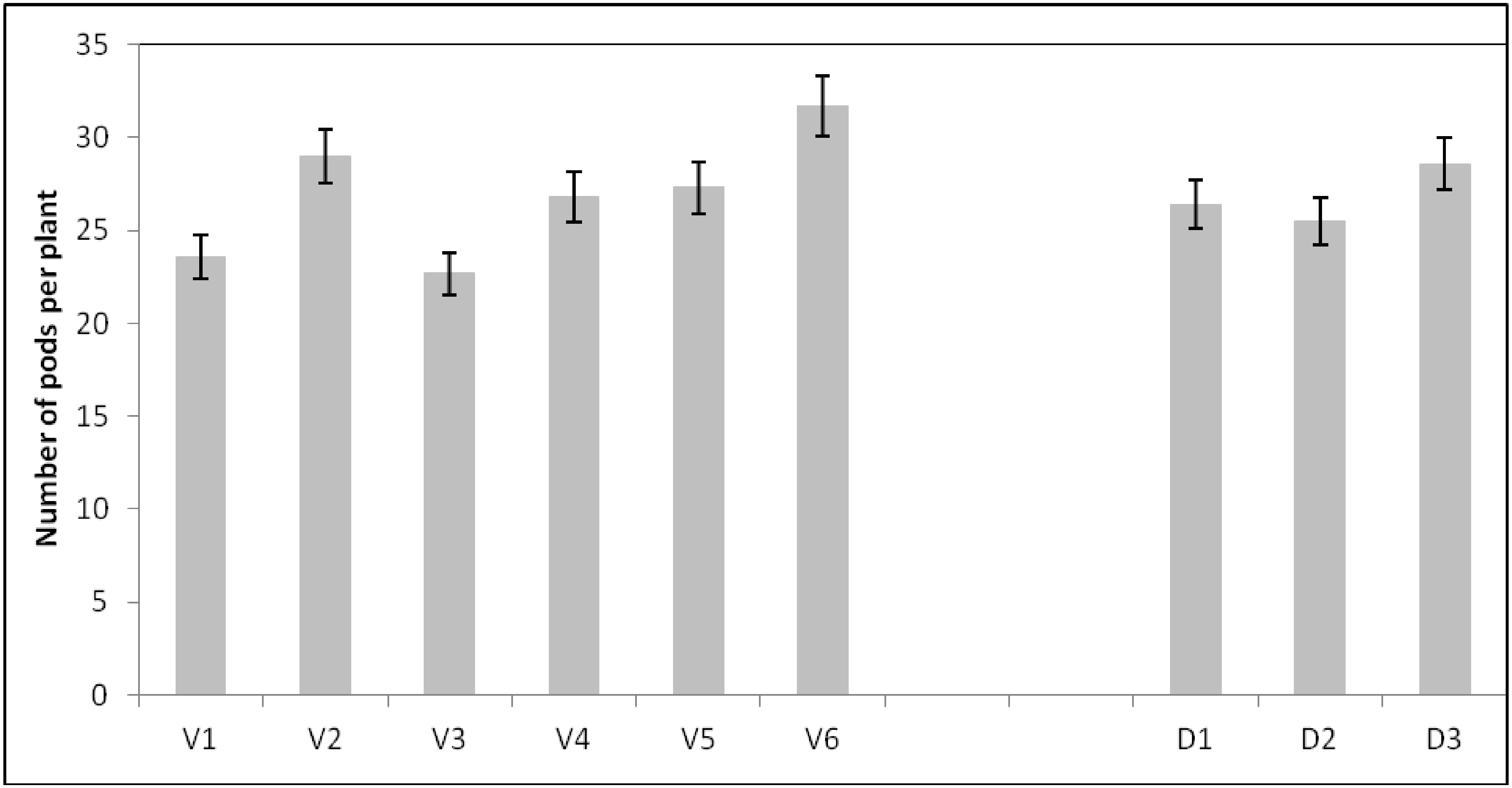

Figure 3: Number of pods per plant of cowpea varieties as influenced by row spacings during March to July 2011 rain season.

Cowpea varieties V1 = IT85F-2841, V2 = MU-93 (Spreading), V3 = IT82D-889, V4 = MU-93 (Erect), V5 = Ebelat and V6 = Ichirikukwai. Row spacings D1 = 75×30cm, D2 = 60×30cm and D3 = 45×30cm row spacing.

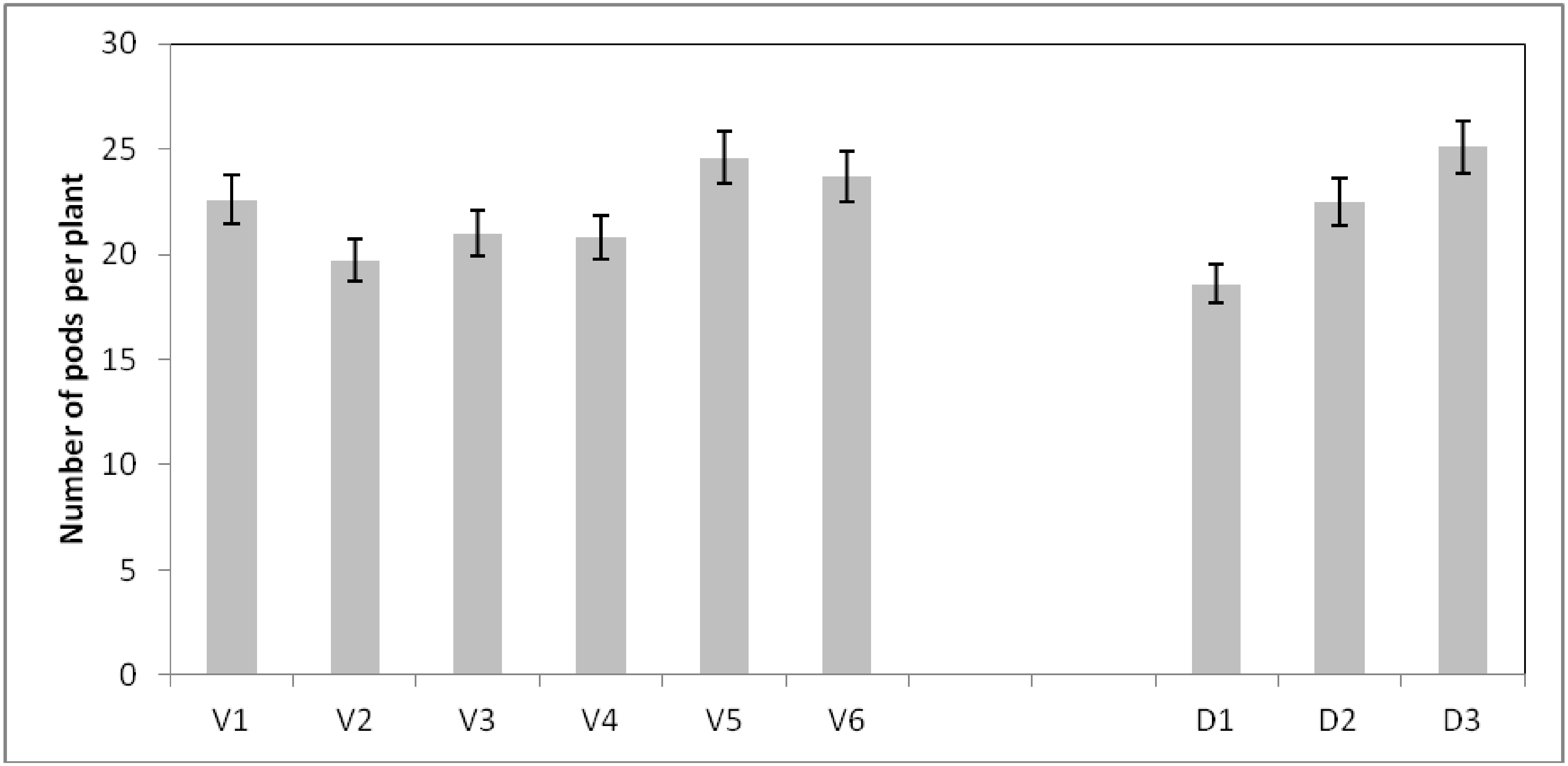

Figure 4: Number of pods per plant of cowpea varieties as influenced by row spacings during September to December 2011 rain season.

Cowpea varieties V1 = IT85F-2841, V2 = MU-93 (Spreading), V3 = IT82D-889, V4 = MU-93 (Erect), V5 = Ebelat and V6 = Ichirikukwai. Row spacings D1 = 75×30cm, D2 = 60×30cm and D3 = 45×30cm row spacing.

to July rain season respectively. However, during the September to December rain season 45×30cm produced significantly (p = 0.05) fewer numbers of pods per plant compared to 60×30cm and 75×30cm row spacing (Figure 4). During the September to December rain season, number of pods per plant increased with an increase in plant density (Figure 4). This is contrary, to the findings of Webber *et al* (1966) and Hamad (2004). They found that plants produced at highest densities set fewer numbers of pods than those at the lowest densities.

4.1.2.2 Pod length

Overall, cowpea varieties produced longer pods in the March to July rain season compared to the September to December rain season (Figure 5). Genotypes differed significantly (P = 0.05) in pod length during both seasons. Among elite cowpea varieties IT82D-889 produced significantly (P = 0.05) the longest pods across the two seasons (Figure 5). The mean pod length ranged from 12.35 cm to 17.74 cm with IT85F-2841 and IT82D-889 having the shortest and longest pod length among elite varieties during the March to July rain season. The mean pod length ranged from 12.87 cm to 16.21 cm with IT85F-2841 and IT82D-889 having the shortest and longest pod length among elite varieties during the September to December rain season.

Row spacing of 75×30cm produced significantly (P = 0.05) the shortest pods during the March to July rain season (Figure 5). There was no significant difference (P = 0.05) in pod length under different row spacings during the September to December rain season (Figure 6). The interaction effects among genotypes and row spacings were not significantly different with respect to pod length.

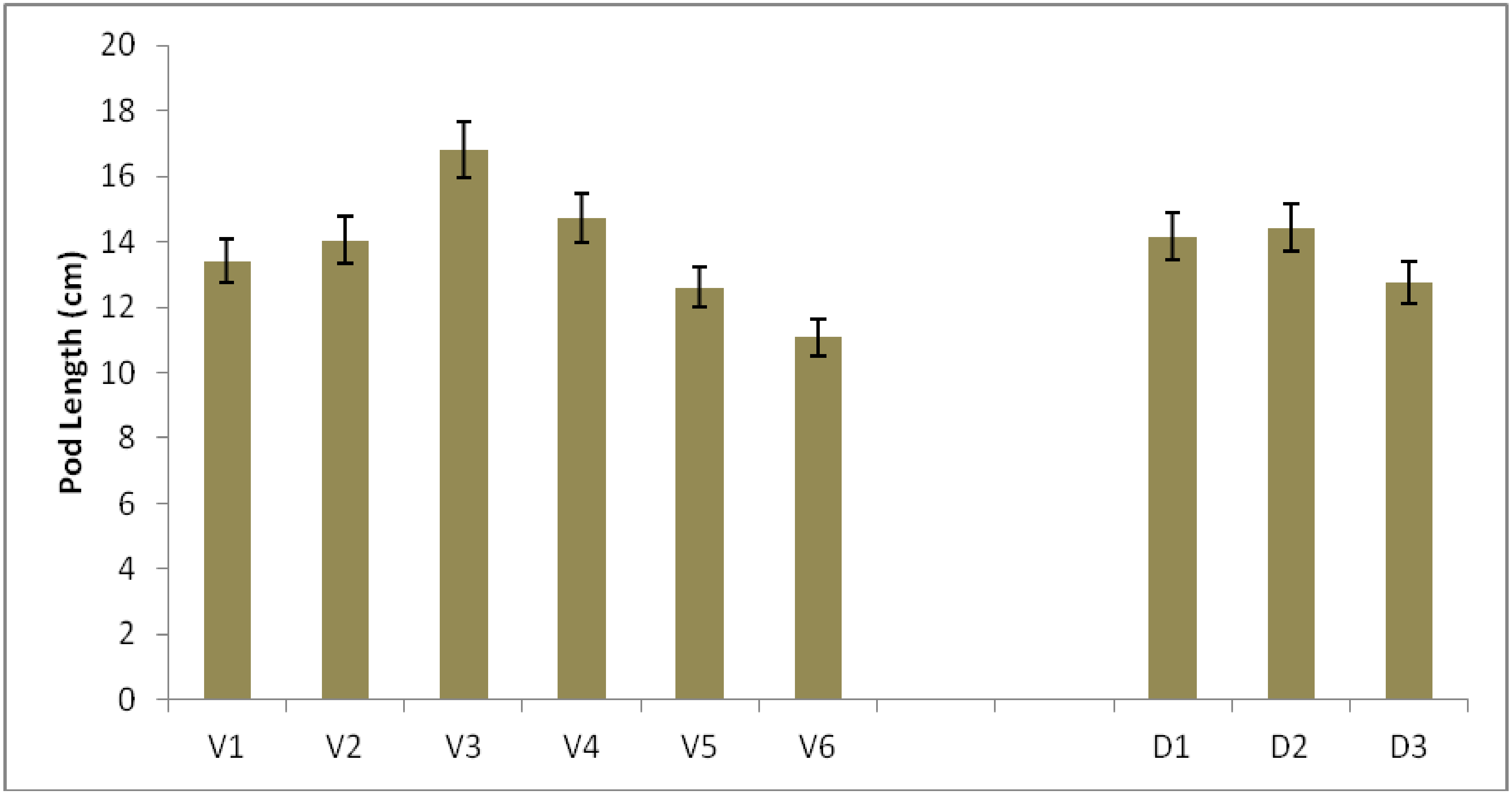

Figure 5: **Pod length (cm) of cowpea varieties as influenced by row spacings during March to July 2011 rain season.**

Cowpea varieties V1 = IT85F-2841, V2 = MU-93 (Spreading), V3 = IT82D-889, V4 = MU-93 (Erect), V5 = Ebelat and V6 = Ichirikukwai. Row spacings D1 = 75×30cm, D2 = 60×30cm and D3 = 45×30cm row spacing.

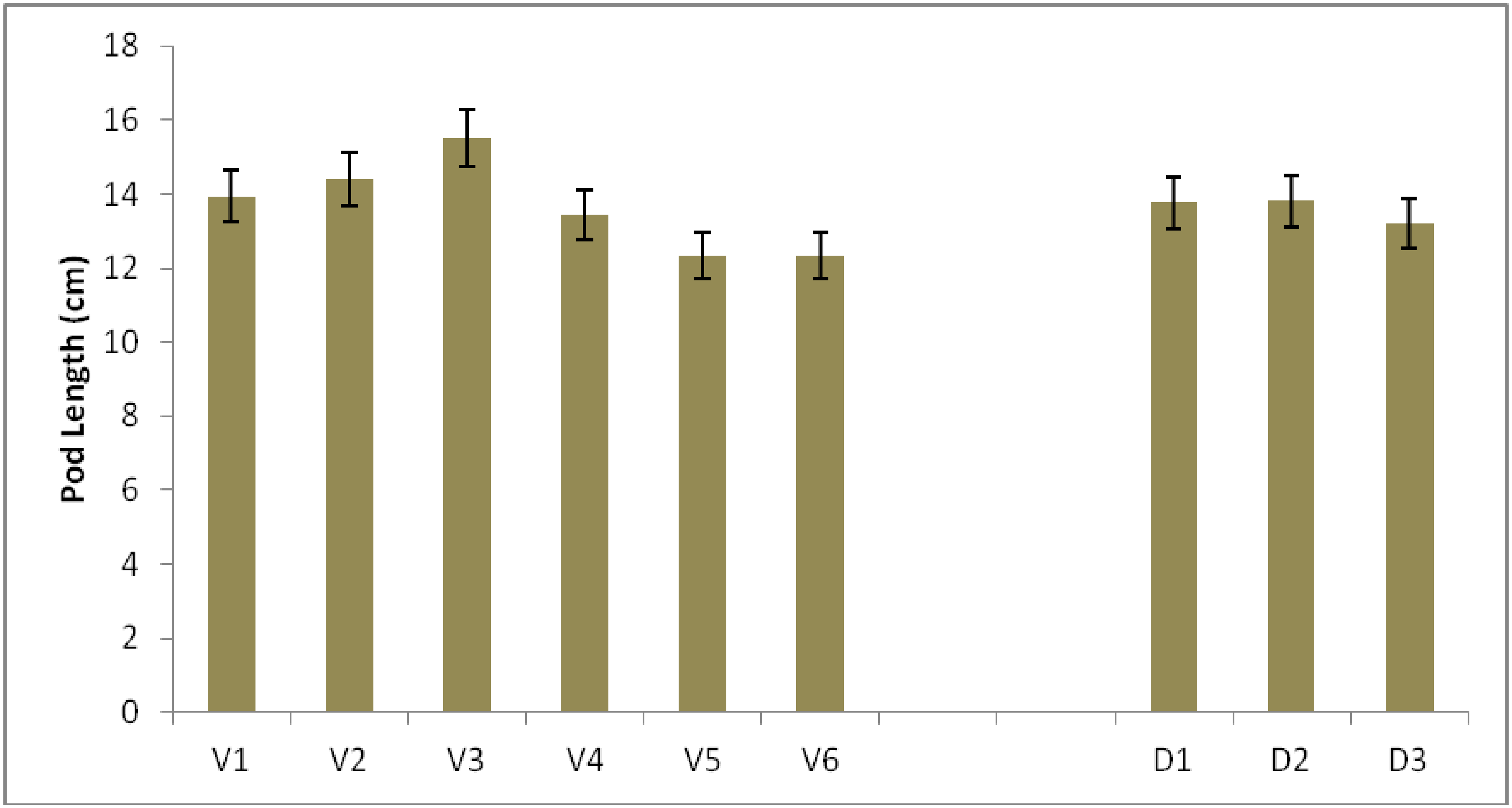

Figure 6: Pod length (cm) of cowpea varieties as influenced by row spacings during September to December 2011 rain season.

Cowpea varieties V1 = IT85F-2841, V2 = MU-93 (Spreading), V3 = IT82D-889, V4 = MU-93 (Erect), V5 = Ebelat and V6 = Ichirikukwai. Row spacings D1 = 75×30cm, D2 = 60×30cm and D3 = 45×30cm row spacing.

4.1.2.2 Number of seeds per pod

Overall, cowpea varieties produced a higher number of seeds per pod in the March to July rain season compared to the September to December rain season. The study also indicated a 4.77% decrease in number of seeds per pod in the September to December rain season (Figure 8).

There were no significant differences (P = 0.05) in number of seeds per pod except for variety IT85F-2841 during the September to December rain season (Figure 8). The mean number of seeds per pod ranged from 14.51 to 12.18 with IT82D-889 and Ichirikukwai having the highest and lowest number of seeds per pod during the March to July rain season (Figure 7). The mean number of seeds per pod ranged from 13.00 to 11.78 with IT85F-2841 and MU-93 (Erect) having the highest and lowest number of seeds per pod during September to December rain seasons (Figure 8).

Spacing patterns 45×30cm, 60×30cm and 75×30cm, were not significantly different (p = 0.05) in number of seeds produced per pod in both seasons. These findings are in accord with the previous results reported by Salih (1992), Mohammed (2002) and Ahmed *et al*., (2010). They all found that plant population had little or no effect on the number of seeds per pod.

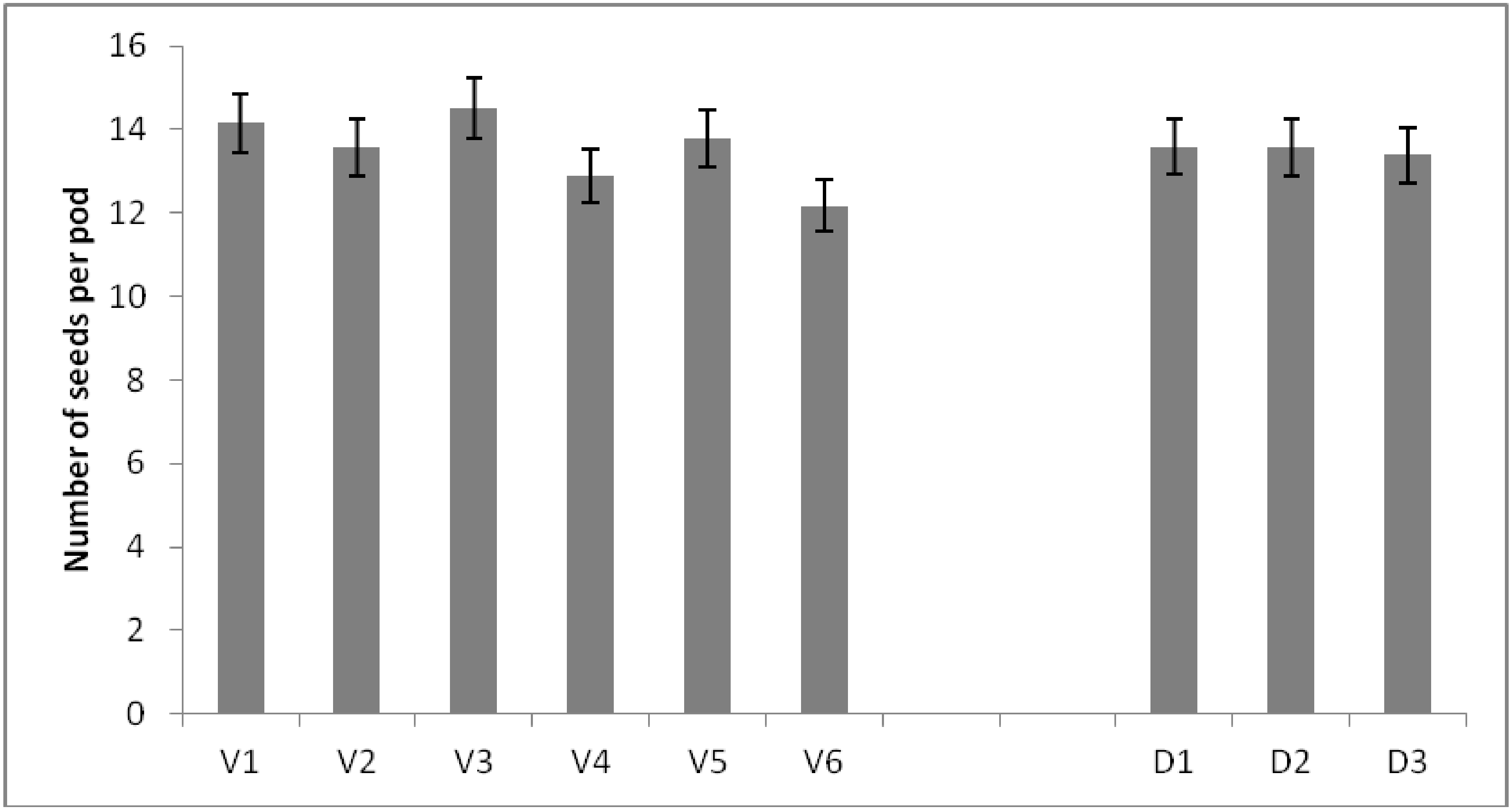

Figure 7: **Number of seeds per pod of cowpea varieties as influenced by row spacings during March to July 2011 rain season.**

Cowpea varieties V1 = IT85F-2841, V2 = MU-93 (Spreading), V3 = IT82D-889, V4 = MU-93 (Erect), V5 = Ebelat and V6 = Ichirikukwai. Row spacings D1 = 75×30cm, D2 = 60×30cm and D3 = 45×30cm row spacing.

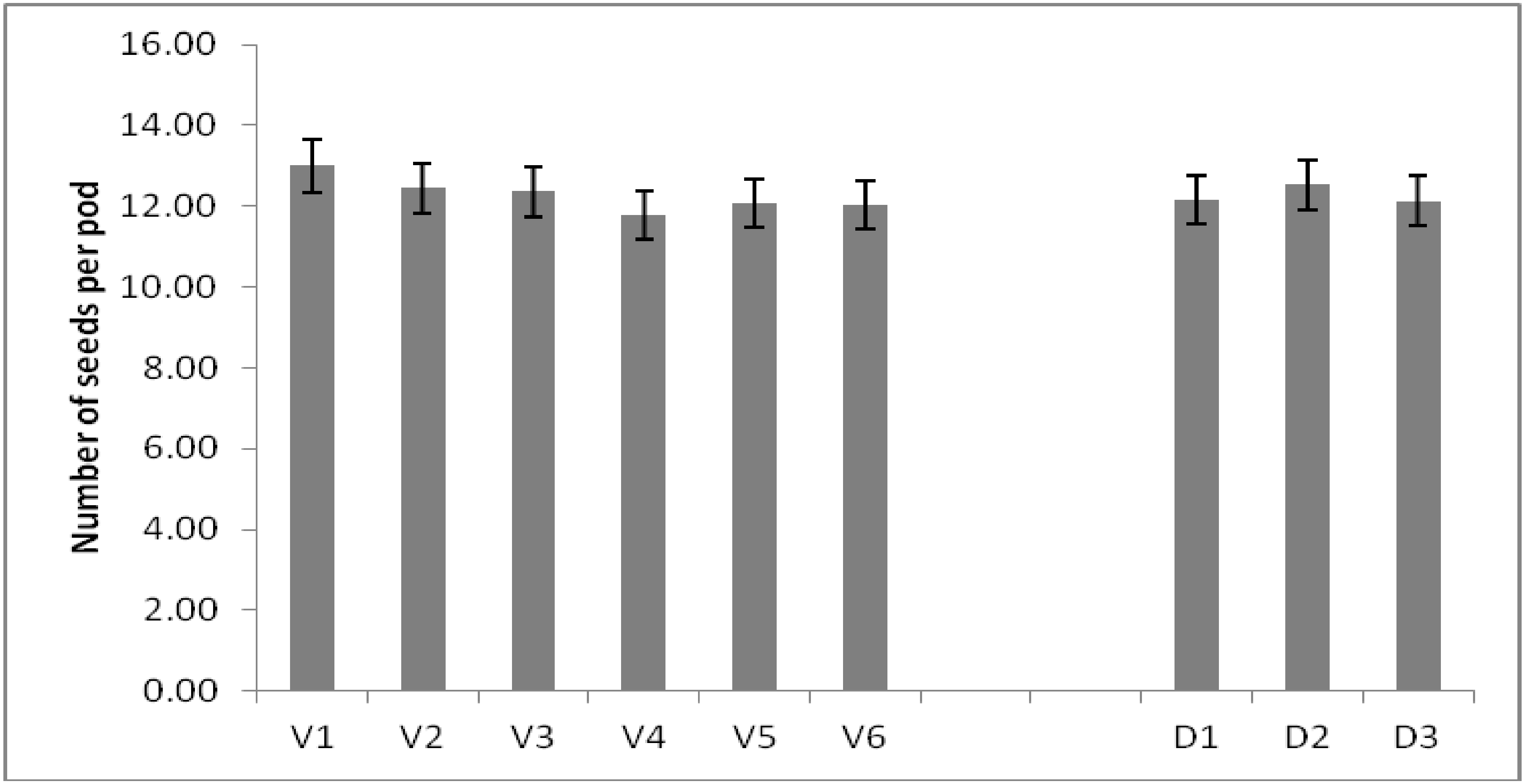

Figure 8: **Number of seeds per pod of cowpea varieties as influenced by row spacings during September to December 2011 rain season.**

Cowpea varieties V1 = IT85F-2841, V2 = MU-93 (Spreading), V3 = IT82D-889, V4 = MU-93 (Erect), V5 = Ebelat and V6 = Ichirikukwai. Row spacings D1 = 75×30cm, D2 = 60×30cm and D3 = 45×30cm row spacing

4.1.2.3 100 Seed weight

Overall, cowpea 100 seed weight was higher in the March to July 2011 rain season compared to the September to December 2011 rain season (Table 10). The reduction in 100 seed weight with increased rainfall for all the varieties could be possibly because of the poor translocation and partitioning of photosynthates from source to sink / seeds Ahmed *et al*., (2010), regardless of the increase in rainfall amounts received in 2011B season. Genotypes differed significantly (p = 0.05) in 100 seed weight during both rain seasons (Table 10). Similar results were obtained by Shivananda (2005), who found significant (p = 0.05) differences among cowpea genotypes in terms of 100 seed weight. The mean 100 seed weight ranged from 11.23 gm to 17.23 gm with Ichirikukwa (local variety) and MU-93 (Erect) having the lightest and heaviest cowpea seeds respectively during the March to July 2011 rain season. The mean 100 seed weight ranged from 11.67 gm to 17.00 gm with Ichirikukwa (local variety) and MU-93 (Spreading) having the lightest and heaviest cowpea seeds respectively during the September to December 2011 rain season. Generally across the two seasons, the elite varieties MU-93 (Spreading) had the heaviest seed weight. This may be due to better translocation and partitioning of photosynthates from source to sink / seeds Ahmed *et al*., (2010).

Spacing patterns had no significant (p = 0.05) effect on mean 100 seed weight in both seasons. This is in agreement with findings of Taha (1988) and Mohammed (2002). They found that plant population had no effect on 100 seed weight. The interaction effect between genotype and row spacing were not significant (p = 0.05) during both rain seasons.

Table 10: Effect of spacing pattern on 100 seed weight of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Spacing pattern (cm)				Spacing pattern (cm)			
Variety	**45 × 30**	**60 × 30**	**75 × 30**	**Variety mean**	**45 × 30**	**60 × 30**	**75 × 30**	**Variety mean**
	100 Seed weight (gm)				100 Seed weight (gm)			
IT85F-2841	15.93	14.67	16.50	**15.70**^{b}	16.00	15.00	15.33	**15.44**^{bc}
MU-93 (Spreading)	16.17	16.53	16.17	**16.29**^{b}	16.00	15.33	17.00	**16.11**^{c}
IT82D-889	15.53	16.37	14.90	**15.60**^{b}	16.00	15.00	15.00	**15.33**^{bc}
MU-93 (Erect)	17.23	16.03	16.47	**16.58**^{b}	15.67	16.67	15.33	**15.89**^{bc}
Ebelat	15.17	15.63	16.27	**15.69**^{b}	14.67	14.00	15.00	**14.56**^{b}
Ichirikukwai	12.17	15.40	11.23	**12.93**^{a}	11.67	12.67	12.67	**12.33**^{a}
Spacing Mean	**15.37**^{d}	**15.77**^{d}	**15.26**^{d}	**15.46**	**15.00**^{e}	**14.78**^{e}	**15.06**^{e}	**14.94**
				CV % = 10.4				**CV % = 7.1**
				Variety LSD: = 1.53				**Variety LSD: = 1.01**
				s.e = 1.60				**s.e = 1.05**
				Genotype x Spacing = NS				**Genotype x Spacing = NS**
								Seasonality mean change = 1.71%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

4.1.2.4 Grain yield

Overall, cowpea grain yield was higher in the September to December 2011 rain season compared to the March to July 2011 rain season (Table 11). The seed yield in the September to December 2011 rain season increased by 21.3% compared to the March to July 2011 rain season. This could be attributed to the high rainfall amount received in the September to December rain season compared to the march to July rain season.

Grain yield differed significantly (p = 0.05) between genotypes (Table 11). Significantly (p = 0.05) higher grain yields were recorded in variety 1T82D-889 in both seasons. The mean grain yield ranged from 397 kgha^{-1} to 1349 kgha^{-1} with MU-93 (Spreading) and 1T82D-889 having the lowest and highest grain yield respectively during the March to July 2011 rain season. The mean grain yield ranged from 619 kgha^{-1} to 1586 kgha^{-1} with Ebelat (Local variety) and 1T82D-889 having the lowest and highest grain yield respectively during the September to December 2011 rain season.

Spacing patterns had no significant (p = 0.05) influence on grain yield during both seasons. However, 60×30cm spacing gave consistently higher yield except in the September to December 2011 rain season. Generally increasing plant population increased seed yield per unit area. This may be attributed to highest number of plants per unit area (Ahmed *et al.*, 2010). Similar results were obtained by Herbert and Baggerman (1982) who found that the highest seed yield was obtained with the higher plant density. Among the local varieties Ichirikukwai (local variety) gave the highest seed yield per unit area compared to Ebelat (local variety) during the two seasons.

Table 11: Effect of spacing pattern on grain yield of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Spacing pattern (cm)				Spacing pattern (cm)			
Variety	**45 × 30**	**60 × 30**	**75 × 30**	**Variety mean**	**45 × 30**	**60 × 30**	**75 × 30**	**Variety mean**
	Grain yield (kgha^{-1})				Grain yield (kgha^{-1})			
IT85F-2841	556	706	635	**632**^{a}	1000	1000	722	**907**^{a}
MU-93 (Spreading)	556	444	397	**466**^{a}	722	869	984	**858**^{a}
IT82D-889	643	1349	865	**952**^{b}	1042	861	1586	**1163**^{b}
MU-93 (Erect)	635	405	476	**505**^{a}	958	1097	917	**991**^{a}
Ebelat	619	484	476	**526**^{a}	619	714	718	**684**^{a}
Ichirikukwai	460	556	540	**519**^{a}	931	1028	875	**944**^{a}
Spacing Mean	**578**^{d}	**657**^{d}	**565**^{d}	**600**	**876**^{d}	**928**^{d}	**969**^{d}	**924**
				CV % = 36.3				**CV % = 72.2**
				Variety LSD: = 208.5				**Variety LSD: = 742.8**
				s.e = 218.1				**s.e = 392.4**
				Genotype x Spacing = NS				**Genotype x Spacing = NS**
								Seasonality mean change = 21.3%

Means within the same row or column followed by same letter are not significantly different from each other at $P \leq 0.05$ according to the LSD test

4.1.3 Correlation analysis between growth and yield parameters of selected elite cowpea varieties

The correlation analysis carried out on all parameters against each other, using the Pearson Product Moment Correlation for linear correlations of continuous data, indicated the whole range from small, medium, to large correlation as interpreted by (Cohen, 1988) and appears in the correlation matrix in Table 12.

Plant height was moderately and positively correlated to grain yield (r = 0.2552), weakly and positively correlated to pods per plant (r = 0.0811) and pod length (r = 0.0297). This implies that plant height contributed minimally to all those reproductive parameters mentioned. However, plant height was moderately and negatively correlated to number of nodes per plant (r = -0.3310), number of leaves (r = -0.2214) and number of branches (r = -0.2507) (Table 12). This implies that a greater plant height could have lowered the number of nodes, branches and leaves per plant.

Branch number was strongly and positively correlated to nodes per plant (r = 0.8483) with a coefficient of determination (r^2 = 0.7196). The number of branches per plant was also moderately and positively correlated to number of leaves (r = 0.3732). This shows that the greater these parameters, the higher the number of branches. However, the number of branches was moderately and negatively correlated to pod length (r = -0.3136), and weakly and negatively correlated to grain yield (r = -0.1713). This implies that a greater number of branches lowered the pod length and grain yield.

Table 12: Correlation matrix of growth and yield parameters of selected elite cowpea varieties during 2011A and 2011B seasons

	Days to50% flowering	Plant height	Branch number	Leaves number	Nodes/ plant	Daysto maturity	Pods/ plant	Pod Length	Seeds/ pod	100-Seed weight	Grain yield
Days to 50% flowering	1.000										
Plant height	-0.3803	1.000									
Branch number	0.0077	-0.2507	1.000								
Leaves number	0.1045	-0.2214	0.3732	1.000							
Nodes per plant	0.1375	-0.3310	0.8483	0.5244	1.000						
Days to maturity	-0.0389	0.1228	-0.0001	0.0288	0.0372	1.000					
Pods per plant	-0.0487	0.0811	0.0268	0.1316	0.1407	0.1256	1.000				
Pod length	-0.0301	0.0297	-0.3136	-0.1917	-0.2772	-0.1916	-0.1268	1.000			
Seeds per pod	-0.0465	-0.1316	0.0324	0.0601	0.0296	-0.1451	-0.0266	0.3206	1.000		
100 Seed weight	-0.1615	0.1231	0.0090	0.0339	-0.0178	-0.1456	-0.0766	0.3205	0.1290	1.000	
Grain yield	-0.3006	0.2552	-0.1713	-0.2815	-0.1843	0.0666	-0.1110	0.1178	-0.0157	0.0792	1.000

Correlation	**Negative**	**Positive**
Small	-0.3 to -0.1	0.1 to 0.3
Medium	-0.5 to -0.3	0.3 to 0.5
Large	-1.0 to -0.5	0.5 to 1.0

The number of leaves was strongly and positively correlated to the number of nodes per plant (r = 0.5244). This shows that the greater the number of nodes per plant, the higher the number of leaves per plant. Leaf number was weakly and positively correlated to pods per plant (r = 0.1316) and seeds per pod (r = 0.0601). This shows that the number of leaves had little contribution to the number of pods and seeds per plant. Leaf number was weakly and negatively correlated to grain yield (r = -0.2815) implying that increased measure of this trait affect yield negatively. Leaf number was weakly and negatively correlated to grain yield because for the cowpea varieties used in this study the source (leaves) had little impact on the sink (grain) thus these cowpea varieties are either good for leaf or yield trait. Correlation coefficient between days to 50% flowering (n-2 = 52) was -0.3006 and significant (P < 0.05), indicating that 9.0% of the differences in seed yield could be attributed to reduction in the number of days to 50% flowering.

Pods per plant was weakly and negatively correlated to pod length (r = -0.1268), seeds per pod (r = -0.0266), 100-seed weight (r = -0.0766) and grain yield (r = -0.1110). This shows that increased measures of pods per plant still affects yield negatively. Pod length was moderately and positively correlated to seeds per pod (r = 0.3206) and 100-seed weight (r = 0.3205). It was also weakly and positively correlated to grain yield (r = 0.1178). This implies that increased measures of pod length affected seeds per pod, 100 seed weight and grain yield positively. This is in line with findings of Asio (2004), who reported that pod length significantly contributed to yield and were considered during selection of high yielding cowpea genotypes. Seeds per pod was weakly and positively correlated to 100-seed weight (r = 0.1290). This shows that seeds per pod minimally influenced 100-seed weight. However, seeds per pod weakly and negatively influenced grain yield (r = -0.0157) implying increased measure of this parameters still affected yield negatively.

4.2 Experiment 2: Effect of intercropping on the performance of elite cowpea varieties in Eastern Uganda.

4.2.1 Effects of intercropping on vegetative growth parameters of cowpea and maize.

Intercropping affects the vegetative growth of both component crops compared to sole cropping, and therefore, is applied to optimize the use of spatial, temporal and physical resources both above and below ground with maximum positive and minimum negative interactions (Jose *et al*., 2000; Silwana and Lucas, 2002). Cowpea and maize are often planted together under intercropping system and develop root systems that at the same time explore the same soil for resources (Jensen *et al*., 2003). Inter-specific competition during intercropping results in the harmful effect on the crop (Connolly and Rahim, 2001) and of which, most interactions occur in the rhizosphere of crop mixtures (Zhang *et al*., 2003, 2004). Differences in phenological and morphological characteristics of crop species in mixtures may lead to an increased capture of growth limiting resources (Lucas, 2002) leading to greater potential to acquire higher total yields than when crops are grown separately on the same area of land (Dapaah *et al*., 2003). Plant growth and biomass partitioning results from high Photosynthetic Active Radiation (PAR) interception, thus determining the rate of dry matter accumulation in crops (Montieth, 1977). Solar radiation is one of the major sources determining growth and yield of component crops when planted simultaneously and together, especially when other resources are limiting plant growth (Watiki *et al*., 1993). Under intercropping, when water is a limiting factor, crops compete for water and thus result in inhibited growth and low yield due to insufficient nutrient supply.

The aim of this study was to investigate the effect of intercropping different cowpea varieties with maize on cowpea and maize growth and yield parameters. Maize was chosen as the component crop because it is one of the major cereal crops grown in Eastern Uganda in a cowpea intercropping system (Bisikwa *et al*., 2013).

4.2.2 Effect of cropping system on cowpea growth parameters.

4.2.2.1 Cowpea plant height

Overall, the September to December 2011 rain season produced plants with a higher plant height than the March to July 2011 rain season (Table 13). There was a 4.5% increase in plant height in the September to December 2011 rain season. This could still be attributed to the more intensive and prolonged rainfall of the September to December 2011 rain season (Figure 1).

Cowpea varieties differed significantly (p = 0.05) in plant height during both seasons (Table 13). During the March to July 2011 rain season, IT82D-889 was significantly (p = 0.05) taller than IT85F-2841 and MU-93 (Spreading) under both intercrop and sole cropping systems. There was no significant difference (p = 0.05) in plant heights between IT82D-889 and MU-93 (Erect) during the March to July 2011 rain season. Plant heights ranged from 39.44 cm to 45.5 cm with IT85F-2841 and IT82D-889 being the shortest and tallest respectively during the March to July 2011 rain season. During the September to December 2011 rain season, IT82D-889 was significantly (p = 0.05) taller than IT85F-2841, MU-93 (Spreading) and MU-93 (Erect) under both intercrop and sole cropping systems. Plant heights during the September to December 2011 rain season ranged from 39.70 cm to 52.65 cm with MU-93 (Spreading) and IT82D-889 being the shortest and tallest respectively.

According to the intercrop pattern, there was a significant difference (p = 0.05) in plant height between the 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercrop planting patterns during the September to December 2011 rain season. The results also indicate that there was

Table 13: Effect of cropping system on plant height of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	Plant height (cm)				Plant height (cm)			
IT85F-2841	39.44	41.10	42.88	**41.14^{a}**	45.97	43.33	42.33	**43.88^{a}**
MU-93 (Spreading)	39.63	40.68	39.83	**40.04^{a}**	43.13	45.33	39.70	**42.72^{a}**
IT82D-889	43.92	43.85	45.45	**44.41^{b}**	52.65	51.99	50.70	**51.78^{b}**
MU-93 (Erect)	42.71	42.02	40.70	**41.81^{ab}**	44.37	45.47	44.20	**44.68^{a}**
Cropping Mean	**41.42^{d}**	**41.91^{d}**	**42.21^{d}**	**41.85**	**46.53^{e}**	**46.53^{e}**	**44.23^{d}**	**45.75**
				CV % = 6.9				**CV % = 4.6**
				Variety LSD: = 2.79				**Variety LSD: = 2.06**
								Seasonality mean change = 4.5%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

no significant difference (p = 0.05) in plant heights under both intercropping and sole cropping systems during the March to July 2011 rain season. Compared to sole cowpea crop treatment, intercrop plant heights were much higher in all cases than the sole crop treatment except in the September to December 2011 rain season. This could probably be attributed to the shading effect of the intercrop system which might have induced greater stem elongation in the intercropped plants.

4.2.2.2 Cowpea branch number per plant

Results presented in Table 14 indicate that, overall, the September to December 2011 rain season produced plants with a higher number of branches than the March to July 2011 rain season. This could still be attributed to the more intensive and prolonged rainfall of the September to December 2011 rain season (Figure 1).

Cowpea varieties differed significantly (p = 0.05) in cowpea number of branches during both seasons (Table 14). During the March to July 2011 rain season, IT82D-889 produced significantly (p = 0.05) fewer number of branches than IT85F-2841, MU-93 (Spreading) and MU-93 (Erect) cowpea varieties which were not significantly (p = 0.05) different from each other, in this intercrop treatment. The number of branches per plant ranged from 3.33 to 4.80 where by IT82D-889 produced the lowest number of branches per plant and MU-93 (Erect) had the highest number of branches. During the September to December 2011 rain season, IT85F-2841 produced significantly (p = 0.05) higher number of branches than IT82D-889, MU-93 (Spreading) and MU-93 (Erect) elite cowpea varieties while IT82D-889 produced significantly (p = 0.05) smaller number of branches than other cowpea varieties. The number of branches per plant ranged from 2.93 to 5.13 where by IT82D-889 produced the least number of branches per plant and IT85F-2841 had the highest number of branches.

Table 14: Effect of cropping system on branch number per plant of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	Branches per plant				Branches per plant			
IT85F-2841	4.20	4.46	3.80	**4.15^{b}**	4.93	5.13	5.13	**5.06^{c}**
MU-93 (Spreading)	4.66	4.00	4.00	**4.22^{b}**	4.40	4.73	4.66	**4.60^{b}**
IT82D-889	3.80	3.33	3.46	**3.53^{a}**	2.93	3.00	2.93	**2.95^{a}**
MU-93 (Erect)	4.80	3.86	3.86	**4.17^{b}**	4.86	4.13	4.06	**4.35^{b}**
Cropping Mean	**4.36^{e}**	**3.91^{d}**	**3.78^{de}**	**4.02**	**4.28^{e}**	**4.25^{e}**	**4.20^{e}**	**4.24**
				CV % = 13.1				**CV % = 9.4**
				Variety LSD: = 0.51				**Variety LSD: = 0.38**
								Seasonality mean change = 2.7%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

Generally, across the two seasons sole crop systems produced the highest number of branches than intercropping (Table 14). This implies that intercropping reduced branching of elite cowpea varieties in both rain seasons. The results also indicate that there was a significant ($p = 0.05$) difference in number of branches produced under 1 row Maize : 2 rows Cowpea intercropping pattern and sole cropping system.

As regards to the intercrop pattern, there was no significant difference ($p = 0.05$) in number of branches produced under 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns during both March to July 2011 rain season and September to December 2011 rain season respectively (Table 14).

4.2.2.3 Cowpea number of leaves per plant

Comparing the two seasons, there were more leaves produced per plant in the September to December 2011 rain season than the March to July 2011 rain season (Table 15). The same reason of more rain fall amounts in the September to December 2011 rain season could still be advanced. This is believed to have enhanced more vegetative growth.

Cowpea varieties differed significantly ($p = 0.05$) in number of leaves per plant during both seasons (Table 15). Results presented in Table 15 indicate that during the March to July 2011 rain season, IT85F-2841 produced significantly ($p = 0.05$) higher number of leaves and MU-93 (Erect) produced significantly ($p = 0.05$) lower number of leaves. MU-93 (Spreading) and IT82D-889 showed no ($p = 0.05$) significant difference from each other in terms of number of leaves, in this intercrop treatment. The mean number of leaves per plant ranged from 49.13 to 55.20 where by MU-93 (Erect) produced the lowest number of leaves per plant and IT85F-2841 had the highest number of leaves for the

Table 15: Effect of cropping system on number of leaves per plant of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	Leaves per plant				Leaves per plant			
IT85F-2841	54.07	55.20	54.33	**54.53**^{b}	59.53	59.60	55.60	**58.24**^{b}
MU-93 (Spreading)	53.80	53.73	51.87	**53.13**^{ab}	56.13	60.33	64.40	**60.29**^{b}
IT82D-889	53.47	51.33	53.27	**52.69**^{ab}	50.47	42.93	44.60	**46.00**^{a}
MU-93 (Erect)	51.47	49.60	49.13	**50.07**^{a}	63.80	64.47	61.40	**63.22**^{b}
Cropping Mean	**53.20**^{d}	**52.47**^{d}	**52.15**^{d}	**52.61**	**57.48**^{d}	**56.83**^{d}	**56.50**^{d}	**56.94**
				CV % = 7.9				**CV % = 3.5**
				Variety LSD: = 4.03				**Variety LSD: = 6.40**
								Seasonality mean change = 3.95%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

March to July 2011 rain season. During the September to December 2011 rain season, IT82D-889 produced significantly lower number of leaves than MU-93 (Erect), MU-93 (Spreading) and IT85F-2841 elite cowpea varieties (Table 15). The mean number of leaves per plant ranged from 42.93 to 64.47 where by IT82D-889 produced the lowest number of leaves per plant and MU-93 (Erect) had the highest number of leaves for the September to December 2011 rain season. Generally, across the two seasons the sole crop system produced the highest number of leaves than intercropping (Table 15).According to the intercrop pattern, there was no significant difference (p = 0.05) in number of leaves per plant between the 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns during both March to July 2011 rain season and September to December 2011 rain season (Table 15).

4.2.2.4 Cowpea number of nodes per plant

Overall, the March to July 2011 rain season produced more nodes per plant than the September to December 2011 rain season (Table 16).

Cowpea varieties differed significantly (p = 0.05) in number of nodes per plant during both seasons (Table 16). During the March to July 2011 rain season, MU-93 (Erect) produced significantly (p = 0.05) fewer number of nodes per plant than the other varieties which were not significantly different (p = 0.05) from each other, in this intercrop treatment. The mean number of nodes per plant ranged from 4.26 to 6.26 where by MU-93 (Erect) produced the lowest number of nodes per plant and MU-93 (Spreading) had the highest number of nodes per plant. During the September to December 2011 rain season, IT82D-889 produced significantly (p = 0.05) fewer nodes per plant than the other cowpea varieties. The mean number of nodes per plant ranged from 3.13 to 6.60 where by IT82D-889

Table 16: Effect of cropping system on number of nodes per plant of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	Nodes per plant				Nodes per plant			
IT85F-2841	5.86	5.80	5.73	**5.80**^{b}	6.27	5.87	5.67	**5.93**^{c}
MU-93 (Spreading)	6.26	5.60	5.33	**5.73**^{b}	6.20	6.60	5.87	**6.22**^{c}
IT82D-889	5.53	5.13	5.60	**5.42**^{b}	5.80	3.27	3.13	**4.07**^{abc}
MU-93 (Erect)	4.53	5.46	4.26	**4.75**^{a}	5.33	5.13	5.13	**5.20**^{bc}
Cropping Mean	**5.55**^{d}	**5.50**^{d}	**5.23**^{d}	**5.42**	**5.90**^{f}	**5.22**^{e}	**4.95**^{e}	**5.36**
				CV % = 9.9				**CV % = 11.9**
				Variety LSD: = 0.52				**Variety LSD: = 0.62**
								Seasonality mean change = 0.55%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

produced the lowest number of nodes per plant and MU-93 (Spreading) had the highest number of nodes per plant (Table 16). The results also indicate that there was no significant difference (p = 0.05) in the number of nodes per plant under both intercrop pattern and sole cropping system during the March to July 2011 rain season (Table 16). However, there was a significant difference (p = 0.05) in the number of nodes per plant between intercrop pattern and sole cropping system during the September to December 2011 rain season.

According to the intercrop pattern, there was no significant difference in number of nodes per plant between 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns during both March to July 2011 rain season and September to December 2011 rain season (Table 16).

4.2.2.5 Cowpea number of days to 50% flowering

Overall, the March to July 2011 rain season gave cowpea plants with less number of days to reach 50% flowering than the September to December 2011 rain season (Table 17).

Results presented in Table 17 indicate that during the March to July 2011 rain season, IT85F-2841 and IT82D-889 were significantly (p = 0.05) the earliest to reach 50% flowering than the other varieties. IT85F-2841 and IT82D-889 were significantly different (p = 0.05) from MU-93 (Spreading) and MU-93 (Erect), which were also significantly different (p = 0.05) from each other in number of days to 50% flowering. The mean number of days to 50% flowering ranged from 47.00 to 49.67 where by IT85F-2841 was the earliest to reach 50% flowering and MU-93 (Spreading) took the longest number of days to reach 50% flowering. During the September to December 2011 rain season, MU-93 (Spreading) though not significantly different (p = 0.05) from IT85F-2841 and MU-93 (Erect) was significantly (p = 0.05) the earliest variety to reach 50% flowering compared to the

Table 17: Effect cropping system on number of days to 50% flowering of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	Days to 50% flowering				Days to 50% flowering			
IT85F-2841	48.33	47.00	48.33	**47.89**^{a}	48.00	49.00	47.67	**48.22**^{ab}
MU-93 (Spreading)	49.00	49.67	49.33	**49.33**^{c}	47.67	48.67	47.33	**47.89**^{a}
IT82D-889	49.33	47.67	47.67	**48.22**^{abc}	49.67	49.67	49.33	**49.56**^{b}
MU-93 (Erect)	49.33	49.00	48.67	**49.00**^{b}	48.33	50.00	49.67	**49.33**^{ab}
Cropping Mean	**49.00**^{e}	**48.33**^{e}	**48.50**^{e}	**48.61**	**48.42**^{d}	**49.33**^{d}	**48.50**^{d}	**48.75**
				CV % = 2.2				**CV % = 3.1**
				Variety LSD: = 1.05				**Variety LSD: = 1.48**
								Seasonality mean change = 0.15%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

other varieties which were not significantly different (p = 0.05) from each other. The mean number of days to 50% flowering ranged from 47.33 to 50.00 where by MU-93 (Spreading) was the earliest to reach 50% flowering and MU-93 (Erect) took the longest number of days to reach 50% flowering. The results also indicate that there was no significant difference (p = 0.05) in the number of days to 50% flowering under both intercrop pattern and sole cropping system during both rain seasons.

According to the intercrop pattern, there was no significant difference (p = 0.05) in number of days to 50% flowering between 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns during both March to July 2011 and September to December 2011 rain season (Table 17).

4.2.2.6 Cowpea number of days to physiological maturity

Overall, the March to July 2011 rain season gave plants with the least number of days to reach physiological maturity compared to the September to December 2011 rain season (Table 18).

Results presented in Table 18 indicate that during the March to July 2011 rain season, IT82D-889 was the earliest to mature compared to the other varieties which were not significantly different (p = 0.05) from each other. The mean number of days to physiological maturity ranged from 74.33 to 76.67 where by IT82D-889 was the earliest to mature and IT85F-2841 took the longest time to reach physiological maturity. During the September to December 2011 rain season, IT85F-2841 and MU-93 (Spreading) were the earliest to mature compared to IT82D-889 and MU-93 (Erect), which were not significantly different (p = 0.05) from each other. The mean number of days to physiological maturity ranged from 75.33 to 77.67 where by MU-93 (Spreading) was the earliest to mature and IT82D-889 took the longest to reach physiological maturity (Table 18). The results also indicate that

Table 18: Effect of cropping system on number of days to physiological maturity of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	Days to physiological maturity				Days to physiological maturity			
IT85F-2841	76.00	75.67	76.67	**76.11**$^{\mathbf{b}}$	75.67	77.67	75.33	**76.22**$^{\mathbf{ab}}$
MU-93 (Spreading)	76.00	75.67	75.67	**75.78**$^{\mathbf{b}}$	75.33	75.33	75.67	**75.44**$^{\mathbf{ab}}$
IT82D-889	75.00	74.33	74.33	**74.56**$^{\mathbf{a}}$	77.00	77.67	77.00	**77.22**$^{\mathbf{b}}$
MU-93 (Erect)	76.33	76.33	75.00	**75.89**$^{\mathbf{b}}$	77.00	77.33	77.33	**77.22**$^{\mathbf{b}}$
Cropping Mean	**75.83**$^{\mathbf{d}}$	**75.50**$^{\mathbf{d}}$	**75.42**$^{\mathbf{d}}$	**75.58**	**76.25**$^{\mathbf{d}}$	**77.00**$^{\mathbf{d}}$	**76.33**$^{\mathbf{d}}$	**76.53**
				CV % = 1.5				**CV % = 1.5**
				Variety LSD: = 1.07				**Variety LSD: = 1.08**
								Seasonality mean change = 0.63%

Means within the same row or column followed by same letter are not significantly different from each other at $P \leq 0.05$ ***according to the LSD test***

there was no significant difference (p = 0.05) in the number of days to physiological maturity under both intercrop patterns and the sole cropping system during both rain seasons.

Considering the intercrop patterns, there was no significant difference in number of days to physiological maturity between 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns during both March to July 2011 rain season and September to December 2011 rain season (Table 18).

4.2.3 Effect of cropping system on maize growth parameters.

4.2.3.1 Maize plant height

Overall, the September to December 2011 rain season produced the tallest maize plants (257.26 cm) compared to the March to July 2011 rain season (231.63 cm), (Table 19). The study also indicated a 5.25% increase in maize plant height in the September to December rain season. This was probably because of the higher rainfall amounts received in the September to December rain season which might have promoted more vigorous cowpea growth (Figure 1).

The results also indicate that during the March to July 2011 rain season, maize monocrop produced significantly (p = 0.05) the tallest plants (246.30 cm) and maize intercropped with IT85F-2841 had the shortest plants (209.70 cm) under 60×30 cm maize spacing pattern (Table 19). There were no significant differences (p = 0.05) in maize plant heights produced under the 120×30 cm maize spacing pattern during both rain seasons. During the September to December rain season maize monocrop produced significantly (p = 0.05) taller plants (266.80 cm) and maize intercropped with MU-93 (Erect) had the shortest plants (233.10 cm) under 60×30 cm maize spacing pattern (Table 19). Across the March to July 2011 rain season and the September to December 2011 rain season, 120×30 cm maize

Table 19: Effect of cowpea genotypes on maize plant height (cm) at Serere for 2011A and 2011B growing seasons.

	March to July season, 2011A			September to December season, 2011B		
	Plant height (cm)			Plant height (cm)		
	Maize Spacing Pattern			Maize Spacing Pattern		
Cropping System	60×30 cm	120×30 cm	Mean	60×30 cm	120×30 cm	Mean
Maize Mono Crop	246.30^{b}	234.10^{a}	240.20^{a}	266.80^{b}	259.30^{a}	263.05^{a}
Maize + IT82D-889	228.00^{ab}	235.60^{a}	231.80^{a}	245.00^{ab}	273.60^{a}	259.30^{a}
Maize + IT85F-2841	209.70^{a}	245.70^{a}	227.70^{a}	235.80^{ab}	270.90^{a}	253.35^{a}
Maize + MU-93 (Erect)	216.90^{a}	231.90^{a}	224.40^{a}	233.10^{a}	277.50^{a}	255.30^{a}
Maize + MU-93 (Spreading)	213.50^{a}	254.60^{a}	234.05^{a}	238.70^{ab}	271.90^{a}	255.30^{a}
Mean	**222.88^{a}**	**240.38^{a}**	**231.63**	**243.88^{a}**	**270.64^{a}**	**257.26**

Seasonality mean change = 5.25%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

spacing pattern had the tallest maize plants compared to 60×30 cm maize spacing pattern. This was possibly because the larger maize spacing pattern of 120×30 cm might have given maize ample space to grow vegetatively with reduced competition from the intercropped cowpea (Table 19). In both seasons, maize monocrop recorded significantly taller plants than intercropped maize because in most intercropping systems, there is plant competition for most part of the companion crop's life cycle (Jose *et al*., 2000). During the two seasons there was no significant difference (p = 0.05) in plant heights of maize intercropped with cowpea. These results are similar to those of Watiki *et al.*(1993) who found that intercropping maize with different cowpea cultivars does not have any effect on maize plant height. Mohammed *et al*. (2008) reported no significant differences (p = 0.05) on sorghum plant height as affected by cowpea genotype.

4.2.3.2 Maize number of days to 50% flowering

Overall, the March to July 2011 rain season produced the earliest maize plants to reach 50% flowering (60.29 days) compared to the September to December 2011 rain season (64.96 days), (Table 20). The study also indicated a 3.73% increase in number of days to 50% flowering in the September to December 2011 rain season.

The results also indicate that across the March to July and September to December 2011 rain season, there was no significant difference (p = 0.05) in number of days to 50% flowering under 60×30 cm and 120×30 cm maize spacing pattern during both rain seasons (Table 20). However, during both rain seasons 120×30 cm maize spacing pattern gave the earliest maize plants to reach 50% flowering compared to 60×30 cm maize spacing pattern. This was possibly due to enough

Table 20: **Effect of cowpea genotypes on maize number of days to 50% flowering at Serere for 2011A and 2011B growing seasons.**

	March to July season, 2011A			September to December season, 2011B		
	Days to 50% flowering			Days to 50% flowering		
	Maize Spacing Pattern			Maize Spacing Pattern		
Cropping System	60×30 cm	120×30 cm	Mean	60×30 cm	120×30 cm	Mean
Maize Mono Crop	61.33^{a}	59.33^{a}	60.33^{a}	64.67^{a}	64.33^{a}	64.50^{a}
Maize + IT82D-889	61.67^{a}	58.67^{a}	60.17^{a}	65.33^{a}	66.00^{a}	65.66^{a}
Maize + IT85F-2841	61.67^{a}	59.33^{a}	60.50^{a}	65.00^{a}	64.00^{a}	64.50^{a}
Maize + MU-93 (Erect)	61.33^{a}	59.33^{a}	60.33^{a}	65.33^{a}	64.67^{a}	65.00^{a}
Maize + MU-93 (Spreading)	62.33^{a}	58.00^{a}	60.16^{a}	65.67^{a}	64.67^{a}	65.17^{a}
Mean	**61.66^{a}**	**58.93^{a}**	**60.29**	**65.20^{a}**	**64.73^{a}**	**64.96**
				Seasonality mean change = 3.73%		

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

available space that might have allowed enough solar radiation to reach the maize plants with in the intercrop that eventually could have induced earliness to flowering. Treatment effects did not affect the number of days to 50% flowering during both seasons at Serere. There was no significant difference (p = 0.05) in number of days to 50% flowering (Table 20) between maize monocrop and maize intercropped with different elite cowpea varieties. These results are similar to those of Thobatsi (2009) who found that maize intercropped with different cowpea cultivars does not have any effect on maize number of days to 50% flowering.

4.3 Effects of intercropping on grain yield and yield components of cowpea and maize.

4.3.1 Effect of cropping system on cowpea yield and yield components parameters

4.3.1.1 Cowpea pod number per plant

Overall, the September to December 2011 rain season produced the highest number of cowpea pods per plant than the March to July 2011 rain season (Table 21). The study also indicated a 4.42% increase in the number of cowpea pods per plant during the September to December 2011 rain season.

Cowpea varieties had no significant difference (p = 0.05) in number of pods per plant during both rain seasons (Table 21). Results presented in Table 21 indicate that during the March to July 2011 rain season, the mean number of pods per plant ranged from 42.80 to 52.20 where by IT82D-889 had the least number of pods per plant while IT85F-2841 and MU-93 (Erect) had the highest number of pods per cowpea plant respectively. The mean number of pods per plant ranged from 49.20 to 56.67 where by IT82D-889 had the least number of pods per plant and IT85F-2841 had the highest number of pods per cowpea plant respectively during the September to December 2011 rain season. The results also indicate that there was no significant difference (p = 0.05) in pod number per plant under intercrop pattern and sole cropping system during both rain seasons (Table 21).

According to the intercrop pattern, there was no significant difference in pod number per plant between 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns for both the March to July and September to December 2011 rain seasons (Table 21).

4.3.1.2 Cowpea pod length

Overall, the March to July 2011 rain season produced cowpea with longer pods than the September to December 2011 rain season (Table 22).

Results presented in Table 22 indicate that during the March to July 2011 rain season, MU-93 (Spreading) and IT82D-889 were significantly different (p = 0.05) from each other in terms of pod length. Further still, varieties MU-93 (Erect) and IT85F-2841 were not significantly different (p = 0.05) from each other in terms of pod length. The mean pod length ranged from 15.43 cm to 16.96 cm with MU-93 (Spreading) and IT82D-889 producing the shortest and longest pods respectively.

During the September to December 2011 rain season, IT85F-284 and IT82D-889 were significantly different (p = 0.05) from each other in terms of pod length. The mean pod length ranged from 15.20 cm to 16.66 cm with IT85F-284 and IT82D-889 producing the shortest and longest pods respectively. The results also indicate that there was a significant difference (p = 0.05) in pod length under intercrop patterns and sole cropping systems during both rain seasons. During March to July 2011 rain season, sole cowpea produced significantly (p = 0.05) longer pods than 1 row Maize : 1 row Cowpea though it was not significantly different (p = 0.05) from 1 row Maize : 2 rows Cowpea intercropping pattern.

Table 21: Effect of cropping system on number of pods per plant of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	Pod number per plant				Pod number per plant			
IT85F-2841	51.33	52.20	44.73	**49.42^{a}**	56.67	53.40	57.20	**55.76^{a}**
MU-93 (Spreading)	49.60	52.87	50.40	**50.96^{a}**	55.47	56.00	54.13	**55.20^{a}**
IT82D-889	42.80	51.80	50.47	**48.36^{a}**	49.20	54.27	54.87	**52.78^{a}**
MU-93 (Erect)	46.53	52.20	49.93	**49.56^{a}**	54.73	50.27	53.47	**52.82^{a}**
Cropping Mean	**47.57^{c}**	**52.27^{c}**	**48.88^{c}**	**49.57**	**54.02^{c}**	**53.48^{c}**	**54.92^{c}**	**54.14**
				CV % = 10.0				**CV % = 8.2**
				Variety LSD: = 4.83				**Variety LSD: = 4.31**
								Seasonality mean change = 4.42%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

Table 22: Effect of cropping system on pod length of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	Pod Length (cm)				Pod Length (cm)			
IT85F-2841	16.58	15.97	16.48	**16.34**^{ab}	15.46	15.20	15.61	**15.42**^{ab}
MU-93 (Spreading)	16.78	15.43	16.02	**16.07**^{a}	16.06	15.63	16.06	**15.92**^{a}
IT82D-889	16.96	16.14	16.61	**16.57**^{b}	16.66	16.00	16.15	**16.27**^{ab}
MU-93 (Erect)	16.79	15.88	16.68	**16.45**^{ab}	15.73	15.25	16.34	**15.77**^{a}
Cropping Mean	**16.78**^{c}	**15.86**^{d}	**16.45**^{c}	**16.36**	**15.98**^{dc}	**15.52**^{d}	**16.04**^{c}	**15.84**
				CV % = 2.7				**CV % = 3.2**
				Variety LSD: = 0.42				**Variety LSD: = 0.50**
								Seasonality mean change = 1.61%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

During the September to December 2011 rain season, there were no significant difference (p = 0.05) between sole cowpea and, 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns (Table 22).

According to the intercrop pattern, there was a significant difference in pod length between 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns for both the March to July 2011 rain season and September to December 2011 rain season (Table 22).

4.3.1.3 Cowpea number of seeds per pod

Overall, the March to July 2011 rain season produced a higher number of cowpea seeds per pod than the September to December 2011 rain season (Table 23).

Results presented in Table 23 indicate that during the March to July 2011 rain season, MU-93 (Erect) was significantly different (p = 0.05) in number of seeds per pod from MU-93 (Spreading) and IT85F-2841 elite cowpea varieties. The mean number of seeds per pod ranged from 14.80 to 16.60 with MU-93 (Spreading) and MU-93 (Erect) producing the least and highest number of seeds per pod respectively. During the September to December 2011 rain season, MU-93 (Spreading) was significantly different in number of seeds per pod from other elite cowpea varieties (Table 23). The mean number of seeds per pod ranged from 10.27 to 16.47 with MU-93 (Spreading) and IT82D-889 producing the least and highest number of seeds per pod respectively. The results also show that there was a significant difference (p = 0.05) in number of seeds per pod under 1 row Maize : 1 row Cowpea intercropping pattern and sole cropping systems. However, there was no significant difference (p = 0.05) in number of seeds per pod under 1 row Maize : 2 rows Cowpea intercropping pattern and sole cropping system during the March to July 2011 rain season. Further still, there was no significant difference (p = 0.05) in number of seeds per pod under intercropping patterns and sole cropping systems during the September to December 2011 rain season (Table 23).

According to the intercrop pattern, there was a significant difference (p = 0.05) in number of seeds per pod between 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns for the March to July 2011 rain season (Table 23). However, during the September to December 2011 rain season, there was no significant difference (p = 0.05) in number of seeds per pod between 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns.

4.3.1.4 Cowpea 100 Seed weight

Overall, the September to December 2011 rain season produced the highest cowpea 100 seed weight than the March to July 2011 rain season (Table 24). Results presented in Table 24 indicate that during the March to July 2011 rain season, IT82D-889 was significantly different (p = 0.05) from other varieties that were not significantly different from each other in this intercrop experiment. The mean values indicate that the 100 Seed weight ranged from 14.33g to 15.67g with IT82D-889 producing the lightest and MU-93 (Erect) produced the heaviest seeds.

During the September to December 2011 rain season, IT82D-889 was significantly different (p = 0.05) from IT85F-2841 and MU-93 (Erect) elite cowpea varieties. The mean values indicate that the 100 Seed weight ranged from 14.00g to 16.00g with MU-93 (Erect) and IT85F-2841 producing the lightest, and MU-93 (Erect) produced the heaviest seeds. The results also indicate that there was no significant difference (p = 0.05) in 100 Seed weight under both intercrop and sole cropping systems during both rain seasons.

Table 23: Effect of cropping system on number of seeds per pod of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	Seeds per pod				Seeds per pod			
IT85F-2841	16.06	15.86	15.93	**15.95**$^{\mathbf{ab}}$	15.87	14.93	15.40	**15.40**$^{\mathbf{b}}$
MU-93 (Spreading)	16.46	14.80	15.93	**15.73**$^{\mathbf{ab}}$	10.27	15.47	15.27	**13.67**$^{\mathbf{a}}$
IT82D-889	16.20	15.93	16.20	**16.11**$^{\mathbf{ac}}$	16.47	15.60	16.13	**16.07**$^{\mathbf{b}}$
MU-93 (Erect)	16.46	16.46	16.60	**16.51**$^{\mathbf{bc}}$	16.00	15.13	15.73	**15.62**$^{\mathbf{b}}$
Cropping Mean	**16.30**$^{\mathbf{f}}$	**15.76**$^{\mathbf{e}}$	**16.16**$^{\mathbf{f}}$	**16.07**	**14.65**$^{\mathbf{d}}$	**15.28**$^{\mathbf{d}}$	**15.63**$^{\mathbf{d}}$	**15.19**
				CV % = 2.8				**CV % = 9.8**
				Variety LSD: = 0.44				**Variety LSD: = 1.45**
								Seasonality mean change = 2.81%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

Table 24: Effect of cropping system on 100 seed weight of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	100 Seed Weight (gms)			100 Seed Weight (gms)				
IT85F-2841	15.33	15.33	14.33	**15.00^{b}**	14.33	14.00	15.00	**14.44^{ab}**
MU-93 (Spreading)	14.67	15.00	15.33	**15.00^{b}**	14.67	15.67	15.33	**15.22^{ac}**
IT82D-889	14.33	14.33	14.33	**14.33^{a}**	15.33	16.00	15.33	**15.56^{bc}**
MU-93 (Erect)	15.67	15.33	15.33	**15.44^{b}**	15.33	14.67	14.00	**14.67^{ab}**
Cropping Mean	**15.00^{d}**	**15.00^{d}**	**14.83^{d}**	**14.94**	**14.92^{e}**	**15.08^{e}**	**14.92^{e}**	**14.97**
				CV % = 4.2				**CV % = 6.0**
				Variety LSD: = 0.60				**Variety LSD: = 0.87**
								Seasonality mean change = 0.11%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

According to the intercrop pattern, there was no significant difference ($p = 0.05$) in 100 Seed mass between 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns for the March to July 2011 rain season and September to December 2011 rain season.

4.3.1.5 Cowpea grain yield

Overall, the March to July 2011 rain season produced the highest cowpea grain yield than the September to December 2011 rain season (Table 25).

Results presented in Table 25 indicate that during March to July 2011 rain season, IT82D-889 and IT85F-2841 were significantly different ($p = 0.05$) from MU-93 (Erect) and MU-93 (Spreading). The mean values indicate that the grain yield ranged from 302 $kgha^{-1}$ to 1556 $kgha^{-1}$ with MU-93 (Erect) and IT82D-889 producing the lowest and highest yields respectively. During the September to December 2011 rain season, there was no significant difference ($p = 0.05$) among elite cowpea varieties. The mean values indicate that the grain yield ranged from 286 $kgha^{-1}$ to 1224 $kgha^{-1}$ with MU-93 (Erect) and IT85F-2841 producing the lowest and highest yields respectively. The results also indicate that there was a significant difference ($p = 0.05$) in grain yield under both intercrop and sole cropping systems, the sole cowpea crop produced significantly more grain yield than the intercrop cropping system during the March to July 2011 rain season. However, during the September to December 2011 rain season, there was no significant difference ($p = 0.05$) in grain yield under both intercrop and sole cropping systems.

Table 25: Effect of cropping system on grain yield of elite cowpea varieties in eastern Uganda.

	March to July season, 2011A				September to December season, 2011B			
	Cropping system				Cropping system			
Variety	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**	**Sole Cowpea**	**1rowM: 1rowC**	**1rowM: 2rowsC**	**Variety mean**
	Grain Yield (kgha^{-1})				Grain Yield (kgha^{-1})			
IT85F-2841	802	389	571	**587^{b}**	476	1224	452	**717^{a}**
MU-93 (Spreading)	640	286	357	**428^{a}**	627	429	690	**582^{a}**
IT82D-889	1556	365	635	**852^{c}**	587	421	413	**474^{a}**
MU-93 (Erect)	619	302	476	**466^{a}**	524	286	603	**471^{a}**
Cropping Mean	**904^{g}**	**335^{e}**	**510^{f}**	**583**	**554^{c}**	**590^{c}**	**540^{c}**	**561**
				CV % = 20.0				**CV % = 79.0**
				Variety LSD: = 113.2				**Variety LSD: = 431.4**
								Seasonality mean change = 1.93%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

The non significant difference in grain yield under both intercrop and sole cropping system might have been caused by the complementary effect since maize and cowpea intercropping productivity depends upon the complementary effect between the companion crops (Vesterager, 2008), hence probably no effect was realized thus no significant difference in intercrop and sole cropping system yield.

According to the intercrop pattern, there was a significant difference (p = 0.05) in grain yield between 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns for the March to July 2011 rain season. However, there was no significant difference (p = 0.05) in grain yield between 1 row Maize : 1 row Cowpea and 1 row Maize : 2 rows Cowpea intercropping patterns for the September to December 2011 rain season (Table 25).

4.3.2 Effect of cropping system on maize grain yield and yield components

4.3.2.1 Maize ear number per plant

Overall, the March to July 2011 rain season produced maize with more ears per plant (1.23) than the September to December 2011 rain season (1.21), (Table 26).

The results also indicate that during the March to July 2011 rain seasons, there was a significant difference (p = 0.05) in number of maize ears between 60×30 cm and 120×30 cm maize spacing pattern. However, there was no significant difference (p = 0.05) in number of maize ears between maize monocrop and maize intercropped with different elite cowpea varieties. During the September to December 2011 rain season, there was no significant difference (p = 0.05) in number of maize ears between 60×30 cm and 120×30 cm maize spacing pattern (Table 26).

Table 26: Effect of cowpea genotypes on maize ear number at Serere for 2011A and 2011B growing seasons.

	March to July season, 2011A			September to December season, 2011B		
	Maize ear number			Maize ear number		
	Maize Spacing Pattern			Maize Spacing Pattern		
Cropping System	60×30 cm	120×30 cm	Mean	60×30 cm	120×30 cm	Mean
Maize Mono Crop	1.06^{a}	1.40^{a}	1.23^{a}	1.46^{b}	1.60^{a}	1.53^{a}
Maize + IT82D-889	1.00^{a}	1.53^{a}	1.26^{a}	1.33^{ab}	1.26^{a}	1.29^{a}
Maize + IT85F-2841	1.06^{a}	1.33^{a}	1.19^{a}	1.26^{ab}	1.46^{a}	1.36^{a}
Maize + MU-93 (Erect)	1.06^{a}	1.33^{a}	1.19^{a}	1.06^{a}	1.46^{a}	1.26^{a}
Maize + MU-93 (Spreading)	1.00^{a}	1.60^{a}	1.30^{a}	1.20^{ab}	1.53^{a}	1.36^{a}
Mean	**1.03^{c}**	**1.43^{d}**	**1.23**	**1.26^{d}**	**1.17^{d}**	**1.21**

Seasonality mean change = 0.81%

Means within the same row or column followed by same letter are not significantly different from each other at $P \leq 0.05$ according to the LSD test

However, maize monocrop was significantly different (p = 0.05) from maize intercropped with MU-93 (Erect) under 60×30 cm maize spacing pattern. There was no significant difference (p = 0.05) in number of maize ears between 60×30 cm and 120×30 cm maize spacing pattern during the September to December 2011 rain season.

4.3.2.2 Maize ear length

Overall, the September to December 2011 rain season produced maize with longer ears (24.36 cm) than the March to July 2011 rain season (23.30 cm), (Table 27). The study also indicated a 2.24% increase in maize ear length (cm) in the September to December rain season. This might have been caused by the higher rain fall amounts received in the September to December rain season. During the March to July 2011 rain season, maize monocrop produced significantly (p = 0.05) the longest maize ear (24.83 cm) and maize intercropped with IT85F-2841 had the shortest maize ear (15.27 cm) under 60×30 cm maize spacing pattern. There were no significant differences (p = 0.05) among maize intercropped with the different elite cowpea varieties under 60×30 cm maize spacing pattern. However, intercropping maize with MU-93 (Erect) produced significantly (p = 0.05) the longer maize ears (31.53 cm) and maize monocrop had the shortest maize ears (25.40 cm) under 120×30 cm maize spacing pattern during the March to July 2011 rain season. During the September to December 2011 rain season, maize monocrop produced significantly (p = 0.05) the longest maize ear (26.87 cm) and maize intercropped with IT85F-2841 had the shortest maize ear (18.19 cm) under 60×30 cm maize spacing pattern. However, there was no significant difference (p = 0.05) between maize monocrop and maize intercropped with elite cowpea varieties under under 120×30 cm maize spacing pattern during the September to December 2011 rain season. This was because of the wider spacing of maize

Table 27: Effect of cowpea genotypes on maize ear length (cm) at Serere for 2011A and 2011B growing seasons.

	March to July season, 2011A			September to December season, 2011B		
	Maize ear length (cm)			Maize ear length (cm)		
	Maize Spacing Pattern			Maize Spacing Pattern		
Cropping System	60×30 cm	120×30 cm	Mean	60×30 cm	120×30 cm	Mean
Maize Mono Crop	24.83^{b}	25.40^{a}	25.11^{a}	26.87^{b}	26.53^{a}	26.70^{a}
Maize + IT82D-889	15.30^{a}	31.13^{ab}	23.21^{a}	22.27^{ab}	27.64^{a}	24.95^{a}
Maize + IT85F-2841	15.27^{a}	27.80^{ab}	21.53^{a}	18.19^{a}	28.24^{a}	23.21^{a}
Maize + MU-93 (Erect)	15.97^{a}	31.53^{b}	23.75^{a}	20.85^{a}	26.43^{a}	23.64^{a}
Maize + MU-93 (Spreading)	16.53^{a}	29.27^{ab}	22.90^{a}	19.73^{a}	26.93^{a}	23.33^{a}
Mean	$\mathbf{17.58^{d}}$	$\mathbf{29.02^{e}}$	**23.30**	$\mathbf{21.58^{d}}$	$\mathbf{27.15^{e}}$	**24.36**
						Seasonality mean change = 2.24%

Means within the same row or column followed by same letter are not significantly different from each other at $P \leq 0.05$ according to the LSD test

monocrop and maize intercrop with elite cowpea varieties hence no difference could be actualized in terms of maize ear length.

4.3.2.3 Maize seeds per ear

Overall, the September to December 2011 rain season produced maize plants with the highest number of seeds per ear (437.9) than the March to July 2011 rain season (384.0), (Table 28). The study also indicated a 6.56% increase in maize number of seeds per ear in the September to December rain season. This might have been caused by the higher rain fall amounts received in the September to December rain season.

The results also indicate that during the March to July 2011 rain season, maize monocrop produced significantly ($p = 0.05$) the highest number of seeds per ear (389.0) and maize intercropped with IT85F-2841 had the least number of seeds per ear (275.0) under 60×30 cm maize spacing pattern. There was no significant difference ($p = 0.05$) in maize number of seeds per ear produced under the 120×30 cm maize spacing pattern during both rain seasons. During the September to December rain season maize monocrop produced significantly ($p = 0.05$) the highest number of maize seeds per ear (471.9) and maize intercropped with IT85F-2841 had the least number of maize seeds per ear (371.2) under 60×30 cm maize spacing pattern. Across the March to July 2011 rain season and the September to December 2011 rain season, 120×30 cm maize spacing pattern had the highest number of maize seeds per ear compared to 60×30 cm maize spacing pattern. This might have been caused by the reduced competition since 120x30 cm gives less plant population compared to 60x30 cm (Table 28).

Table 28: **Effect of cowpea genotypes on number of maize seeds per ear at Serere for 2011A and 2011B growing seasons.**

	March to July season, 2011A			September to December season, 2011B		
	Number of maize seeds per ear			Number of maize seeds per ear		
	Maize Spacing Pattern			Maize Spacing Pattern		
Cropping System	60×30 cm	120×30 cm	Mean	60×30 cm	120×30 cm	Mean
Maize Mono Crop	389.0^{b}	391.0^{a}	390.0^{a}	471.9^{b}	466.3^{a}	469.1^{a}
Maize + IT82D-889	340.0^{ab}	434.0^{a}	387.0^{a}	428.1^{ab}	471.1^{a}	449.6^{a}
Maize + IT85F-2841	275.0^{a}	457.0^{a}	366.0^{a}	371.2^{a}	472.3^{a}	421.7^{a}
Maize + MU-93 (Erect)	307.0^{ab}	450.0^{a}	378.5^{a}	407.5^{ab}	445.5^{a}	426.5^{a}
Maize + MU-93 (Spreading)	316.0^{a}	481.0^{a}	398.5^{a}	389.8^{a}	456.1^{a}	422.9^{a}
Mean	**325.4^{d}**	**442.6^{e}**	**384.0**	**413.7^{a}**	**462.2^{a}**	**437.9**
						Seasonality mean change = 6.56%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

Table 29: Effect of cowpea genotypes on maize 100 seed mass (gm) at Serere for 2011A and 2011B growing seasons.

	March to July season, 2011A			September to December season, 2011B		
	Maize 100 seed mass (gm)			Maize 100 seed mass (gm)		
	Maize Spacing Pattern			Maize Spacing Pattern		
Cropping System	60×30 cm	120×30 cm	Mean	60×30 cm	120×30 cm	Mean
Maize Mono Crop	41.70^{b}	40.27^{a}	40.98^{a}	31.83^{a}	33.33^{ab}	32.58^{ab}
Maize + IT82D-889	36.77^{ab}	41.70^{a}	39.23^{a}	35.83^{b}	34.13^{b}	34.98^{b}
Maize + IT85F-2841	31.83^{a}	43.43^{a}	37.63^{a}	32.47^{a}	32.50^{ab}	32.48^{ab}
Maize + MU-93 (Erect)	36.67^{ab}	38.60^{a}	37.63^{a}	31.47^{a}	30.97^{ab}	31.22^{a}
Maize + MU-93 (Spreading)	35.20^{ab}	40.13^{a}	37.66^{a}	32.60^{ab}	30.20^{a}	31.40^{a}
Mean	$\mathbf{36.43^{d}}$	$\mathbf{40.82^{d}}$	**38.62**	$\mathbf{32.84^{d}}$	$\mathbf{32.22^{d}}$	**32.53**

Seasonality mean change = 8.54%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

4.3.2.4 Maize 100 seed mass

Overall, the March to July 2011 rain season produced maize with the heaviest 100 seed mass (38.62 gm) than the September to December 2011 rain season (32.53 gm), (Table 29). The study also indicated a 8.54% decrease in maize 100 seed mass in the September to December 2011 rain season.

The results also indicate that during the March to July 2011 rain season, maize monocrop produced maize with the highest 100 seed mass (41.70 gm) and maize intercropped with IT85F-2841 had the lowest 100 seed mass (31.83 gm) under 60×30 cm maize spacing pattern. There was no significant difference ($p = 0.05$) in maize 100 seed mass produced under the 120×30 cm maize spacing pattern during both rain seasons (Table 29). During the September to December 2011 rain season, maize intercropped with IT82D-889 had the highest 100 seed mass (35.83 gm) and maize intercropped with MU-93 (Erect) had the lowest 100 seed mass (31.47 gm) under 60×30 cm maize spacing pattern. However, maize intercropped with IT82D-889 produced had the highest 100 seed mass (34.13 gm) and maize intercropped with MU-93 (Spreading) had the lowest 100 seed mass (30.20 gm) under 120×30 cm maize spacing pattern.

4.3.2.5 Maize grain yield

Overall, the March to July 2011 rain season produced the highest maize grain yield (2619.0 $kgha^{-1}$) compared to the September to December 2011 rain season (2050.9 $kgha^{-1}$), (Table 30). The study also indicated a 12.16% decrease in maize grain yield in the September to December 2011 rain season. The decrease in maize grain yield yet the September to December 2011 rain season receive higher rainfall than the March to July 2011 rain season could be attributed to the genetic attribute of the maize variety since it can produce yield beyond its genetic potential.

The results also indicate that during the March to July 2011 rain season, maize monocrop produced significantly ($p = 0.05$) the highest grain yield (3690.0 $kgha^{-1}$) and maize intercropped with IT85F-2841 had the lowest grain yield (1706.0 $kgha^{-1}$) under 60×30 cm maize spacing pattern. There was no significant difference ($p = 0.05$) in maize grain yield produced under the 120×30 cm maize spacing pattern during both rain seasons. This could be because of enough resource utilization as a result of wider spacing enhancing limited competition among the crops.

During the September to December 2011 rain season, maize intercropped with IT85F-2841 produced significantly ($p = 0.05$) the highest maize grain yield (2794.0 $kgha^{-1}$) and maize intercropped with IT82D-889 had the lowest maize yield (1794.0 $kgha^{-1}$) under 60×30 cm maize spacing pattern (Table 30).

Table 30: Effect of cowpea genotypes on maize grain yield (kgha^{-1}) at Serere for 2011A and 2011B growing seasons.

	March to July season, 2011A			September to December season, 2011B		
	Maize grain yield (kgha^{-1})			Maize grain yield (kgha^{-1})		
	Maize Spacing Pattern			Maize Spacing Pattern		
Cropping System	60×30 cm	120×30 cm	Mean	60×30 cm	120×30 cm	Mean
Maize Mono Crop	3690.0^{c}	2635.0^{a}	3162.5^{b}	2175.0^{ab}	2214.0^{a}	2194.5^{a}
Maize + IT82D-889	2619.0^{b}	3024.0^{a}	2821.5^{ab}	1794.0^{a}	2048.0^{a}	1921.0^{a}
Maize + IT85F-2841	1706.0^{a}	2635.0^{a}	2170.5^{a}	2794.0^{b}	1913.0^{a}	2353.5^{a}
Maize + MU-93 (Erect)	2365.0^{ab}	2500.0^{a}	2432.5^{ab}	1833.0^{a}	1563.0^{a}	1698.0^{a}
Maize + MU-93 (Spreading)	2262.0^{ab}	2754.0^{a}	2508.0^{ab}	2310.0^{ab}	1865.0^{a}	2087.5^{a}
Mean	**2528.4^{a}**	**2709.6^{a}**	**2619.0**	**2181.2^{a}**	**1920.6^{a}**	**2050.9**

Seasonality mean change = 12.16%

Means within the same row or column followed by same letter are not significantly different from each other at P ≤ 0.05 according to the LSD test

4.3.3 Correlation analysis between growth and yield parameters of selected elite cowpea varieties

The correlation analysis carried out on all parameters against each other, using the Pearson Product Moment Correlation for linear correlations of continuous data, indicated the whole range from small, medium, to large correlation as interpreted by (Cohen, 1988) and appears in the correlation matrix in Table 31.

Plant height was moderately and positively correlated to days to maturity (r = 0.2525), it was also weakly and positively correlated to seeds per pod (r = 0.1097) and grain yield (r = 0.0042). This implies that plant height contributed minimally to all those reproductive parameters mentioned. However, plant height was strongly and negatively correlated to number of branches (r = -0.4674), and moderately and negatively correlated to number of leaves. This shows that increase in plant height decreased the number of leaves and branches. The number of branches was strongly and positively correlated to number of leaves (r = 0.5297) and number of nodes per plant (r = 0.5013). Branch number per plant was also weakly and positively correlated to number of pods per plant (r = 0.2625). This shows that the greater these parameters, the higher the number of branches. However, branch number was weakly and negatively correlated to seeds per pod (r = -0.1686), pod length (r = -0.2371), seed weight (r = -0.0626) and grain yield (r = -0.0330) implying that increased measure of number of branches reduces the mentioned traits. The number of leaves was strongly and positively correlated to the number of nodes per plant (r = 0.4199). This shows that the greater the number of leaves per plant, the higher the number of pod per plant.

Table 31: Correlation matrix of growth and yield parameters of selected elite cowpea varieties during 2011A and 2011B seasons

	Days to 50% flowering	Plant height	Branch number	Leaves number	Days to maturity	Nodes/ plant	Pods/ plant	Pod Length	Seeds pod	Seed weight	100-Seed weigth	Grain yield
Days to 50% flowering	1.000											
Plant height	0.114	1.000										
Branch number	-0.204	-0.467	1.000									
Leaves number	-0.180	-0.322	0.529	1.000								
Days to maturity	0.339	0.252	0.017	-0.006	1.000							
Nodes per plant	-0.203	-0.276	0.501	0.419	-0.152	1.000						
Pods per plant	-0.064	-0.015	0.262	0.103	0.178	0.056	1.000					
Pod length	0.001	-0.043	-0.237	-0.321	-0.087	-0.079	-0.337	1.000				
Seeds per pod	0.113	0.109	-0.168	-0.239	0.118	-0.186	-0.175	0.251	1.000			
Seed weight	-0.036	-0.008	-0.062	-0.004	-0.123	0.139	-0.390	0.495	0.125	1.000		
100 Seed weight	0.084	0.125	-0.108	-0.234	0.127	-0.199	0.230	0.102	0.101	-0.064	1.000	
Grain yield	-0.125	0.004	-0.033	0.051	-0.123	0.151	-0.394	0.443	0.105	0.960	-0.141	1.000

Correlation	**Negative**	**Positive**
Small	-0.3 to -0.1	0.1 to 0.3
Medium	-0.5 to -0.3	0.3 to 0.5
Large	-1.0 to -0.5	0.5 to 1.0

Leaf number was weakly and positively correlated to pods per plant (r = 0.1036) and grain yield (r = 0.0513). This shows that the number of leaves had little contribution to the number of pods per plant and grain yield. Further implication, could be for the case of dual purpose cowpea that can be targeted for leaf and grain yield, leaves can be harvested without affecting the overall grain yield. Leaf number was moderately and negatively correlated to pod length (r = -0.3211), and weakly and negatively correlated to seed weight (r = -0.0046) and days to maturity (r = -0.0060) implying that increased measure of this trait affect seed weight and days to maturity negatively (Table 31). Pod length was strongly and positively correlated to seed weight (r = 0.4958) and grain yield (r = 0.4436). This is in line with the findings of Asio (2004), who reported that pod length significantly contributed to both seed weight and yield, and was considered during selection of high yielding cowpea genotypes. It was also weakly and positively correlated to seeds per pod (r = 0.2514) (Table 31). This implies that increased measures of pod length affected seeds weight, seeds per pod and grain yield positively.

Seed weight was strongly and positively correlated to grain yield (r = 0.9605), with coefficient of determination (r = 0.9225) (Table 31). This implies that increase in seed weight increased the grain yield. Thus, basing on this study cowpea seed weight was the main determinant of cowpea grain yield. This is in agreement with works of Nakawuka and Adipala, (1999), who observed that cowpea grain yield, depends upon other components traits such as seed weight.

4.3.3.1 Correlation analysis between growth and yield parameters of maize.

The correlation analysis carried out between all maize parameters against each other, using the Pearson Product Moment Correlation for linear correlations of continuous data appears in correlation matrix (Table 32).

Table 32: Correlation matrix of growth and yield parameters of maize during 2011A and 2011B Season

	Days to 50% flowering	Plant height	Ears/plant	Ear length	Seeds/ear	100-Seed mass	Grain yield
Days to50%_Flowering	1.000						
Plant_Heigth	0.023	1.000					
Ear number_per_plant	-0.198	0.551	1.000				
Ear_Length	-0.290	0.477	0.575	1.000			
Seeds_per_ear	0.006	0.627	0.578	0.724	1.000		
100_Seed_mass	-0.598	-0.092	0.051	0.228	0.131	1.000	
Grain_yield	-0.532	0.094	-0.004	0.148	-0.005	0.573	1.000

Pooled data for two seasons; 2011A and 2011B rain seasons

Correlation	**Negative**	**Positive**
Small	-0.3 to -0.1	0.1 to 0.3
Medium	-0.5 to -0.3	0.3 to 0.5
High	-1.0 to -0.5	0.5 to 1.0

Days to 50% flowering were highly and negatively correlated to 100 seed mass (gm) and maize grain yield (kgha^{-1}) (Table 32). This implies that increase in days to 50% flowering decreased 100 seed mass and maize grain yield. Plant height was highly and positively correlated to number of ears per plant, ear length (cm) and seeds per pod. This shows that the greater the plant height (cm), the ear length increase and number of seeds per ear of maize plant also increases.

Ear number per plant was highly and positively correlated to ear length (cm) and seeds per ear (Table 32). This implies that increase in the number of ears per plant increased ear length and seeds per ear positively. Ear length (cm) was highly and positively correlated to number of seeds per ear. This shows that increase in maize ear length increased number of seeds per ear. Maize 100-Seed mass (gm) was highly and positively correlated to maize grain yield (kgha^{-1}). This means that increase in 100 seed mass increased maize grain yield (kgha^{-1}). Similar results were obtained by Thobatsi (2009) who reported a significant correlation between 100 seed mass and grain yield of maize.

4.3.4 Land Equivalent Ratio Analysis Results.

Land Equivalent Ratios (LERs) were used to determine whether intercropping any of the elite cowpea varieties with maize variety, Longe 5 was beneficial. The partial LER for elite cowpea varieties in 2011A rain season, indicate that MU-93 (Spreading) has the highest intercropping advantage with partial LER of 1.34 in 1 row Maize : 1 row Cowpea intercropping pattern and MU-93 (Erect) had the highest partial LER of 0.77 in 1 row Maize : 2 rows Cowpea intercropping pattern (Table 33). The highest total LER in 2011A rain season, was 1.94 with MU-93 (Spreading) in 1 row Maize : 1 row Cowpea intercropping pattern, and the lowest was 1.02 with IT82D-889 still in the 1 row Maize : 1 row Cowpea intercropping patterns (Table 33).

Table 33: Effect of Intercropping Elite Cowpea varieties with maize (Longe 5) at Serere, Land Equivalent Ratio (L.E.R) Analysis.

Season	Cowpea Variety	Intercrop pattern Yield(kg/ha)	Intercrop Cowpea Yield(kg/ha)	Sole Cowpea (kg/ha)	Intercrop Maize (kg/ha)	Sole Maize (kg/ha)	P/LER Cowpea	P/LER Maize	TOTAL LER
2011A	**IT85F-2841**	**1 row**	476.19	801.58	1706.35	3785.71	0.60	0.45	**1.05**
2011A	**IT85F-2841**	**2 rows**	571.42	801.58	2634.92	2634.92	0.71	1.00	**1.71**
2011A	**IT82D-889**	**1 row**	365.07	1555.55	2987.05	3785.71	0.23	0.79	**1.02**
2011A	**IT82D-889**	**2 rows**	634.91	1555.55	3023.80	2634.92	0.41	1.15	**1.56**
2011A	**MU-93 (Spreading)**	**1 row**	857.13	640.04	2261.90	3785.71	1.34	0.60	**1.94**
2011A	**MU-93 (Spreading)**	**2 rows**	357.14	640.04	2706.34	2634.92	0.56	1.03	**1.59**
2011A	**MU-93 (Erect)**	**1 row**	301.58	619.04	2142.85	3785.71	0.49	0.57	**1.06**
2011A	**MU-93 (Erect)**	**2 rows**	476.18	619.04	2619.04	2634.92	0.77	0.99	**1.76**
2011B	**IT85F-2841**	**1 row**	523.81	476.19	2182.53	2174.60	1.10	1.00	**2.10**
2011B	**IT85F-2841**	**2 rows**	452.38	476.19	1912.70	2214.28	0.95	0.86	**1.81**
2011B	**IT82D-889**	**1 row**	420.63	587.30	1793.65	2174.60	0.72	0.83	**1.55**
2011B	**IT82D-889**	**2 rows**	412.69	587.30	2047.61	2214.28	0.70	0.92	**1.62**
2011B	**MU-93 (Spreading)**	**1 row**	428.57	626.98	2309.52	2174.60	0.68	1.06	**1.74**
2011B	**MU-93 (Spreading)**	**2 rows**	690.47	626.98	1865.08	2214.28	1.10	0.84	**1.94**
2011B	**MU-93 (Erect)**	**1 row**	285.71	523.81	1928.57	2174.60	0.54	0.89	**1.44**
2011B	**MU-93 (Erect)**	**2 rows**	603.17	523.81	1563.49	2214.28	1.15	0.70	**1.85**

Results also indicate that the best intercrop advantage occurred in 1 row Maize : 2 rows Cowpea intercropping pattern possibly because of adequate spacing of the maize rows (120×30cm^2) that reduced the inter specific competition. For the maize variety superimposed over the cowpea rows in 2011A rain season, all treatments in 1 row Maize : 2 rows Cowpea intercropping pattern had a partial LER greater than 1 (Table 33). The highest partial LER for maize was 1.15 within the 1 row Maize : 2 rows Cowpea intercrop treatment of IT82D-889. This shows that there was a big yield advantage from intercropping maize with the elite cowpea varieties especially within 2-row intercrop treatment. It is possible that the maize benefited from Biological Nitrogen Fixation (BNF) by legumes through intermingling of their roots (Fujita *et al*., 2001).

During 2011B Season, the partial LER for elite cowpea varieties indicate that IT85F-2841 had the highest intercropping advantage with partial LER of 2.57 in the 1-row intercropping pattern 1 row Maize : 1 row Cowpea intercropping patterns and MU-93 (Erect) had the highest partial LER of 1.15 in 1 row Maize : 2 rows Cowpea intercropping pattern (Table 33). Results also indicate that the best intercrop advantage occurred in 1 row Maize : 2 rows Cowpea intercropping pattern except for IT85-2841 which had a very high LER under 1 row Maize : 1 row Cowpea intercropping pattern possibly because of adequate spacing of the maize rows (120×30cm) that reduced the inter species shading. The highest total LER in 2011B rain Season, was 3.57 with IT85F-2841 in 1 row Maize : 1 row Cowpea intercropping pattern and the lowest was 1.44 with MU-93 (Erect) still in the 1 row Maize : 1 row Cowpea intercropping pattern (Table 33). For the maize variety superimposed over the cowpea rows in 2011B rain season, the highest partial LER for maize was 1.06 within the 1 row Maize : 1 row Cowpea intercropping patterns intercrop treatment of MU-93 (Spreading). Total Land Equivalent Ratio (LER) calculated indicated that for all planting densities, intercropping patterns and for all replications, there is intercropping advantage as exhibited by all total LER values that are greater than 1 (Table 33). A LER of 1.56, for example indicates that the area planted in pure stand would require 56% more land to yield the same as an area planted with intercrop. A LER for instance of 1.94 (Table 15), indicates that the intercrop area would almost be twice as much as the sole crop. There was greater advantage from intercropping maize with cowpeas in 2011B season probably because of minimum intercropping competition and maximum complementary effects [Rao and Mittra, 1990].

Overall, LER an index of intercrop productivity, showed an advantage of intercrops over the sole crop (Table 33). The values of LERs were greater than 1.00, indicating an advantage over sole cropping. Similar findings have been reported by Burton *et al*. (1983) and Ibrahim Hamza (2008). The highest LER obtained from this study was 2.10 in 2011B season and 1.94 in 2011A season, respectively with increases of 110% and 94% (Table 33), These LERs appear high, but other researchers have reported similar LERs. For example research done by Ibrahim Hamza (2008) working on yield performance of cowpea varieties under sole and intercropping with maize at Bauchi, Nigeria, obtained a LER of 2.29. Also Dahmardeh *et al*. (2007) working on the role of intercropping maize and cowpea on yield and soil properties reported LERs of 2.31 and 2.57 in years one and two, respectively.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From the data presented, analyzed, and discussed, the following conclusions can be drawn:

1. From the plant density or planting pattern of elite cowpea experiment, cowpea genotypes performed differently in their growth and development parameters. Overall, vegetative growth among the elite cowpea varieties was greatest in the March to July 2011 rain season especially with IT85F-2841 elite cowpea variety. However, local check variety, Ichirikukwai dominated vegetatively especially in number of branches and number of nodes yet the other local check variety, Ebelat dominated in the number of leaves per cowpea plant during the March to July 2011 rain season. During the September to December 2011 rain season, the same elite cowpea variety IT85F-2841 dominated most of the vegetative growth parameters among elite cowpea varieties except in plant height. However, local check variety, Ebelat dominated vegetatively especially in plant height and cowpea number of branches during September to December 2011 rain season. The significant differences observed in growth attributes among the cowpea cultivars might have been due to the growth habit and the genetic potential of each cowpea genotype. Plant population had no significant effect on most of cowpea growth parameters in this present study.

2. Elite cowpea varieties MU-93 (spreading growth habit) and IT85F-2841 (spreading growth habit) gave consistently the highest leaf yield during both the March to July 2011 rain season and the September to December 2011 rain season. The high leaf yield from these two elite cowpea varieties could still be attributed to their growth habit and genetic potential of each genotype. Cowpea elite variety IT82D-889 flowered earlier during both the March to July 2011 rain season and the

September to December 2011 rain season. The same cowpea elite variety IT82D-889 reached physiological maturity earlier among the elite cowpea cultivars except in the September to December 2011 rain season. In terms of correlation from the results obtained in this study, there was a strong, positive and significant correlation between number of branches, number of leaves per plant and number of nodes per plant for the plant density experiment.

3. It was also noted that, there was a significant difference in cowpea yield and yield components parameters among the cowpea varieties. Plant population had no significant effect on most of cowpea yield and yields components parameters in this present study. However, increase in plant population increased grain yield of cowpea (kgha^{-1}). Row spacing of 60×30 cm at plant population of 55,555 plants per hectare gave consistently higher grain yield for the plant density experiment. Overall, cowpea grain yield was highest in the September to December 2011 rain season because of the high rainfall amounts received compared to the March to July 2011 rain season. The grain yield was dominated by IT82D-889 elite variety which was found on station to be high yielding during both the March to July 2011 rain season and the September to December 2011 rain season for the plant density experiment. Cowpea elite varieties IT85F-2841 and MU-93 (spreading) gave both high cowpea leaf yields and high cowpea grain yields in this study.

4. In the intercrop experiment, the practice of intercropping depressed the number of branches per plant, nodes per plant, leaves per plant and cowpea grain yield, but did not influence number of pods per plant, seeds per pod and pod length of cowpea. Cowpea vegetative parameters like; plant height, number of branches and number of leaves were higher in the September to December 2011 rain season because of the higher rainfall amounts received in this season. It was also noted that, there was

a strong, positive and significant correlation between cowpea number of branches, nodes per plant and leaves of cowpea in this intercrop experiment. Among the yield and yield component parameters there was a strong, positive and significant correlation between pod length, seed weight and cowpea grain yield.

5. Intercrop advantages measured by Land Equivalent Ration (LER) analysis indicated that cowpea varieties IT85F-2841 and MU-93 (spreading) with spreading growth habit proved to be more productive under intercropping than cowpea varieties IT82D-889 and MU-93 (erect) with erect growth habit. The LER analysis further showed that the best intercropping advantage occurred in 1 row maize : 2 rows Cowpea intercropping arrangement because of less inter and intra specific competition among component crops. Intercropping and mono cropping systems affected most of the growth and yield parameters of maize except for days taken for maize to reach 50% flowering. Maize mono crop system gave higher maize grain yield than maize under intercropping system during the March to July 2011 rain season. However, the contrary happened during the September to December 2011 rain season. Maize intercropped with IT82D-889 and IT85F-2841 gave higher grain yield during the March to July 2011 rain season and the September to December 2011 rain season. Maize planting pattern of 120×30 cm gave the highest maize grain yield in the March to July 2011 rain season, yet the contrary happened in the September to December 2011 rain season.

5.2 Recommendations

1. Stakeholders such as plant breeders and farmers interested in increasing cowpea leaf yield production in Uganda should adopt two elite cowpea varieties namely MU-93 (spreading growth habit) and IT85F-2841 (spreading growth habit) for better leaf yield. However, more research is

needed especially about the culinary aspect of these two varieties because production of high leaf yield may not mean palatability to farmers.

2. Farmers should adopt cowpea elite variety IT82D-889 for early maturity and higher cowpea grain yield (Plate 2). However, further research should be conducted to test the yield performance of this variety on-farm and under different Agro ecological zones before it can be forwarded to the Uganda National Variety Release Committee.

3. Cowpea varieties IT85F-2841 and MU-93 (spreading) should be recommended as dual purpose cowpea cultivars to Ugandan farmers for higher leaf yields and high grain yield. However, still further research is needed to check their performance as dual purpose cultivars under on-farm and multi location trials.

4. Farmers should also adopt the intercropping pattern preferably the 1 row maize : 2 rows Cowpea technique for yield advantage (Plate 1). However, more research is needed to further understand the associated additional benefits to enhance the benefits of intercropping achieved in this study.

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