CHAPTER ONE

INTODUCTION

Sudan is a tropical country with a large area and is predominantly arid and semi- arid. The natural resources may appear to be plentiful, but in fact there are limiting agricultural production. Moreover cycles of drought and desertification that occurred in the twentieth century have provided reason to considering the Sudan facing water scarcity (WMO. 1996).

The industrial sectors and the fast growing petroleum activity will compete with agriculture for water resources and may also act as a source of underground water pollution. Consequently, in dry areas; water,and not land is the most limiting resource for crop growth and production (Reij *et al*., 1988). Also water scarcity is a significant problem for Africa, Asia and Near East where 80- 90% of the water withdrawals a response for agriculture (FAO, 2000), however most of the small holding farmer in the developing countries are depend on rain fed agriculture and practices will continue for several reasons; irrigation and infrastructure are expensive and environmentally hazardous. The potential for expansion of irrigation scheme in arid and semi-arid areas is limited by land suitability, water availability and conflict over water- share among farmers and non farmers (FAO, 2005).

Therefore, water conservation techniques and deep tillage are used to improve soil moisture capacity by increasing soil porosity to capture the rain water that fall on it, in addition run off is reduced through increased roughness of soil surface this will increase the availability of water to root zone and assist better plant growth (Irshal *et al*2007) to high variable rainfall, of dry spells and recurrent droughts. Water management is a key for agriculture production in dry areas (Irshal *et a*l., 2007).

Although various agronomic practices are applied to minimize adverse effects of moisture stress on plant growth, in this study rainfall water is conserved by land preparation using animal traction and hand hoe(Mukmuk and Geria local instrument) to rough soil surface to capture rain water in site and terrace to minimize water runoff.

Intercropping is a simultaneous growing of two or more crops in the same field (Legwaila,et al., (2012). The practice of growing sorghum and cowpea on the same piece of land is one of the most important cropping systems. Reasons of intercropping vary depending on individual farmer production goals. Yield of intercropping are often higher than in sole cropping systems because resources like water, light and nutrients can be utilized more effectively than in sole cropping systems(Sun,et al., 2006).

This area lies in Southern Sudan which suffers from civil war and different climatic change. Traditional methods of cultivation were applied and no research was done in this area. This study aimed to highlight the effect of different land preparations by using local instruments hand hoe(Geria) and animal traction plough and terrace to determined the effect of these approaches on growth and yield of sorghum, *Sorghum bicolor* (L. Moench) intercropped with cowpea *Vigna ungiculata (*L. Walp) under two locations Elfola and Babanosa in(Western Kordofan State).

The specific objectives of this study was to determine:

1- The effect of soil water conservation on vegetative growth and yield parameters of sorghum intercropped with cowpea.

2- The variation of growth and yield of sorghum intercropped with cowpea within seasons

CHAPTER TWO

LITERATURE REVIEW

2.1Sorghum:

Sorghum is the fifth most important cereal crop world wild as an important source of feed, fiber and bio fuel (Doggelt, 1988). Sorghum is well adapted to drought environments compare to other cereals (Lndlow and Muchow 1990, Mullet *et al*., 2001; Sanchez *et al*., 2002; Borrel *et al*., 2006).Sorghum is considered as a staple food grain for some of the world's poorest and most insecure people across developing countries of Asia and Africa (Murly *et al*., 2007). Sorghum is a member of the grass family.

2.1.1 Latin name and Common name:

Alternate scientific name: Sorghum vulgar pres., *Andropogon, Sorghum (L.),* Brot*, Sorghum bicolor (L.) Moech ssp*. *Arunfinaaceum (Desv*) dewet and *Harlan, Sorghum bicolor (L.), Moench ssp,bicolor, sorghum bicolor stend, dewet and Harlan*. ain sorghum.

Sweet sorghum sorgo forrijero (Spanish), dura (Africa), guiuea corn, black amber,chicken corn, shatter corn, wild corn, broom corn, grain sorghum, forage sorghum and Sudan grass.

2.1.2 Crop description and climate:

The sorghum is of tropical origin (Bark Worth, 2003), but more spread all over the world, with current production in many places including Africa, China, Central South America, India and United States.

General sorghum is an upright short day, summer annual that is a member of poaceae family. The grass blades are flat, stems are rigid and there is no creeping rihzomes. Sorghum has a loose open panicle of short few- flowered

racemes. As seed matures, the panicle may drop. Glumes vary in color from red or reddish brown to yellowish. The grain is predominately red to reddish brown (Kearney and Peebles, 1969; Bark Worth, 2003).

Sorghum exhibit different height and maturity dates, growth characteristics also vary depending on location of grown inputs and agronomic practices in general. Forage sorghum are taller plants with late maturity dates and more vegetative growth than grain sorghum (Undersande, 2003).

2.1.3 Cultural practices of sorghum:

Sorghum can grow in low fertility, moderately acidic and highly alkaline soils, but it is best adapted to fertile well drained soils of a pH between 6.0- 6.5. Sorghum is not tolerant of frost, shade or sustained flooding (Clark, 2007; FAO, 2012; Undersander, 2003). The crop can be established in conventional, reduce of tillage or no till cropping systems with drill seedling or broad casting. Soil temperatures should be between 60- 70°F before planting sorghum.

Fertilizer application frequency and amounts will vary with type of sorghum planted and the goals of planting. Soils should tested prior planting to determine fertilizer requirements. Sorghum bio mass will increase with amount of nitrogen applied (Clark, 2007). There are multitudes of bacterial, fungal and viral disease of sorghum (Kucharek, 1992; Toler, 1985).

2.1.4 Pests and disease

Common fungal diseases include anthracnose, leaf blight, sorghum downy mildew, zouate leaf spot, rough spot, sorghum rust, charcoal rot and stalk rot/ grain mold. Grain can also be affected by fungal smut. Most viral diseases of sorghum are mosaics with the most important being maize dwarf mosaics (Toler, 1985). One of the most common bacterial diseases of sorghum is bacterial leaf strip (Kucharek, 1992).

Insect pests of sorghum can be split into groups including soil and seedling (wirp worms, white groups, beetle larvae, root worms, corn stalk borers, cut worms and chinch bugs), leaf and stalk boring (aphids, green bugs, whorl worms, bund worms, fall army worms, grass hopes, mites, stalk boring moth caterpillars and panckle) and seed pests (sorghum midgi, corn ear worm, fall army worms, sorghum web worms, stink bugs, false chinch bugs) (Teeles,. and Pendelton. 1999., Buntiu, 2012).

2.1.5 Uses:

Sorghum is a staple cereal in diet of over 750 million people in Africa and India to whom it provides the bulk of the dietary energy and protein (Aribisala, 1989,Aluko andOlugbemi.1990). Sorghum also contributes more energy and digestible protein in the diet of the majority of people in the Sub Saharan regions than those obtained from roots and tuber crops (Aba *et al*., 2004). It is prepared as food and drinks including unleavened or leavened breads thick provide (Asida).

The leaves and stalk are used as livestock feed and stalk mainly used for fencing, as fuel, or for making baskets and huts ,the emerging principal uses of sorghum as industrial raw material include the production of biscuits and confedionery, beverages, weaning food, foods and malted drinks (Aribisala, 1989).

Sorghum is recommended for infants, pregnant and lactating mothers (Obilana, 2005). Grits, flour, cakes, wax, syrups, starch and meals from sorghum are now common items in the markets (Abu, 2008).

2.1.6 Crop response to soil moisture:

Light, water and temperature are among the major determinants of plant growth. Combination of high light intensities, high temperature and water deficit, which

arise during drought stress are known to severely inhibit photosynthesis and hence crop productivity (Lndlow *et al*., 1990). High temperature and water deficit predispose plants to photo inhibition (Powles, 1989; Greer *et al*., 1986; Feierabend *et al*., 1992) besides affecting photosynthesis directly (Havgur, 1992). Several drought tolerant varieties of sorghum have been identified on the basis of their ability to give good yields under drought condition in the field. (Virita Tagtoy *et al*., 1998) studied the effect of water, heat and light stress on sorghum, they found that the drought tolerant variety showed high yield than other varieties. Jana Kholova *et al*., 2013 reported that most severe droughts were when stress began before flowering and resulted in failure of grain production in most cases, although biomass production was not affected so severely. The frequency of drought stress types were analyzed for selected locations through rabi tract and showed different zones had different predominating stress patterns. This knowledge can help better focusing research for adaptive traits and management practices to specific stress situations and accelerate improvement of rabi sorghum via targeted specific adaptation. The case study presented here is applicable to other sorghum growing environments.

The nature of crop water stress has been described as "terminal drought" with variable timing of onset during the crop cycle (Kassahum *et al*., 2010; Murty *et al*., 2007; Sajjanset *et al*., 2011). However no attention has been paid to quantifying the detailed nature of those drought patterns across seasons.

Stont, Darryl G. *et al*., (1988) reported that water stress influenced both rate and period of growth of sorghum bicolor L. Moench plants. Change in growth rate is one of the most sensitive plant responses to water stress (Hgiao, 1973). The final yield of sorghum crop is decreased when the plant exposed to water stress during the late vegetative to blown stage (Lewis *et al*., 1974). Also Stont and Simpson, (1978) reported that the effect of water stress on sorghum yield.

Kenneth L. Giles. *et al*., (1976) reported that sub cellular changes occurred in sorghum leaves during increasing water stress and subsequent re watering are described. Stomata were closed abscise acid levels were elevated the amount of starch in the bundle sheath. Chloroplast was much reduced and complete structural disruption of the tonoplase was formed.

Shahidumar (2006) reported that the amount of soil moisture available to plants in arid and semi- arid regions is a major limiting factor for crop yield under such conditions potassium fertilization proved helpful in mitigating the adverse water effects of water stress. The interaction of plant K status and water stress on yield and water relation of sorghum and ground nut was studied and it was found that the water content of leaf tissue was significantly increased by K application and also water stress caused grain yield reductions and K application could enhance yield to a grant extent.

Prabhjot Kanr Gill *et al*., (2001) studied the effect of various a biotic stresses on growth, soluble sugar, sugars and water relation of sorghum seedlings grown in light and darkness and he reported under these stress conditions relative water content and water potential of seedlings decreased dramatically subsequently. This reduction resulted in mark able decrease in fresh weight and a substantial increase in dry weight of stressed seedlings.

2.2 Cowpea:

Cultivars grown for the dry seeds are also known as black-eye bean, southern bean, china bean, kaffir pea and marble pea. Cultivars grown for immature pods are variously known as yard long bean, asparagus bean, bodi bean and snake bean.

There is considerable confusion in the synonymy and names, partly due to the presence of a number of distinctive forms of these cultivars. The wild cowpea,

indigenous to tropical Africa is *Vigna* ungiculata (L.) Walp. (Syn. baonlensis A. chev.). Some authorities consider that all cultivars belong to this species as they all cross readily with each other and produce fertile hybrids.

According to this view, *V. sinensis* and *V. sesquipedalis* become synonyms of *V. unguiculuta* (Purseglove, 1968a).

Others taxonomists recognize three species as follows:

Vigna unguiculata (L.) Walp. (syn. *Dolichos unguiculatas* L., *Phaseolus cylindricus* L., *Dolichos catjang Burm., Vigna cylinderica* (L.) Skeels, *Vigna catjang Burm.* Walp., *Vigna sinensis* var. cylindricus).

This is the catjany cowpea, which is the most primitive of the cultivars, and is cultivated in Africa, but isi commoner and has more cultivars (CVS) in Asia.

2) Vigna sinensis (L.), is known by the common name cowpea, with most CVS in Africa.

3) Vigna sesquipedalis (L.) Koem. This is commonly known as the asparagus bean or yard long bean, and is mostly grown for its immature pods. The crop is widely cultivated in the Far East, but it is also found in Africa.

If it is desired to separate the cultivated forms, from the wild *V. unguiculata,* the former should then bear the name *V. sinensis* All cultivated cowpeas varieties are grouped under *V. unguiculata,* subspecies *unguiculata,* which is subdivided into four culti groups, namely *unguiculata, Biflora sesquipedalis* and *Textilis* (Wesphal, 1974; Ng and Marechal, 1985).

2.2.1 Crop description and climate:

Cowpea is an annual, herbaceous legume. Plant types are often erect, semi-erect; prostrate (trailing) or climbing. There is much variability within the species; growth habit ranges from indeterminate, fairly determinate, to more determinate types. Cowpea generally is strongly tap rooted.

Cowpea seeds are variable in size, shape and colour, 2-12 mm long, and the weight of 100 seeds range between 10 and25 g. Seed shape is a major characteristic correlated with seed development in the pod, seeds develop a kidney shape if not restricted by pod. When the seed growth is restricted by the pod the seed becomes more globular.

The seed coat can be either smooth or wrinkled and of various colours including white, cream, green, buff red, brown and black (Purseglove, 1968b).

Many types are also referred to as "eyed" (black eye, pink eye, purple hull), where the white coloured hilum is surrounded by another colour. Emergence is epigeal (the cotyledons emerge from the ground after germination).

Cowpea generally is a short day plant; flowers are borne in multiple racemes of 20 to 25 cm length. Flower stalks (peduncles) arise from the leaf axils with two or three pods per peduncle but four or more pods may be carried in a single peduncle.

Cowpea is a warm season crop, well adapted to the humid, tropics and temperate zones. It tolerates heat and dry conditions, but is intolerant to frost. Germination is rapid at temperature above 18°C. Cowpea performs well on a wide variety of soil conditions, but performs on well-drained sandy loams or sandy soil where soil pH in the range of 5.5 to 6.5.

2.2.2 Crop establishment:

The crop should not be planted until soil temperatures are consistently above 18°C and soil moisture is adequate for germination and growth. Seeds will decay in cool wet soils.

In tropical Africa cowpeas are grown mixed with other crops or in pure stand. The seeds may be broadcast or sown in holes 15 cm apart with 2 seeds per hole at a depth of 2.5 - 7.5 cm. Sometimes cowpea is intercropped with sorghum or maize after 1 - 2 weeks from emergence of the main crops seedling.

In the Sudan the seed rate is 18 - 40 kg/ha depending on seed size and weight. It has been found that one kilogram of seeds contain 4000 - 9000 seeds (Khair 1999).

Excess nitrogen (N) promotes lush vegetative growth, delays maturity, may suppress (N) fixation and may reduce seed yield.

The seed yield ranges from 750 to 2800 kg/ha (Skerman 1977), cowpea maybe harvested for hay when the pods begin to turn yellow; the best quality of hay is obtained when the pods are fully mature. Hay yields range from 2.3 to 4.0 tons/ha (Milford and Minson 1968).

2.2.3 Crop responses to soil moisture:

During water stress, cowpea maintains fairly constant predawn leaf water potential (PL WP) at a level not much lower than that of unstressed plants, (Turk and Hall 1980). The same authors showed that small differences between leaf water potential of stressed and unstressed cowpea even after 43 days without irrigation was also similar, although drought stressed plants usually have lower leaf water potential than well-watered plants.

This behaviour of cowpea is unlike crops such as soybean (Wien *et al.*, 1979; Villalobs Rodriguiez and Shibles, 1985) and maize (Lai, *et aI.*, 1978), for which big differences in leaf water potential were found between drought stressed and unstressed leaves. The constancy of slow decline in PL WP suggests that cowpea can conserve water.

An explanation for this behaviour may be found in the change in leaf growth that limits evaporative water loss (Akyeampong, 1985).

Leaf expansion and abscission were sensitive to drought stress at the vegetative, flowering or pod-filling stage (Akyeampong, 1983). El Nadi *et al.* (1969) pointed out that shoots grew less with a dry treatment in both the vegetative and the flowering phases.

Abdelazim (1988) reported that frequent water intervals increase plant height while prolonged water intervals decreased grain yield.

Early erect cowpea cultivars, which flower about 30 days after sowing in the tropics, have proved to be useful in some dry environments because of their ability to escape drought (Hall and Patel, 1985).

Unfortunately, these cowpea cultivars may be more sensitive to mid season drought than medium spreading cultivars (Thiaw *et al.*, 1993).

Grain yield of cowpea is more sensitive to soil water deficit during flowering and pod-filling than during the vegetative stage (Ziska and Hall, 1983; Ziska *et al.*, 1985 and Akyeampong, 1983). A similar response was found for broad bean and for haricot beans
(El Nadi, 1970, 1975).

Indeterminate cowpeas begin flowering early but have delayed leaf senescence (DLS) after producing the first flush of pods, and the new leaves enable cow pea plants to produce a second flush of pods (Gwathmey *et al.*, 1992a).

Delayed leaf senescence (DLS) results from a higher proportion of plants surviving after the production of the first flush of pods and probably results from the maintenance of root activity in water transport (Gwathmey *et al.*, 1992b).

Hall and Schulze (2006) studied the factors responsible for the extreme drought avoidance of cowpeas and reported that well watered cowpea plants avoid drought by two mechanisms: by avoiding water loss, and efficient water transport.

2.3 Crop water stress and use:

Many aspects of plant growth are affected by water stress,(Slatyer(1967), Kramer(1969). Hsiao (1973) and Karamanos (1980) studied the effect of water stress on cowpea and pointed that water stress reduced leaf

production, promoted senescence and abscission and decreased total leaf area per plant, thus reducing biomass production.

Rawson and Turner (1982), seed production, which is positively con-related with leaf area, may also be reduced by leaf area reduction induced by water stress. Husman *et al.* (2000) reported that delaying irrigation had the effect of increasing grain protein content and decreased seed weight in Durum wheat. (Ricardo 1985), reported that cowpea seed content 24.8% of crude protein. Saeed and El N adi (1996, 1997), studied the effect of irrigation on growth, yield and water use efficiency of alfalfa and forage sorghum, they pointed out that dry matter production was consistently lower for the stressed plants, and also stressed plants have low WUE than the unstressed plants.

Mingcai, Z. *et al* (2004), reported that water deficit decreased biomass of stem and leaves and induced significant yield loss in Soya bean.

El Nadi (I 973) studied the significance of leaf area in evapotranspiration of cotton plants *(Gossypium barbadense* L.) and hyacinth bean *(Dolichos lablab* L.) and found that evapotranspiration per unit area of leaf surface per day declined progressively with age for both species.

Bauder *et al.* (I 978) found that alfalfa dry matter yield is directly related to water use and irrigation in linear manner and consequently the efficiency of water use increased with each increase in irrigation level.

McDonald *et al.* (2006) determined that lablab produced more biomass production and fixed more nitrogen (177 kg N/ha) than lucerne and thus lablab had a higher water use efficiency. The study indicated that lablab produces more green matter with greater water use efficiency than Lucerne.

Ali and Ahmed (2006) reviewed the effect of water stress on arrange of crops and reported that crops growth and production was adversely affected by water stress.

Abu Elgasim and ElNadi(2009) studied the response of pulse crop to different moisture condition and reported that irrigation ever 14 days reduced dry matter production and seed yield .

2.4 Intercropping:

In Sudan, intercropping of cereals with legumes is a predominant feature in the cropping system which is practiced in small scales as a means of maximizing the use of limited farm lands as well as attaining food security to the subsistence farmers. In western Sudan, the usual intercrop system practice is a cereal-legume mixture, where millet and sorghum are widely used as a cereal component of intercropping with crops such as a cowpea, groundnut, sesame and roselle (Osman,2003). Therefore, this system is considered to help farmers utilizing their limited resources (natural and labor resources) for attaining yield stability, obtaining higher yields per unit area, and having better control of weeds, pests, and diseases. In addition, it provides safeguard against familiar practice of the single crop. Some farmers grow it as mixture with sorghum or pearl millet without particular arrangement. The cowpea crop shows a great advantages through its use for human consumption, using the remaining biomass for animal fodder, attaining a good prevention of water run-off and evaporation from the soil surface according to its prostrating growth habit, besides its mothering the germination of Striga hermothica plants and other weeds and increasing soil fertility through the nitrogen fixation(ELNaim. *Et. al*.,2013).

Intercropping is a popular and traditional cropping system in the tropical part of the world. It is a strategy used by farmers for increasing crop yields, crop diversity and stability of crop production and returns (Remison, 1980). Willey (1979) observed that the yield advantages in mixed cropping could be substantial especially when the components of the mixture are complementary. Previous studies have indicated that sorghum/cowpea intercropping

combination is an important cropping system in the Sudan savanna of Nigeria (Henriet *et al.*, 1997). Sorghum being the major crop is planted at the beginning of the rainy season while cowpea is intercropped later. Under the indigenous systems, farmers use local sorghum varieties, which is tall, late maturing and photoperiod sensitive, producing heads at the end of the rainy season. Apart from having long period of vegetative growth, their growth is slow at the initial stage (Oluwasemire *et al*., 2002). Similarly, the cowpea cultivars used for intercropping with sorghum are late maturing, photoperiod sensitive, indeterminate and low yield. In such intercropping situation, competition among component crops becomes severe since both crops mature almost at the same time. However, a number of improved high yielding cowpea cultivars with a range of maturities and desirable agronomic characters have been developed (Singh and Ntare, 1985; Singh *et al.,* 1997).Intercropping the local sorghum with a fast maturing cowpea variety may ensure efficient utilization of solar radiation wasted at the initial stage as well as reduction of late season competition for water.

Another means of further reduction in competition for growth resources is by manipulating crop arrangement (Natarajan and Willey, 1985). Willey and Rao (1980) observed that increasing the total plant population markedly increased the competitive ability in favour of a component relative to the other. However, Rao and Willey (1980) observed virtually no difference in intercrop advantages between 1:1 and 2:1, sorghum/pigeon pea row arrangements Intercropping is the growing of two or more crops together on the same piece of land at the same time in a systematic manner that the growth of some or all the component plant types overlap in space and time (Elemo *et al.,* 1990. Baker ,1978) observed that in the tropics, cereals are commonly intercropped with legumes, in the hope that the farmer will benefit from the N-fixed by the later. Other benefits include maximum resource utilization and income stability (Abalu, 1976) and higher total returns (Elemo *et al.,* 1990).

Intercropping is the growing of two or more crops simultaneously on the same field during the season (Ofori and Stern, 1987) and is a traditional practice in the tropics. Okigho and Gerunland (1976) described intercropping as the most wide spread system in Africa. Ntare (1990) reported that farmers plant sorghum and cowpea in clusters at relatively wide spacing to avoid yield reduction in both crops. Aggarwal *et al.*, (1992) reported that the yield advantage of any intercrop is attributed to below-and above-ground plant interactions which are likely to vary depending upon the temporal and spatial differences in resource use by component crops. Thus, a fundamental understanding of how intercrops capture and use resources would provide a scientific basis of recommending appropriate crop combinations and spatial arrangements at different locations. Willey, (1979) reported that intercrop performance can be improved with respect to temporal and spatial complementarities by improving the compatibility of genotypes used as components of the mixture. Staggering the relative planting time of the crops would be an example to account for temporal differences in resource use by the crops. Intercropping is being looked at as an efficient and most economical production system as it not only increase the production per unit area and time but also improve the resource use efficiency and economic standard of farmer in the sub-Saharan Africa. Presently, interest in intercropping is increasing and fast becoming important among the small scale farmers because of their diversified needs and low farm income from the mono-cropping system.

The challenge therefore is to identify crops capable of sustaining their potential yield when grown in specific row arrangements with other crops. Spitters (1983) reported that yield of grain per unit area is an essential measure of mixture performance which represent only a part of total plant biomass and may not fully reflect the result of competition between species in mixture. A number of indices such as land equivalent ratio, relative crowding coefficient,

competitive ratio, actual yield loss, monetary advantage and intercropping advantage have been proposed to describe competition within and economic advantages of intercropping systems (Banik *et al*., 2000).

Intercropping is a common cropping system practiced by almost all small scale farmers. Many researchers have reported that the advantages of intercropping over mono cropping (Allen and Obura, 1983; Cahug and Shiles, 1985; Olasanian, 1988; Stoop, 1987Ogunwole, 2000; Quanies *et al*., 2009; Makirade *et al*., 2011). Other researchers have concentrated their work on how intercrops utilize more efficiently (Vandermee, 1981) and on plant water status (Wahna and Miller, 1978; Shacrel and Hall 1989). Intercrop ensures better interception of sun light energy, more effective utilization of water and nutrient and a higher exploration of the growing factors related to the environment (Willey abd Osim, 1972)

Sani .*et al*.,(2011) studied the growth yield and water use efficiency of maize-sorghum intercrop, then the results indicate that the row planting arrangement significantly out yield than alternate arrangement but was similar to the sole crop planting arrangement.

Land Equivalent Ratio (LER) values indicated more efficient utilization of space by intercrops than sole cropping. Intercropping also resulted in more efficient utilization of moisture by the intercrops comparing to sole crops.

(AbdElraham and Hago. 2005) studied the effect of intercropping on growth and yield of sorghum and reported that intercropping tended to reduce vegetative growth of sorghum. Moreover intercropping sorghum with pigeon pea and cow pea significantly increased seed yield/ plant and straw yield but it significantly reduced seed protein content and final seed yield. Intercropping increase 100- seed weight also intercropping depressed vegetative growth of both legumes. Intercropped pigeon pea showed no changes in number of seed/

pod and 100- seed weight. Intercropping of cow pea with sorghum resulted in non- significant reduction in the number of seed/ pod and 100 seed weight, but final seed yield of cow pea showed significant reduction with intercropping.

The land equivalent ratio for all the intercropping system was greater than one indicating that intercropping was more efficient than sole cropping in utilizing the available resources and resulted in higher productivity.

Oseni .and Aliyu (2010) reported that the grain and straw yields of both sorghum and cow pea were higher in sole cropping than in the intercropping mixtures and also 2S:1C(two row of sorghum and one row of cowpea) planting arrangement exhibited higher land equivalent ratio (LER) compared to other planting arrangements and sole crops and he found that intercropping of sorghum with cow pea at 2S: 1C planting pattern will give higher income better land efficiency and enhancing sustainability of crop production than sole culture of each species.

Mohammed *et al*., (2009) studied cowpea genotype and row arrangement affects on the productivity and economic returns of sorghum/cowpea intercrop in the Nigerian Savanna, the results indicated that grain yield and yield parameters of intercropped sorghum were not affected by cowpea genotype and row arrangement.

ELNaim *et al*., (2013) study the agronomic evaluation of sorghum and cowpea intercropped at different spatial arrangements, their results indicated that yield showed significant differences among the spatial arrangements. 1:1 arrangement obtained the highest values of sorghum panicle weight (57g), sorghum grain yield (1079kg/ha), sorghum hay weight (5572kg/ha) and combined total hay weight (7337kg/ha) for both sorghum and cowpea. Moreover, the best total land equivalent ratio(L.E.R) was obtained under 1:1 spatial arrangement.

2.5 Water conservation:

Water harvesting in its broadest sense is an umbrella term covering a wide range of techniques and methodologies to collect and conserve various forms of runoff water, originating from ephemeral water flows generated during tropical rainstorms, the aim is to mitigate the effects of temporal water shortages to cover both domestic and agricultural needs. In terms of upgrading rain fed agriculture, water harvesting can be categorized according to:

1) Systems that improve infiltration of rainwater into the soil.

2) Systems that prolong the duration of soil moisture availability in the soil. (Kaumbutho and Simalenga .1999).Arid and Semi-arid zones are characterized by low erratic rainfall of up to 700 mm per annum, periodic droughts and different associations of vegetative cover and soils. In the Semi-arid zones inter-annual rainfall varies from 20-50 % with averages of up to 700 mm (CASL, 2006).

The majority of the population in the Arid and Semi-arid areas depend on agriculture and pastoralism for subsistence. There is a need of a more efficient capture and use of the scarce water resources in Arid and Semi arid areas. An optimization of the rainfall management, through water harvesting in sustainable and integrated production systems can contribute for improving the small-scale farmers' livelihood by upgrading the rain fed agriculture production. In crop production systems, rainwater harvesting is composed of a runoff producing area normally called catchment area and a runoff utilization area usually called cropped basin. The major categories are classified according to the distance between catchment area and cropped basin as follow: In-situ rainwater harvesting ,Internal (Micro) catchment rainwater harvesting and External (Macro) catchment rainwater harvesting and spate irrigation (flood water harvesting) (Hatibu, and Mahoo, 1999).

Other important requirements to be considered in the implementation of water harvesting systems for crop production are the slope of the area and operation

costs. Such techniques are not recommended for areas where slopes are greater than 5 %, due to uneven distribution of runoff and large quantities of earthwork required which is not economical (Critchley and Siegert, 1991). Labor cost for construction and maintenance of water harvesting systems is the most important factor to be considered, which determines if a technique will be widely adopted at the individual farm level. Many farmers in arid and semi-arid areas do not have the manpower available to move large amounts of earth that is necessary in some of the large water harvesting systems .

2.6 Types of water harvesting techniques:

According to (Nasr, 1999), there are two basic types of runoff-farming systems: Direct water application system, where the runoff water is stored in the soil of the crop growing area during the precipitation and supplemental water system, where the collected water is stored offsite in some reservoirs and later used to irrigate a certain crop area.

Some of the typical examples reported by (Prinz, 2002) and (Critchley and Siegert, 1991) are:

a) Inter-row water harvesting: is applied either on flat land or on gentle slopes of up to 5% having soil at least 1 m deep. The annual rainfall should not be less than 200 mm/year. On flat terrain (0- 1% inclination) bunds are constructed, compacted and under higher-input conditions, treated with chemicals to increase runoff. The ridges of about 0.40 m height are built 2 to 20 m apart, depending on slope, soil surface treatment, and type of crop to be grown. On sloping land, this system is recommended only for areas with a known regular rainfall pattern; very high rainfall intensities may cause breakages of the bunds.

Crops cultivated in row water harvesting systems are maize, beans, millet, rice or (in the USA) grapes and olives (Pacey and Cullis, 1986). The preparation of the land for inter-row water harvesting can be fully mechanized.

b) Micro-catchments systems: Micro-catchments water harvesting (MC-WH) is a method of collecting surface runoff from a small catchments area and storing

it in the root zone of an adjacent infiltration basin. This infiltration basin may be planted with a single tree, bush or with annual crops (Boers and Ben-Asher, 1982).

Their main characteristics include a simplet design and cheap to install, therefore easily replicable and adaptable, higher runoff efficiency than medium or large scale water harvesting systems and have no conveyance losses.

c) Medium-sized catchments water harvesting: Water harvesting from medium-sized catchments (1,000 m2 –200 ha) is referred to by some authors as "water harvesting from long slopes", as "macro-catchments water harvesting" or as "harvesting from external catchments systems" (Reij et al., 1988). It is characterized by the C/CA ratio is 10:1 to 100:1; the catchments being located outside the arable areas. The catchments area may have an inclination of 5 to 50%; the cropping area is either terraced or located in flat terrain.

d) Large catchments water harvesting: Large catchments water harvesting comprises systems with catchments being many square kilometers in size, from which runoff water flows through a major Wadi (bed of an ephemeral stream), necessitating more complex structures or dams and distribution network.

In-situ rainwater harvesting: In-situ rain water harvesting, also called soil and water conservation, involves the use of methods that increase the amount of water stored in the soil profile by trapping or holding the rain where it falls (Hatibu and Mahoo, 1999; Stott *et al*., 2001). In this application there is no separation between the collection area and the storage area, the water is collected and stored where it is going to be utilized (UNEP, 1997). It is basically a prevention of net runoff from a given cropped area by holding rain water and prolonging the time for infiltration. This system works better where the soil water holding capacity is large enough and the rainfall is equal or more than the crop water requirement, but moisture amount in the soil is restricted by the amount of infiltration and or deep percolation (Hatibu and Mahoo, 1999).

The *in-situ* rainwater harvesting for crop production purposes is better achieved by the means of conservation tillage, conservation farming and conventional tillage. Such physical conservation measure involves land shaping, the construction of contour bunds, terraces and ridges (FAO, 1993).

Ridge tillage has been defined as "a method of land preparation whereby the topsoil is scraped and concentrated in a defined region to deliberately raise the seedbed above the natural terrain" crops are usually grown on the ridges in rows, with one or more rows per ridge, even though in some cases crops may be grown in the furrows to take the advantage of the wetter condition of the soil under the furrow. It is an effective water management and erosion control practice when the system is established in the contour (contour ridge) and the slope of the land is less than 7 percent (Moldenhauer and Onstah 1977 and Storey, 2003). Ridge tillage is very effective in conserving water in the root zone in semi-arid to sub-humid regions, particularly when ridges have cross ties in the furrows (known either as tied-ridging, furrow blocking or basin tillage) (Gardner *et al*. 1999). In clayey soil, tied-ridging is likely to reduce surface runoff and increase retained water within the field if carefully designed across the slope. Past and recent research works in Africa has shown that tied ridging often leads to little or no runoff. In Zimbabwe; Piha (1993) and Vogel (1993), in Botswana; Carter and Miller (1991) and in Burkina Faso; Hulugalle and Malton (1990) have shown similar results of more retained water and less runoff. Similar results were also obtained in USA; Krishna (1989). Growing a crop on or between ridges has the following advantages and disadvantages:

On lightly sloping land, ridges along the contour can curb rainwater runoff and thus erosion by increasing the surface relief; however, tillage along the contour lines is complicated, especially if a particular field has slopes in more than one direction, it can easily lead to increased erosion; in high rainfall areas and poorly drained soils, ridges allow a better water management; on the other hand, ridges often dry faster and will take longer to wet after a dry spell, and

germination of a crop planted on ridges is quite often observed to be slower than a crop planted on flat land; by ridging, any organic matter or fertilizer which is present at or near the soil surface, will be concentrated in the ridge and will thus be of greater benefit to the crops contour ridges, sometimes called contour furrows, are small earthen banks, with a furrow on the higher side which collects runoff from an uncultivated strip between the ridges. In Israel and North America they are called ‘desert strips’. Through their shape, soil moisture is increased under the ridge and the furrow, in the vicinity of
plant roots. The advantage of this system is that the runoff yield from the short catchment length is very efficient. Labor requirements are relatively low and contour ridges are easy to make using hand tools. Ridging is done by constructing small earth banks parallel to the contours of a slope.

A variation on ridging is the partitioned furrow technique, better known as tied-ridging. In this system lower ridges, cross-ties (15-20 cm high), are made every few meters across the contour furrows, creating mini basins.

In case of light rainfall, the water remains in the mini-basins. When rainfall is heavy, the water runs off over the cross-ties along the contour, because the cross-ties are lower than the ridges and the furrows are built at an angle to the contour. Tied-ridging can be used only where rainfall does not exceed the storage capacity of the furrows; otherwise severe erosion may be the result. The construction and maintenance of ridges is hard work, especially on heavy (clayey) soil. In order to spread the work out, in the first year the contour ridges can be ploughed using an ox-plow or tractor drawn implement with a reversible blade and the cross-ties can be made by hand.

2.7 Tillage:

One of the basic and important components of agricultural production technology is soil tillage. Various forms of tillage are practiced throughout the world, ranging from the use of simple stick or jab to the sophisticated para-

plough. The practices developed, with whatever equipment used, can be broadly classified into no tillage, minimum tillage, conservation tillage and conventional tillage. Energy plays a key role in the various tillage systems. An important question underlying all these practices is: why till? Much has been written on this topic and it can be summarized as follows:

- seedbed preparation
- soil and water conservation
- erosion prevention
- loosening compacted soil
- weed control

The best management practices usually entail the least amount of tillage necessary to grow the desired crop. This not only involves a substantial saving in energy costs, but also ensures that a resource base, namely the soil, is maintained to produce on a sustainable basis. Tillage affects soil physical, chemical and biological properties. Research results have been widely reported on the effects of tillage on soil aggregation, temperature, water infiltration and retention as the main physical parameters affected. The magnitude of the changes depends on soil types as well as soil composition. Changes in chemical properties are dependent mainly on the organic matter content of the soils. Tillage affects aeration and thus the rate of organic matter decomposition. Biological activities in the soil are vital to soil productivity through the activities of earthworms, termites and the many other living creatures in the soil. These influence water infiltration rates by their burrowing in the soil and their mucilage promotes soil aggregation. Tillage effects on soils are closely related to the management of crop residues in and on the surface of the soil. Unger *et al*. (1991) point out that the two practices with major impact on soil conservation are crop residue management and tillage. The traditional plough-in

of crop residues is now giving way to surface soil residue management, which is more related to soil and water conservation, particularly in the semi-arid tropics.

A large volume of experimental data has been published on tillage effects on crop yields under various climates, agro-ecological conditions, soils, crops and residue management systems. Under some of these conditions, the tillage effect is either closely linked to soil aggregation, hence water infiltration rate and water storage capacity, or indirectly related to soil and water conservation. Moisture conservation is particularly important in semi-arid conditions.

Soil types and their various reactions to tillage are of paramount importance in determining the superiority of one practice over the other. Socio-economic considerations, however, should always be taken into account in decision making for the adoption of one practice over another. Difficulties have arisen in the past because limited information was given on soil types when comparing one tillage treatment with another. There must be some caution with technology transfer from one agro-ecological zone or one soil type to the other. There has also been some confusion with the treatment regarded as no-tillage. Whereas in some cases, surface soil was mulched, or herbicides used to kill weeds *in situ*, there have been many instances in which residues were removed. In such cases comparison becomes not only difficult but conclusions are drawn which may not apply to similar agro-ecological conditions and soils.

Tillage is defined as the mechanical manipulation of soil for any purpose. Manipulation involves soil disturbance and this can have great deteriorative consequences if not carefully or adequately incorporated.

Tillage modifies the soil surface where the complex and crucial partitioning of rainfall into runoff, infiltration and subsequent evaporation occur (Mwendera, 1992). Tillage systems affect the amount of water moving both over the surface and through the soil. Moldboard or other inversion types of plowing increase

the rate at which water moves into soil over the short term. However, after several rainfall events, a crust often forms at the surface, reducing infiltration rate. The highest runoff sediment losses were observed for conventional tillage. Runoff rate is inversely related to soil infiltration rate (Rockwood and Lal 1974). Studies by Lindstrom and Onstad (1984) showed a higher runoff volume for no tillage as compared to conventional tillage. Conservation tillage reduces soil losses ,but does not always reduce the volume of runoff as effectively as it reduces sediment losses Tillage is an important crop production practices which may affect crop performance differently. Tillage creates an ideal seedbed condition for plant emergence, plant development and unimpeded root growth. Tillage practices are critical components of soil management systems (Mosaddeghi *et al.* 2009). Inappropriate tillage practices could inhibit crop growth and yield. The selection of an appropriate tillage practice for the production of sorghum is very important for optimum productivity. A good soil management protects the soil from water and wind erosion, destroys hardpans or compacted layers that may limit root development. The objectives of tillage are to develop a desirable soil structure or suitable tilth for a seedbed (Srivastava *et al*, 2006) for the tillage optimum growth and yield of the crop. Different tillage practices may influence the growth and yield of grain sorghum. ELNaim *et al*., (2012) studied the effect of tillage depth and pattern on growth and yield of sorghum under rain fed and reported that the tillage practices treatments consist of no tillage, tillage at depth 15 and 25 cm and two tillage patterns namely: headland and continuous patterns, using chisel plough. The results showed that tillage treatments had significant effect on most of the parameters measured in this study. In this respect, it was observed that increased tillage depth increased plant height, length of internodes. Length of flag leaf, panicle length, number of seeds per panicle, panicle seed weight, grain yield (Kg/ha) and harvest index. The tillage depth of 25cm with head land pattern had the highest number of grains per panicle, panicle grain weight and grain yield

(t/ha), while the no tillage treatment had a lesser grain yield and yield's components. Based on the results of this study, chisel plough at depth of 25cm with headland operation had the highest grain yield and yields components and preferred to maximized the productivity of grain sorghum in gardoud soil like Khorelabeid and Kaba areas in North Kordofan of Sudan.

The in-situ rainwater harvesting for crop production purposes is better achieved by the following means: conservation tillage, conservation farming and conventional tillage.

Where these biological soil conservation measures cannot be done to full effect, particularly in areas of high intensity storms, or where there are periods of poor crop cover, earth works (physical control measures) can provide surface protection by holding water to give it time to soak through the surface. Such physical conservation measures involve land shaping, the construction of contour bunds, terraces and ridges

Mohamed *et al*., (2012).studied the performance of soil moisture retention and conservation tillage techniques as indicated by sorghum (*Sorghum bicolor* L. Moench.) yield and yield components, and reported that the potential advantages of conservation tillage for semi-arid zones and in particular for Northern Gedaref, Sudan. In reference to the rationale of adopting tillage techniques and depending on the results of this work the following conclusions can be summarized as follows:

1. Conservation tillage techniques improved soil moisture stored within the root zone as compared to the conventional harrowing using the wide level disc, resulting in higher dry matter and grain yield of sorghum.

2- The zero-tillage technique was best than conventional tillage, but becomes clearer late in the season and in coming seasons, this effect may be due to the absence of the plant residues that they could be removed for other uses.

3- The zero-tillage and wide level disc treatments were found not conservative to the effect on initial infiltration rate. For time to reach final intake rate chisel plow is the one that takes little time.

4- The zero-tillage treatment has a small effect on precipitation use efficiency. Some authors have thus ascertained no differences in cereal production between tillage systems (Unger, 1994; Schillinger, 2001), other researchers observed greater soil water storage under no-tillage and thus better crop yields and water use efficiencies (Lawrence *et al*., 1994; Bonfil *et al*., 1999). Since 1945, the wide level disk (WLD) with seeder box constitutes the lonely machine used for sorghum cultivation in all mechanized farming areas of the Sudan. Yousif (2001) stated that continuous use of WLD is believed to have led to the deterioration of the soil physical properties and may have created a hard pan at the depth of cut. This in turn had resulted in decreased water infiltration rates, reduced crop root growth, caused water runoff and decreases the yield of sorghum (Salih and El Amin, 1986). Inaccurate seeding depth, with seeds often placed too deep or too shallow thus causing uneven emergence and randomly scattered and patchy stand. These scattered plants make it impossible to control weeds with an inter row cultivator. Moreover, manual weeding of scattered plants usually results in decreasing the plant stand by unintentional eradication of the crop.

Aikins and Afuakwa (2012),studied the effects of four different tillage practices on cowpea performance, then reported that, there was significant difference in *Asontem* cowpea growth, dry matter yield and yield components between tillage practices. Disc plough followed by disc harrowing gave the best results producing the highest percentage seedling emergence, tallest plant, biggest stem girth and greatest number of leaves. Furthermore, disc plough followed by disc harrowing resulted in the longest root length, highest dry matter yield, highest number of pods per plant, highest number of seeds per pod and highest 1000 seed-weight. The no tillage plots produced the shortest plants, smallest stem

girth and smallest number of leaves. In addition, the no tillage plots gave the shortest root length, lowest dry matter yield, smallest number of pods per plant, smallest number of seeds per pod and smallest 1000 seed-weight. Therefore, considering the soil and weather conditions of the experiment the best tillage practice for *Asontem* cowpea growth and yield is disc plough followed by disc harrowing.

Mohamed1 *et al*.,(2011),study the of tillage and farm yard manure on yield and yields components of grain sorghum (*Sorghum bicolor* l.monech) in rain-fed and reported that tillage depth of 15cm and cow manure of 24 t/ha are effective and recommended to improved yield of grain sorghum in gardoud soil of North Kordofan of Sudan under rain-fed.

2.7 Traditional tools and implements:

Animal traction continues to increase in many parts of the world, particularly those where there are significant numbers of smallholder farmers. Animal power will continue to be important for food security, self-reliance and poverty alleviation.

Animal power is renewable natural resource that can assist not only in production, but also in land and water management and conservation. All countries, whatever their degree of industrialization and urbanization, can benefit from ecologically sustainable power sources.

In past years, animal power has been a neglected option, but governments, planners; agencies and the private sector are now taking it more seriously. Animal power should become an integral part of national development strategies, including those relating to food security, resource conservation, rural transport, employment and women in development. With a favorable policy environment and developmental support, the private sector can sustain and develop animal power technologies, benefiting rural communities and economies. Animal power issues need to be adequately covered in education and training programs and in modern media.

The trend with small-scale farmers is more towards conventional tillage where nearly all farmers using draft animals, and mould board plough their fields and those who have access to tractors disc plough and harrow. A hand hoe is most common and has been used by some farmers to prepare their fields for dry planting (minimum tillage), a method that has been reported to be restricted to very small portions of land. It is a tiresome operation as it is performed during hot season and farmers only use it because they have no other options. Planting on ridges and broad beds has also been observed but the practice seems to be a traditional land preparing method that eases planting and weeding. Ridges are rarely made across the slope. Recently, draft animal power projects have introduced animal drawn tine implements such as rippers and results from the two-year trials appear promising. These implements work the soil faster than the mould board ploughs and hoes, however, there are also negative outputs associated with their use. They do not allow incorporation of manure into the soil and weeds tend to grow faster than in conventional tillage systems and weeding is constraint if cultivators are not applied.

Over years, agricultural practices in Sudan have been carried out by small-holder farmers, using hand and animal drawn traditional tools and implements. Traditional agricultural tools and implements refer to those invented in ancient times, and used for a long time, until recently or still being used now. Traditional farm tools and implements for self sustenance have been developed and modified through experience over generations to meet emerging socio-economic and farming challenges. Traditional agricultural tools and implements were made up of locally available materials like stone, wood and iron, constructed at local level or standardized factory-made implements. These tools and implements were economical in term of labour, money and time saving (Karthikeyan *et al*., 2009). Also, they are operated easily without any special skills. Each of these tools and implements are usually used in connection with specific operation in the sequence of agricultural operations; land clearance and

preparation, sowing, weeding, irrigation, harvesting, post-harvesting operations and transportation.

Plough (Mehrath or Mohrat) usually, small farmers and farm owners of scattered lands are unable to use tractors and in that case ox-ploughs are highly preferred. The basic components of the plough are a shoe, a body, a handle and a beam .This implement can be used with a pair of oxen to till fields before planting. It has a single bottom mould board plough and in most working conditions the depth of plough is 15 cm. The hitching point can be adjusted height-wise and sideways to control the working depth and stabilizes the plough while in operation.

In Sudan the main energy source on small farms is still the human being and animal for carry out farm work. Many traditional hand and animal drawn tools and implements soon become dull, but farmers continue to use them until they are worn beyond efficient use because there is no alternative. Some of them are disappearing and being replaced either with factory-made implements or with more standard tools Elzubeir (2014).

2.8 Terrace:

In the Sudan, many indigenous water-harvesting techniques are practiced in different parts of the country e.g. Jebel Marra area and Red Sea Hills. The local people in Western Sudan, in general, use several techniques; namely, Haffirs, Rahads, Fulas, and Turdas, beside many other techniques to harvest water for agriculture and domestic use. In Southern Darfur, the local people grow pearl millets, groundnut and sesame on sands and grow cowpea, sorghum, fruits garden and vegetables on clay, and valley soils using indigenous water harvesting techniques ,the harvesting of sheet flow runoff is traditional techniques practiced in many parts of the Sudan (Van Dijk, 1991). It was found to be very successful for establishing trees under semi-arid conditions.

The terrace is a relatively elevated land non-flooded by Khors to utilize runoff water on steep slopes. This is accomplished by constructing U-shape bunds across the slope of rolling lend to arrest or trap sheet flow runoff generated after rain storms on catchments usually 2-3 times the size of the cultivated land (Van Dijk, 1991; Critchley and Reij, 1989). Simple stone lines and earth bonding systems are found in Eastern Sudan.

Water harvesting reduces the increasing pressure over the (limited) blue water. In the Nile Basin, only 5% of the rainfall comprises the river discharge (blue water). However, water harvesting, utilizes part of the rain which hardly finds its way to the Nile. This increases water productivity in general, while relaxing the mounting tension over the limited Nile water

Karrar *et al.*, (2012) study the Effects of some *in-situ* water harvesting techniques on soil moisture and sorghum(*Sorghum bicolor* (L.) Moench) production in Northern Gedaref State.The study revealed the potential advantages of *in-situ* water harvesting for semi-arid zones and in particular for Northern Gedaref, Sudan. Depending on the results of this work the following conclusions can be summarized as follows:

1- *In-situ* water harvesting techniques improved soil moisture stored within the root zone as compared to the conventional harrowing using the wide level disc, resulting in higher dry matter and grain yield of sorghum.

2- Ridge and furrow techniques were the best, but the distance between furrows, furrow height and ridges width in TR(Tied ridge) and CR(Contour ridge) as well as the distance between ties in TR(Tied ridge), should be intensively studied to determine the best

ratio of run-on to run-off area, also the possibility of growing more than one row per ridge.

3- *In-situ* water harvesting techniques conserve a good infiltration rate till the end of the season this appears in initial infiltration rate measured at the end of

the seasons. Also they took less time to reach final infiltration which reflects the easiness of water percolation into the soil.

4- *In-situ* water harvesting techniques affect yield and yield component in an increasing manner especially grain and dry matter yield.

2.9 Season and location:

The sub-humid climatic zone of Africa permits the cultivation of a variety of crops in a pattern that emerged in earlier centuries in response to local conditions (Onyekwelu *et al.*, 2006). It follows therefore that any change in climate may impact the agricultural sector in particular and other socio-economic activities in general. Climate change could have both positive and negative impacts and these could be measured in terms of effects on crop growth, availability of soil water, soil fertility and erosion, incidents of pests and diseases, and seal everise (Onyekwelu *et al*., 2006).

Semenov, (2009) Butterworth et al.,(2009) Seasonal weather variability has a direct influence on the quantity and quality of agricultural production in tropical Africa. Specifically in Nigeria, Agricultural production is at the mercy of weather which had been providing the opportunities to use agriculture for economic means most importantly the rural dwellers. It is for this reason among others that the farmers in the forest-savanna transition zone of Nigeria mostly practice intercropping since, there is more regular pattern of water availability in the zone. Intercropping which has been associated with such advantages as better utilization of environmental factors, greater yield stability, soil protection, variability of food supply increasing the return per unit area and insurance against crop failure.

Makinde, *et al.*,(2011)studied the seasonality and crop combination effects on growth and yield of two sorghum (*sorghum bicolor*) cultivars in sorghum/maize/okra intercrop in a forest-savanna transition zone of nigeria , and reported the results showed that the season 2010 crops had relatively longer

growth duration, received more rainfall than season 2009 (692 vs. 487.2 mm) while 2009 experienced warmer temperature during establishment cum early vegetative stage than 2010 season (33.2 vs. 32°C) and (28.5 vs. 27°C) during the reproductive phase for season 2009 and 2010, respectively. The mean grain yields of sorghum cultivars were significantly higher in the season 2009 especially in okra combination than in the season 2010. Perhaps, this was due to higher mean soil temperature of 28 and 26°C at 5 and 20 cm in 2009 season compared with season 2010 when mean soil temperature was 27 and 25°C at 5 and 20 cm, respectively.

In this study, the result indicated that the pattern in the variation of principal environmental parameters led to increase in the sorghum yield during the season 2009 and reduction in season 2010 sorghum yield in both sole and mixed crop.

CHAPER THREE

MATERIALS AND METHODS

3.1Experimental site:

A field experiment was conducted for two consecutive seasons 2011/12 and 2012/13 in two locations in the demonstration farm of Faculty of Natural Resources and Environmental Studies of EL salam University in Elfoula and Babanous, Western Kordofan State, to study the effect of soil water conservation of sorghum intercropped with cow pea.

The experimental sites lie at the border of savanna belt, latitude 9°:2ˉ - 14°: 50 north and longitude 27°: 30ˉ 32ˉ East. The distance between the experimental sites is 75km. The climate of the locality is semi- arid and tropical with maximum rainfall in August. Average rainfall was 400- 650mm. The soil is loamy to sand clay in the south (Elfoula Agric. Report, 2014).

3.2 Land preparation:

The land was prepared by Had hoe (local farmer instruments) and animal traction plough, half of the area ploughed by both methods was terraced and the other without terrace, the spacing was 60cm between lines and 40cm between holes. The area of the plot was $5\times5m^2$ consisting of eight lines of 4.8cm length. Sowing was done on the first week of July for season 2011/ 2012- 2012/ 2013 of Babanousa location and third week of July at Elfoula location.

Seeds were sown in holes for both crops then thinned after three weeks from sowing to 4 plants per hole and 3plant per hole for sorghum and cowpea respectively. The intercrop was row/row(1:1) planting.

3.3 Layout and experimental treatment:

Split- plot design with three replications were used, the main plots used for land preparation methods include hand hoeL_1), hand hoe with Terrace (L_2), animal plough (L_3), animal plough with terrace (L_4). The sub plot was used for crop sowing methods mainly sorghum mono cropping (S_1), sorghum intercrop (S_2), cowpea mono cropping (C_2) and cowpea intercropped (C_1).

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3. 4 Source of seeds:

The seeds of sorghum , and cowpea crops were obtained from Elfoula local source.

3. 4 Seed rate:

The seed rate was as follows:

7.5kg/ha for sorghum and 19kg/ha for cowpea

3. 5Weeds and insects control:

Three hand weeding were done during the growing seasons. The insecticide Sevein 85% was sprayed after 21 days from sowing to protect the sorghum crop from stem borer, also Mathione 75% was used mainly after cowpea flowering and pods setting to control flee beetle and bugs and it was severe affected during the second season in Babanousa location.

3.6 Characters studied:

3.6.1 Growth attributes:

Five plants were randomly selected from the centered line every 15 days at 30, 45 and 60 days after sowing to study the following characters:

3.6.1.1 Plant height (cm):

Measured from the base of the main stem to the tip of the youngest leaf using measuring tape.

3.6.1.2 Stem diameter:

Measured using Vernior Caliper.

3.6.1.3 Leaf area (L. A.):

Measured on the three leaves on the stem down the flag leaf, the length was measured from leaf base up to apex, also leaf width was measured then leaf area was calculated as follows for sorghum:

L. A. = length of fourth leaf × maximum leaf width x 0.75(sorghum)

L.A. = Tip leaf length x maximum leaf width x 0.624(cowpea)

3.6.1.4 Seed per pod:

Number of seeds per pod of cowpea crop were determined by selecting ten pods randomly from each treatment.

3.5.1.5 Panicle length(mm)

It was measured from panicle base up to panicle tip of ten randomly selected panicle for each treatment.

3.7 Fresh weight (t/ha):

Half from the outer line from each plot was harvested and immediately weighted to determine fresh yield then transferred into(kg/ha).

3.8 Dry weight (t/ha):

250 gm sub sample from each plot fresh were taken using a sensitive balance to determine the dry weight of each treatment then expressed in(t/ha).

3.5.1.8 Seed yield:

The seeds from the harvested area (five lines) were collected threshed and the seed yield was expressed in t/ ha, also 1000s seed weight for sorghum and 100s seed weight of cowpea were determined using a sensitive balance.

3.9 Final hay yield:

Final hay yield was taken from the reserved five lines of each experimental plot. A spring balance was used for weighing the samples in the field and then expressed in t/ha. The plant harvested after 150 days from sowing date for the two seasons and location.

3.10 Harvest index (%):

Harvest index was calculated as follows:

Harvest index = Economic yield / Biological yield × 100

3.11 Land Equivalent Ratio (L. E. R):

Land Equivalent Ratio (L. E. R) was calculated as follows:

$L.E.R_{Sorghum} = (Y_{si}/Y_{ss})$;

$L.E.R_{Cowpea} = (Y_{Ci}/Y_{Cs})$;

Y_{ss} = Yield of sole (mono crop) sorghum

Y_{si} = Yield of sorghum intercrop

Y_{Ci} =Yield of cowpea intercrop

Y_{Cs} = Yield of cowpea mono crop.

3. 12Statistical analysis:

Statistical analysis carried out by using statistix 8.0 .Data collected were subjected io individual analysis of variance for Elfoula and Babanousa separately and the combined analysis of variance using the method described by Gomez and Gomez(1984) for split-plot design, where as the meaning were compared through (LSD) test(Steel,et al.,1997) at p=0.05

CHAPTER FOUR

RESULTS

4.1 growth parameters:

The effect of soil water conservation methods on growth parameter of sorghum intercropped with cowpea in Elfoula season 2011/12 and of 2012/13 is summarized of as follows:

4.1.1plant height in (cm):

The effects of soil water conservation on plant height in Elfoula season one and two are in table (1a and 1b) for the two seasons respectively. Generally the soil water conservation method L_4 (animal traction with terrace) gave higher plant height compared with other soil water conservation methods and L_1 (hand hoe)showed of the lowest plant height in the three sampling (30, 45 and 60 days, after sowing), and S_1 (sorghum mono crop) showed the highest of plant height in three samplings of the two seasons.

Statistical analysis shows that there was a high significant difference between soil water conservation methods of in season 2011/12 in the three samples (30, 45,60days, also there was significant difference between methods of crops sowing in (45,60days) but 30days sample was not significant.

statistical analysis of season two showed that there was a significant difference in soil moisture conservation and methods of crop sowing in sample (30, 45 days), and 60 days sample showed no significant. Interaction between soil water conservation methods and crop sowing show a highly significant of differences in the three samplings for the two seasons.

Table 1_a. The effect of soil water conservation methods on plant height (cm)of sorghum intercropped with cowpea in ELfuola season 2011/12:

Day after sowing	**30 days**					**45 days**					**60 days**				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	33.8^{ab}	30.4^{ab}	31.2^{ab}	27.4^{b}	30.2^{b}	51.2^{ab}	48.3^{ab}	48.1^{ab}	54.1^{ab}	50.4^{b}	80.8^{bc}	75.2^{c}	90.7^{abc}	92.2^{abc}	84.7^{c}
L_2	40.6^{a}	36.3^{ab}	39.3^{ab}	31.9^{ab}	37.02^{a}	54.5^{ab}	53.9^{ab}	52.4^{ab}	59.8^{ab}	55.2^{ab}	101.5^{ab}	92.4^{abc}	98.6^{abc}	105.5^{a}	99.6^{ab}
L_3	36.5^{ab}	31.5^{ab}	37.6^{ab}	33.8^{ab}	34.9^{ab}	53.1^{ab}	52.1^{ab}	47.2^{b}	54.2^{ab}	51.7^{ab}	101.6^{ab}	81.5^{bc}	93.3^{abc}	93.5^{abc}	91.7^{bc}
L_4	40.4^{a}	37.9^{ab}	41.0^{a}	36.5^{ab}	39.55^{a}	64.2^{ab}	59.9^{ab}	50.4^{ab}	65.9^{a}	60.1^{a}	107.5^{a}	98.1^{abc}	104.0^{ab}	105.6^{a}	103.9^{a}
X	37.9^{a}	34.1^{a}	37.3^{a}	32.4^{a}		55.8^{ab}	53.6^{ab}	49.5^{b}	58.5^{a}		97.96^{ab}	86.8^{b}	95.9^{ab}	99.5^{a}	
CV%					21.3					19.81					14.92
LSD_C					2.17					3.12					4.59
LSD_L					2.17					3.12					4.59
LSD_{CXL}					4.35					6.22					8.18

L_1 hand hoe, hand hoe , L_2 Geria with terrace, L_3 animal plough and L_4 animal plough with terrace. S_1 Sorghum mono crop,S_2 Sorghum intercrop,C_1 Cowpea intercrop, C_2 = Cowpea mono crop. Means followed by different letters are significantly at $p < 0.05$ (Duncant test).

Table 1_b. The effect of soil water conservation methods on plant height(cm) of sorghum intercropped w 2011/13:

Day after sowing	30 days					45 days				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	47.5^{cde}	46.3^{def}	42.3^{def}	40.1^{ef}	44.1^{b}	89.4^{ef}	85.0^{f}	87.1^{ef}	91.5^{ef}	88.2^{c}
L_2	55.8^{ab}	49.3^{bcd}	42.6^{def}	42.8^{def}	47.6^{ab}	101.2^{bcde}	97.1^{cdef}	93.1^{cdef}	101.9^{bcd}	98.3^{b}
L_3	48.9^{bcd}	51.8^{abc}	39.3^{f}	42.2^{def}	45.6^{b}	98.5^{cdef}	87.1^{def}	86.1^{ef}	91.7^{def}	90.8^{bc}
L_4	50.9^{a}	56.2^{ab}	45.8^{cdef}	44.2^{cdef}	51.3^{a}	124.1^{a}	116.2^{ab}	99.0^{cdef}	107.6^{bc}	111.7^{a}
X	52.8^{a}	50.9^{a}	42.5^{a}	42.9^{a}		103.3^{a}	96.3^{ab}	91.3^{b}	98.2^{ab}	
CV%					10.2					9.6
LSD_C					1.97					3.81
LSD_L					1.97					3.81
LSD_{CXL}					3.93					7.61

Symbols are as in Table 1a

4.1.2 Stem diameter(mm):

The effect of soil water conservation on stem diameter in Elfoula in season 2011/12 and 2012/13 are shown in Tables ($2_a$and 2_b) respectively.

The soil water conservation methods L_4 and L_2 gave the highest stem diameter in the thee samplings (30, 45, 60 days, also S_2 (sorghum intercrop) show high stem diameter, the trend was constant in the three samplings .

Statistical analysis showed that there was highly significant difference of soil water conservation methods, crop sowing method and interaction of soil water conservation method with crop sowing in the three sampling of the two seasons.

4.1.3 Leaf area(mm2) (L.A. about 30, 45, 60 days):

The effect of soil water conservation methods on (L.A.I) in Elfoula seasons 2011/12 and 2012/13 are shown in Tables (3_a and 3_b) for the two seasons respectively.

The soil water conservation method L_4 (animal traction with terrace) showed the highest L.A and, S_1 (sorghum mono-crop) sowing methods gave high L.A. in the three samplings for the two seasons. Statistical analysis showed that L_4 (animal traction), results was significant different in three sampling of the two seasons and also S_1 (sorghum mono crop), shows significantly difference in the three samplings of the two seasons. Interaction of soil water conservation methods with crop sowing showed highly significant differences in the three samplings of the two seasons and $L_4 S_1$ (animal traction with terrace and sorghum mono crop sowing gave highest L.A. compared with the others.

Table 2_a. The effect of soil water conservation method on stem diameter (mm)of sorghum intercrop with cowpea in ELfoula season 2011/2012:

Day after sowing	**30 days**					**45 days**					**60 days**				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	1.26^{b}	1.36^{b}	0.73^{e}	0.77^{e}	1.1^{b}	2.34^{b}	2.46^{ab}	0.90^{d}	1.20^{cd}	1.72^{ab}	2.47c	2.53^{c}	0.98^{h}	1.28^{fgh}	1.81^{c}
L_2	1.47^{b}	1.72^{a}	0.79^{c}	0.89^{e}	1.2^{a}	2.60^{ab}	2.81^{a}	0.96^{d}	1.56^{c}	1.98^{a}	2.71abc	3.00^{abc}	1.07^{fgh}	1.65^{de}	2.11^{ab}
L_3	1.28^{b}	1.33^{b}	0.73^{e}	0.84^{e}	1.0^{b}	2.53^{ab}	2.63^{ab}	0.93^{d}	1.20^{cd}	1.82^{ab}	2.57bc	2.78^{abc}	1.01^{fgh}	1.37^{efg}	1.93^{be}
L_4	1.73^{a}	1.78^{a}	0.81^{c}	0.97^{e}	1.3^{a}	2.96^{ab}	2.88^{a}	0.96^{d}	1.56^{e}	2.02^{a}	2.85ab	3.03^{a}	1.40^{ef}	1.77^{d}	2.27^{a}
X	1.4^{a}	1.5^{a}	0.76^{b}	0.86^{b}		2.53^{a}	2.69^{a}	0.94^{e}	1.38^{b}		2.65^{b}	2.83^{a}	1.12^{d}	1.56^{c}	
CV%					12.84					14.06					10.87
LSD_C					0.123					0.221					0.184
LSD_L					0.123					0.221					0.184
LSD_{CXL}					0.246					0.442					0.368

Symbols are as in Table 1a.

Table 2 $_b$. The effect of soil water conservation method on stem diameter(mm) of sorghum intercrop wi 2012/2013:

Day after sowing	**30 days**					**45 days**					
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1
L_1	1.02^{bcd}	1.11^{bc}	0.72^{de}	0.71^{cd}	0.89^{bc}	1.50^{de}	1.56^{cd}	0.95^{fg}	0.93^{fg}	1.23^{c}	1.78^{e}
L_2	1.25^{b}	0.44^{d}	0.80^{cd}	0.85^{ed}	0.83^{c}	1.75^{bcd}	1.81^{abc}	1.01^{fg}	1.13^{fg}	1.43^{b}	1.92^{bc}
L_3	1.26^{b}	1.257^{b}	0.78^{d}	0.84^{ed}	1.03^{b}	1.79^{abc}	1.82^{abc}	0.97^{fg}	1.10^{fg}	1.42^{b}	1.91^{be}
L_4	1.63^{a}	1.75^{a}	0.79^{cd}	0.84^{ed}	1.26^{a}	1.87^{ab}	2.05^{a}	1.18^{fg}	1.22^{fg}	1.58^{a}	2.04^{ab}
X	1.29^{a}	1.14^{a}	0.77^{b}	0.81^{b}		1.73^{a}	1.82^{a}	1.03^{b}	1.09^{b}		1.91^{a}
CV%					19.34					12.16	
LSD_C					0.162					0.143	
LSD_L					0.162					0.143	
LSD_{CXL}					0.323					0.286	

Symbols are as in Table 1a.

Table 3a. The effect of soil water conservation method on leaf area (mm2) of sorghum intercrop with c

Day after sowing	30 days					45 days					
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1
L_1	1.8^{be}	1.4^{e}	0.28^{d}	0.26^{d}	0.94^{b}	3.2^{b}	3.1^{b}	0.51^{e}	0.42^{c}	1.8^{b}	4.1^{e}
L_2	2.3^{ab}	1.8^{be}	0.39^{d}	0.27^{d}	1.2^{ab}	4.6^{a}	3.6^{ab}	0.27^{e}	0.53^{c}	2.3^{ab}	5.2^{b}
L_3	1.9^{be}	1.8^{be}	0.36^{d}	0.27^{d}	1.1^{ab}	3.2^{b}	3.1^{b}	0.39^{c}	0.45^{c}	1.8^{b}	4.8^{b}
L_4	2.7^{a}	1.97^{be}	0.42^{d}	0.32^{d}	1.4^{a}	4.7^{a}	4.0^{ab}	0.53^{e}	0.66^{c}	2.5^{a}	6.5^{a}
X	2.2^{a}	1.8^{b}	0.40^{c}	0.30^{c}		3.9^{a}	3.4^{a}	0.50^{b}	0.52^{b}		5.1^{a}
CV%					30.76					33.96	
LSD_C					0.2921					0.593	
LSD_L					0.2921					0.593	
LSD_{CXL}					0.5842					1.18	

Symbols are as in Table 1a.

Table 3 b. the effect of soil water conservation method on leaf area(mm2) of sorghum intercrop with co

Day after sowing	30 days					45 days					
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1
L_1	2.96^{de}	2.59^{e}	0.327^{f}	0.284^{f}	1.54^{c}	4.59^{be}	4.01^{c}	0.28^{d}	0.27^{d}	2.29^{b}	4.91^{c}
L_2	3.363^{cd}	2.911^{de}	0.339^{f}	0.315^{f}	1.73^{bc}	5.44^{ab}	4.91^{abe}	0.36^{d}	0.35^{d}	2.79^{ab}	5.92^{ab}
L_3	3.79^{be}	3.56^{cd}	0.307^{f}	0.324^{f}	1.99^{b}	4.62^{b}	4.50^{bc}	0.29^{d}	0.32^{d}	2.43^{b}	5.32^{bc}
L_4	4.55^{a}	4.37^{ab}	0.317^{f}	0.357^{f}	2.40^{a}	5.88^{a}	5.78^{a}	0.43^{d}	0.40^{d}	3.12^{a}	6.42^{a}
X	3.67^{a}	3.36^{a}	0.322^{b}	0.320^{b}		5.16^{a}	4.8^{a}	0.34^{b}	0.33^{b}		5.64^{a}
CV%					20.88					26.26	
LSD_C					0.334					0.581	
LSD_L					0.334					0.581	
LSD_{CXL}										1.164	

Symbols are as in Table 1a.

4.1.4 Fresh weight (t/ha):

The effects of soil water conservation methods on fresh weight yield in Elofoula seasons 2011/12 and 2012/ 13 were represented in Tables (4_a and 4_b) for the two seasons respectively.

Generally L_4(animal traction with terrace) soil water conservation methods showed high fresh weight in all samplings expect in season 2001/12, 60 of days. sample L_2(hand hoe with terrace) gave high fresh weight in season 2011/ 12, whereas C_2(cowpea mono crop) showed high yield in season 2012/13 sample (45and60 days after sowing). Statistical analysis showed that there were significant differences in soil water conservation methods for the two seasons expect in season 2011/12 at 60days after sowing, for crop sowing methods the difference was significant in all samples. Interaction between soil water conservation method and crop sowing showed highly significant differences in all samples for the two seasons.

4.1.5 Dry weight (t/ha):

The effect of soil water conservation on dry weight (t/ha) in Elfoula seasons 2011/12 and 2012/13 was represented in Tables ($5_a$and 5_b) for the two seasons respectively.

Generally L_4(animal traction with terrace) shows high fresh weight yield in the three samples for the two seasons expect in season 2012/13 L_2 (hand hoe with terrace), result is high in sample 30 days after sowing, and also S_1(sorghum mono crop) method of sowing showed high dry weight in the three samples for the two seasons.

Statistical analysis showed highly significant difference in soil water conservation methods, crop sowing and interaction between, soil water conservation method and crop sowing, for all samples in the two seasons.

Table 4a. The effect of soil water conservation methods on fresh weight(t/ha.) of sorghum intercrop with cowpea in ELfoula season 2011/12:

Day after sowing	30 days					45 days					60 days				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	6.05^{ab}	5.49^{b}	2.50cde	2.35^{de}	4.10^{b}	8.00^{ed}	7.25^{d}	4.86^{e}	7.94^{ed}	7.01^{c}	10.82^{ab}	9.06^{bcd}	6.55^{e}	8.52^{d}	8.74^{a}
L_2	6.86^{ab}	6.79^{ab}	2.39de	3.50^{cd}	4.88^{a}	10.22^{ab}	9.43^{b}	4.53^{e}	8.23^{ed}	8.01^{ab}	11.84^{a}	11.00^{a}	6.18^{e}	8.89^{cd}	9.48^{a}
L_3	6.79^{ab}	6.50^{ab}	2.48de	2.8^{cde}	4.67^{ab}	9.42^{be}	8.10^{cd}	5.01^{e}	8.44^{ed}	7.74^{bc}	10.92^{abc}	10.46^{abc}	6.43^{e}	8.64^{d}	9.11^{a}
L_4	7.50^{a}	7.01^{a}	1.99c	3.94^{c}	5.11^{a}	11.18^{a}	11.05^{a}	4.09^{e}	9.15^{bc}	8.87^{a}	12.23^{a}	11.72^{a}	4.80^{e}	9.09^{bcd}	9.46^{a}
X	6.80^{a}	6.45^{a}	2.34c	3.17^{b}		9.71^{a}	8.96^{ab}	4.62^{e}	8.44^{b}		11.45^{a}	10.56^{a}	5.99^{e}	8.79^{b}	
CV%					18.62					12.61					11.65
LSD_C					0.356					0.389					0.437
LSD_L					0.356					0.389					0.437
LSD_{CXL}					0.712					0.778					0.874

Symbols are as in Table 1a.

Table 4b. The effect of soil water conservation methods on fresh weight (t/ha.)of sorghum intercrop wi 2012/13:

Day after sowing	30 days					45 days					
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1
L_1	2.30^{a}	1.28^{bcd}	0.87^{d}	1.07cd	1.38^{a}	3.87^{abcd}	3.13^{cd}	3.81^{bed}	5.16^{abed}	3.99^{a}	6.75^{b}
L_2	2.17^{ab}	2.03^{abc}	0.85^{d}	1.15^{cd}	1.55^{a}	5.57^{abc}	5.04^{abed}	3.61^{bed}	6.40^{ab}	5.16^{a}	9.41^{a}
L_3	1.96^{abe}	1.59^{abcd}	0.97^{d}	1.12^{cd}	1.41^{a}	5.01^{abed}	2.96^{cd}	3.68^{bed}	5.30^{abed}	4.24^{a}	6.92^{b}
L_4	2.48^{a}	2.16^{ab}	0.92^{d}	1.24^{bcd}	1.70^{a}	5.42^{abc}	4.88^{abcd}	2.47^{d}	6.68^{a}	4.86^{a}	11.25
X	2.23^{a}	1.77^{a}	0.90^{b}	1.14^{b}		4.97^{ab}	4.00^{be}	3.39^{c}	5.88^{a}		8.58^{a}
CV%					38.82					37.36	
LSD_C					0.488					1.421	
LSD_L					0.488					1.421	
LSD_{CXL}					0.978					2.852	

Symbols are as in Table 1a.

Table 5a. The effect of soil water conservation methods on dry weight(t/ha.) of sorghum intercrop with 2011/12:

Day after sowing	**30 days**					**45 days**					
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1
L_1	1.41^{cd}	1.21^{d}	0.34^{f}	0.39^{f}	0.84^{c}	1.90^{de}	1.60^{efg}	0.77^{h}	1.43^{g}	1.42^{c}	3.03^{ed}
L_2	1.87^{ab}	1.62^{bc}	0.40^{f}	0.59^{ef}	1.12^{ab}	2.91^{ab}	2.65^{bc}	0.87^{h}	1.56^{efg}	1.99^{b}	3.47^{ab}
L_3	1.70^{bc}	1.50^{cd}	0.41^{f}	0.43^{ef}	1.01^{b}	2.68^{b}	2.26^{cd}	0.80^{h}	1.48^{fg}	1.81^{b}	3.16^{be}
L_4	2.05^{a}	1.91^{ab}	0.34^{f}	0.74^{e}	1.26^{a}	3.27^{a}	3.19^{a}	0.80^{h}	1.86^{ef}	2.28^{a}	3.71^{a}
X	1.76^{a}	1.56^{b}	0.37^{d}	0.54^{c}		2.69^{a}	2.43^{b}	0.81^{d}	1.58^{c}		3.34^{a}
CV%					18.63					12.49	
LSD_C					0.164					0.195	
LSD_L					0.164					0.195	
LSD_{CXL}					0.328					0.391	

Symbols are as in Table 1a.

Table 5b. The effect of soil water conservation methods on dry weight(t/ha) of sorghum intercrop with 2012/13:

Day after sowing	30 days					45 days					
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1
L_1	0.30^{b}	0.26^{bc}	0.13^{cd}	0.11^{cd}	0.20^{b}	0.82^{bcd}	0.69^{abcde}	0.49^{cde}	0.79^{abcd}	0.70^{a}	1.50^{cde}
L_2	0.39^{b}	0.59^{a}	0.07^{d}	0.10^{cd}	0.29^{a}	1.16^{a}	0.91^{abcd}	0.44^{de}	0.70^{abcde}	0.80^{a}	2.01^{abe}
L_3	0.36^{b}	0.30^{b}	0.11^{cd}	0.13^{cd}	0.22^{ab}	1.05^{ab}	0.63^{bcde}	0.50^{cde}	0.79^{abcd}	0.74^{a}	1.52^{cde}
L_4	0.43^{ab}	0.38^{b}	0.06^{c}	0.09^{d}	0.24^{ab}	1.01^{ab}	0.95^{abc}	0.22^{e}	0.77^{abed}	0.74^{a}	2.36^{ab}
X	0.37^{a}	0.38^{a}	0.09^{b}	0.11^{b}		1.01^{a}	0.79^{a}	0.41^{b}	0.76^{a}		1.85^{a}
CV%					42.07					40.70	
LSD_C					0.083					0.253	
LSD_L					0.083					0.253	
LSD_{CXL}					0.166					0.505	

Symbols are as in Table 1a.

4.2 Growth parameters (Babanousa):

The effects of soil water conservation methods on growth parameters of sorghum intercropped with cowpea in Babanousa. experimental site, season 2011/12 and 2012/13are summarized as follows:

4.2.1 Plant height (cm):

The effect of soil water conservation on plant height in Babanousa seasons 2011/13 are shown in Tables (6_a and 6b) for the two seasons respectively.

Generally soil water conservation method L_4 (animal traction with terra) showed high plant height and S_1 (sorghum mono crop) resulted in high plant height than the other sowing methods, for the two growing seasons and samplings.

Statistical analysis showed that there was ahighly significant difference between soil water conservation methods crop sowing methods .and the interaction between them in the three samples for the two seasons.

Table 6 a. The effect of soil water conservation methods on plant height(cm) of sorghum intercrop with cowpea in Babanousa season 2011/12:

Day after sowing	**30 days**					**45 days**					**60 days**				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	79.7^{bc}	67.6^{c}	40.2^{d}	42.9^{d}	56.4^{c}	112.1^{bc}	104.3^{cd}	79.97^{g}	85.0^{fg}	95.3^{c}	191.8^{abc}	168.8^{bcd}	128.7^{e}	132.0^{de}	155.3^{c}
L_2	84.3^{ab}	80.2^{bc}	42.4^{d}	45.1^{d}	63.7^{ab}	125.8^{a}	122.9^{ab}	97.4^{def}	100.8^{cde}	111.8^{a}	212.0^{a}	209.5^{a}	141.0^{e}	136.9^{de}	174.9^{ab}
L_3	80.1^{bc}	77.7^{bc}	40.6^{d}	44.5^{d}	60.7^{bc}	122.6^{ab}	120.3^{ab}	82.3^{g}	88.97^{efg}	103.5^{b}	211.4^{a}	204.0^{ab}	126.6^{e}	130.6^{e}	168.2bc
L_4	95.6^{a}	86.3^{ab}	45.7^{d}	48.6^{d}	69.3^{b}	131.97^{a}	128.8^{a}	98.0^{def}	102.97^{cd}	115.4^{a}	225.6^{a}	217.8^{a}	149.1^{de}	160.8^{cde}	188.3^{a}
X	83.7^{a}	77.9^{a}	42.4^{b}	46.1^{b}		123.1^{a}	119.1^{a}	89.2^{b}	94.6^{b}		210.2^{a}	200.0^{a}	136.4^{b}	140.1^{b}	
CV%					12.53					7.00					10.85
LSD_C					3.2					3.04					9.1
LSD_L					3.2					3.04					9.1
LSD_{CXL}					6.4					6.1					18.2

Symbols are as in Table 1a.

Table 6 b. The effect of soil water conservation methods on plant height(cm) of sorghum intercrop wit 2012/13:

Day after sowing	**30 days**					**45 days**					
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1
L_1	43.8^{abc}	39.8^{c}	43.8^{abc}	42.1^{bc}	42.4^{b}	93.9^{ef}	99.3^{bcdef}	90.3^{f}	84.9^{f}	92.1^{c}	191.3^{bc}
L_2	44.8^{ab}	42.0^{bc}	43.4^{bc}	41.8^{bc}	42.99^{ab}	114.7^{ab}	106.8^{abcde}	95.6^{def}	100.1^{bcdef}	104.3^{ab}	212.7^{ab}
L_3	43.7^{abc}	41.3^{bc}	44.1^{abc}	43.4^{bc}	43.1^{ab}	110.4^{abcd}	109.8^{abcd}	95.6^{def}	94.4^{ef}	102.5^{b}	206.6^{abc}
L_4	47.9^{a}	45.1^{ab}	43.3^{bc}	43.4^{bc}	44.9^{a}	120.1^{a}	119.1^{a}	96.3^{cdef}	111.3^{abc}	111.7^{a}	216.8^{a}
X	45.12^{a}	43.6^{ab}	42.7^{b}	42.0^{b}		109.8^{a}	108.8^{a}	97.7^{a}	94.4^{b}		206.8^{a}
CV%					6.06					7.27	
LSD_C					1.1					3.8	
LSD_L					1.1					3.8	
LSD_{CXL}										7.5	

Symbols are as in Table 1a.

4.2.2 Stem diameter(mm):

The effects of soil water conservation methods on stem diameter in Babanousa season 2011/12 and 2012/13are represented in Tables (7_a and 7_b) for the two seasons respectively.

Soil water conservation method L_4 (animal traction with terrace) showed a larger stem diameter, and S_2 (sorghum inter crop) also gave larger stem diameter and C_1 (cowpea inter crop) resulted in a smaller diameter in all samplings and for the two seasons.

Statistical analysis showed that there were significant differences between water conservation methods, crops sowing method, and highly significant differences between interaction of soil water conservation methods and crop sowing methods L_4 S_2 (animal traction conservation methods and sorghum intercrop sowing) showed highly significant difference in all samples and for the two seasons.

Table 7 a. The effect of soil water conservation methods on stem diameter(mm) of sorghum intercrop with cowpea in Babanousa season 2011/12:

Day after sowing	**30 days**					**45 days**					**60 days**				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	1.26^{b}	1.30^{b}	0.73^{c}	0.77^{c}	1.02^{b}	2.34^{c}	2.45^{be}	0.90^{e}	1.20^{de}	1.72^{c}	2.46^{e}	2.53^{bc}	0.98^{h}	1.28^{fgh}	1.81^{c}
L_2	1.47^{b}	1.73^{a}	0.79^{c}	0.89^{c}	1.22^{a}	2.60^{abc}	2.81^{ab}	0.96^{e}	1.56^{d}	1.98^{ab}	2.70^{abc}	3.00^{a}	1.07^{fgh}	1.65^{de}	2.11^{ab}
L_3	1.28^{b}	1.33^{b}	0.74^{c}	0.84^{c}	1.05^{b}	2.41^{be}	2.63^{abc}	0.93^{e}	1.20^{de}	1.79^{bc}	2.57^{bc}	2.78^{abc}	1.01^{gh}	1.37^{efg}	1.93^{bc}
L_4	1.73^{a}	1.78^{a}	0.81^{c}	0.96^{c}	1.32^{a}	2.69^{abc}	2.88^{a}	0.96^{e}	1.56^{d}	2.02^{a}	2.85^{ab}	3.03^{a}	1.40^{ef}	1.77^{d}	2.27^{a}
X	1.43^{a}	1.53^{a}	0.77^{b}	0.87^{b}		2.51^{a}	2.69^{a}	0.94^{c}	1.38^{b}		2.65^{b}	2.83^{a}	1.12^{d}	1.52^{c}	
CV%					6.06					13.71					8.7
LSD_C					0.124					0.215					0.184
LSD_L					0.124					0.215					0.184
LSD_{CXL}					0.247					0.430					0.368

Symbols are as in Table 1a.

Table 7 b. The effect of soil water conservation methods on stem(mm) diameter of sorghum intercrop 2012/13:

Day after sowing	**30 days**					**45 days**					
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1
L_1	1.60^{c}	1.68^{be}	0.85^{d}	0.81^{d}	1.24^{b}	2.02^{b}	2.08^{b}	1.10^{ed}	0.95^{cd}	1.54^{bc}	2.00^{c}
L_2	1.69^{abc}	1.80^{ab}	0.86^{d}	0.89^{d}	1.31^{a}	2.20^{ab}	2.35^{a}	1.01^{cd}	1.04^{cd}	1.65^{ab}	2.35^{ab}
L_3	1.71^{abc}	1.72^{abc}	0.85^{d}	0.86^{d}	1.28^{ab}	2.04^{b}	2.09^{b}	0.97^{cd}	1.03^{cd}	1.53^{c}	2.22^{be}
L_4	1.75^{ab}	1.82^{a}	0.77^{d}	0.88^{d}	1.31^{a}	2.18^{ab}	2.34^{a}	0.92^{d}	1.17^{c}	1.65^{a}	2.34^{ab}
X	1.69^{b}	1.76^{a}	0.83^{c}	0.86^{c}		2.11^{a}	2.21^{a}	1.00^{b}	1.05^{b}		2.25^{a}
CV%					6.24					8.76	
LSD_C					0.067					0.116	
LSD_L					0.067					0.116	
LSD_{CXL}					0.134					0.233	

Symbols are as in Table 1a.

4.2.3 Leaf area (L.A.):

The effect of soil water conservation methods on L.A. in Babanousa season 2011/12 and 2012/13 are shown in Tables ($8_a$and 8_b) for the two seasons respectively.

Soil water conservation methods L_4(animal traction with terrace). showed a larger leaf area index in the three samplings (30, 45, and 60days)after sowing and also S_1(sorghum mono crop) for the two seasons.

Statistical analysis showed that there were significant differences in soil water conservation methods in season 2011/12, and there were no significant differences in soil water conservation methods in season two in sample, taken 30 and 60days after sowing, but the sample of 45 days was significantly different.

Crop sowing methods statistical analysis showed significant differences in all samplings for the two seasons interaction between soil water conservation methods and crop sowing method showed differences in all samplings for the two seasons L_4S_1(animal traction with terrace and sorghum mono crop) result ed in a larger L.A. in all samples taken for the two seasons.

Table 8 a. The effect of soil water conservation methods on leaf area(mm2) of sorghum intercrop with cowpea Babanousa season 2011/12:

Day after sowing	**30 days**					**45 days**					**60 days**				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	2.45^{b}	2.39^{b}	0.29^{c}	0.41^{c}	1.38^{b}	4.73^{cde}	4.23^{c}	0.36^{f}	0.46^{f}	2.44^{c}	5.37^{bc}	4.97^{c}	0.37^{d}	0.50^{d}	2.81^{b}
L_2	3.51^{a}	2.86^{ab}	0.31^{c}	0.48^{c}	1.79^{ab}	5.66^{ab}	5.15^{bcd}	0.47^{f}	0.52^{f}	2.95^{ab}	4.98^{ab}	5.46^{bc}	0.52^{d}	0.54^{d}	3.13^{b}
L_3	2.76^{ab}	2.81^{ab}	0.39^{c}	0.42^{c}	1.59^{ab}	5.14^{bcd}	4.37^{de}	0.43^{f}	0.42^{f}	2.59^{bc}	5.42^{bc}	5.67^{bc}	0.47^{d}	0.47^{d}	3.01^{b}
L_4	3.52^{a}	2.87^{ab}	0.56^{c}	0.61^{c}	1.89^{a}	6.38^{a}	5.42^{be}	0.56^{f}	0.65^{f}	3.25^{a}	6.79^{a}	5.79^{b}	0.77^{d}	0.86^{d}	3.55^{a}
X	3.06^{a}	2.73^{a}	0.39^{b}	0.48^{b}		5.477^{a}	4.79^{b}	0.45^{e}	0.51^{c}		5.89^{a}	5.47^{b}	0.53^{c}	0.60^{c}	
CV%					30.12					20.24					15.44
LSD_C					0.419					0.437					0.402
LSD_L					0.419					0.437					0.402
LSD_{CXL}					0.836					0.874					0.804

Symbols are as in Table 1a.

Table 8 b. The effect of soil water conservation methods on leaf area i(mm2)of sorghum intercrop with 2012/13:

Day after sowing	**30 days**					**45 days**					
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1
L_1	2.99^{ab}	2.82^{b}	0.25^{c}	0.28^{c}	1.58^{a}	4.00^{b}	3.64^{b}	0.32^{c}	0.30^{c}	2.06^{b}	6.03^{e}
L_2	3.05^{ab}	2.97^{ab}	0.22^{c}	0.29^{c}	1.63^{a}	4.79^{a}	4.61^{a}	0.33^{c}	0.38^{c}	2.52^{a}	7.57^{ab}
L_3	2.99^{ab}	2.87^{b}	0.24^{c}	0.30^{c}	1.60^{a}	4.49^{a}	4.48^{a}	0.33^{c}	0.37^{c}	2.42^{a}	7.13^{ab}
L_4	3.53^{ab}	3.27^{ab}	0.21^{c}	0.31^{c}	1.83^{a}	4.95^{a}	4.77^{a}	0.32^{c}	0.40^{c}	2.61^{a}	7.72^{a}
X	3.14^{a}	2.98^{a}	0.23^{b}	0.30^{b}		4.56^{a}	4.37^{a}	0.32^{b}	0.36^{b}		7.11a
CV%					22.14					11.89	
LSD_C					0.307					0.238	
LSD_L					0.307					0.238	
LSD_{CXL}					0.613					0.477	

Symbols are as in Table 1a.

4.2.4 Fresh weight (t/ha):

The effect of soil water conservation methods on fresh weight (t/ha) in Babanousa season 2011/12- 2012/13 was represented in Tables ($9_a$and 9_b) for the two season respectively.

Generally, soil water conservation L_4 (animal traction with terrace) shows high fresh weight in all samples taken for the two seasons, but in 2012/13 L_2 (Geria with terrace) resulted in high fresher weight, while crop sowing method S_1(sorghum mono crop) gave high fresh weight in all samplings dates taken for the two seasons expect in season 2012/13 S_2(sorghum intercrop) sowing method was higher compared with the other sowing methods.

Statistical analysis showed that there were significant difference between soil water conservation methods, expect for the 30days after sowing sampling for the season 2011/13. Interaction between soil water conservation methods and crop sowing methods showed highly significant differences.

Table 9 a. The effect of soil water conservation methods on fresh weight(t/ha.) of sorghum intercrop with cowpea in Babanousa season 2011/12:

Day after sowing	**30 days**					**45 days**					**60 days**				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	5.95^{ab}	5.61^{b}	1.75^{def}	2.62^{cdf}	3.98^{a}	12.17^{cd}	11.06^{d}	2.95^{e}	3.12^{e}	7.32^{c}	19.50^{bc}	19.11^{c}	5.21^{e}	11.11^{d}	13.73^{b}
L_2	6.58^{ab}	6.26^{ab}	1.51^{ef}	2.83^{cd}	4.30^{a}	15.06^{ab}	14.19^{bc}	2.74^{e}	3.86^{e}	8.96^{ab}	24.49^{ab}	23.81^{abc}	5.06^{e}	13.83^{d}	16.80a
L_3	6.04^{ab}	5.72^{b}	1.54^{ef}	2.69^{cde}	4.00^{a}	13.28^{bcd}	12.60^{bcd}	2.62^{e}	3.02^{e}	7.88^{bc}	23.92^{abc}	23.50^{abc}	5.20^{e}	10.78^{d}	15.85^{ab}
L_4	6.97^{ab}	6.32^{ab}	1.24^{f}	3.36^{c}	4.47^{a}	17.70^{a}	14.75^{bc}	2.19^{e}	3.86^{e}	9.62^{a}	24.94^{a}	24.17^{abc}	4.94^{e}	13.97^{d}	17.01^{a}
X	6.39^{a}	5.98^{a}	1.51^{c}	2.88^{b}		14.54^{a}	13.15^{a}	2.62^{b}	3.48^{b}		23.21^{a}	22.65^{a}	5.10^{c}	12.42^{b}	
CV%					17.05					19.37					29.77
LSD_C					0.595					1.392					2.559
LSD_L					0.595					1.392					2.559
LSD_{CXL}					1.190					2.783					5.119

Symbols are as in Table 1a.

Table 9 b. The effect of soil water conservation methods on fresh weigh(t/ha.) of sorghum intercrop wi 2012/13:

Day after sowing	**30 days**					**45 days**					
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S
L_1	2.463^{bcd}	2.330^{bcde}	0.973^{f}	1.250^{ef}	1.754^{b}	11.600^{abcd}	10.760^{abe}	3.517^{g}	5.000^{fg}	7.719^{a}	1
L_2	3.143^{ab}	2.890^{abe}	1.287^{ef}	1.980^{cdef}	3.325^{ab}	14.723^{ab}	13.420^{abe}	3.473^{g}	6.47^{efg}	9.506^{a}	2
L_3	2.673^{abc}	2.567^{abed}	1.430^{def}	1.887^{cdef}	2.139^{ab}	14.223^{abc}	12.710^{abe}	3.767^{fg}	5.073^{fg}	8.943^{a}	2
L_4	3.663^{a}	2.807^{abc}	1.043^{f}	2.223^{bcde}	2.434^{a}	9.887^{cde}	15.820^{a}	2.507^{g}	7.887^{def}	9.025^{a}	2
X	2.986^{a}	2.645^{a}	1.183^{c}	1.835^{b}		12.608^{a}	13.178^{a}	3.316^{c}	6.092^{b}		2
CV%					31.68					29.71	
LSD_C					0.571					2.179	
LSD_L					0.571					2.179	
LSD_{CXL}					1.143					4.356	

Symbols are as in Table 1a.

4.2.5 Dry weight (t/ha):

The effect of soil water conservation methods on dry weight in Babanosa season 2011/12-2012/13 are represented in tables ($10_a$and 10_b) for the two season respectively.

Generally, soil water conservation method L_4(animal traction with terrace) gave a high dry weight, in all samplings for the two seasons in the 60 days samples of sowing L_1(Geria) resulted in higher dry weight than than other soil water conservation methods. S_1(sorghum mono crops) showed a higher dry weight than the other crop sowing methods.

Statistical analysis showed that there were highly significant differences between soil water conservation methods, expect in season 2012 /2013 sample 60 days after sowing sampling showed no significant differences between soil water conservation methods, while crop sowing methods showed highly significant differences in all samplings taken for the two seasons.

Interaction between soil water conservation methods and crop sowing method showed highly significant differences in all sampling dates for the two seasons.

Table 10a. The effect of soil water conservation methods on dry weight(t/ha.) of sorghum intercrop with cowpea in Babanousa season 2011/12

Day after sowing	**30 days**					**45 days**					**60 days**				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	1.09^{bcd}	0.98^{cd}	0.26^{h}	0.44^{gh}	0.49^{b}	2.74^{cd}	2.46^{d}	0.58^{e}	0.56^{e}	1.58^{c}	4.59^{e}	4.78^{cd}	1.10^{i}	2.41^{efg}	3.29^{c}
L_2	1.32^{ab}	1.22^{abc}	0.26^{h}	0.51^{fg}	0.83^{a}	3.43^{b}	3.22^{bc}	0.58^{e}	0.83^{e}	2.01^{ab}	6.74^{ab}	6.25^{ab}	1.19^{ghi}	3.32^{ef}	4.37^{ab}
L_3	1.12^{bcd}	0.94^{de}	0.23^{h}	0.45^{gh}	0.69^{b}	2.98^{bcd}	2.81^{bcd}	0.52^{e}	0.65^{e}	1.74^{bc}	6.58^{ab}	5.88^{bc}	1.13^{hi}	2.34^{fgh}	3.98^{b}
L_4	1.45^{a}	1.26^{ab}	0.22^{h}	0.73^{ef}	0.92^{a}	4.12^{a}	3.39^{b}	0.49^{e}	0.91^{e}	2.26^{a}	7.20^{a}	6.95^{ab}	1.17^{hi}	3.58^{de}	4.72^{a}
X	1.24^{a}	1.10^{b}	0.24^{d}	0.53^{c}		3.31^{a}	2.97^{b}	0.54^{c}	0.74^{c}		6.35^{a}	5.96^{a}	1.15^{c}	2.91^{b}	
CV%					18.23					19.86					18.02
LSD_C					0.119					0.313					0.616
LSD_L					0.119					0.313					0.616
LSD_{CXL}					0.232					0.626					1.233

Symbols are as in Table 1a.

Table 10_b. The effect of soil water conservation methods on dry weight(t/ha.) of sorghum intercrop wit 2012/13

Day after sowing	**30 days**					**45 days**				
Treatment Land preparation	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	0.386^{bcd}	0.370^{bcd}	0.143^{e}	0.157e	0.26^{b}	2.729^{abc}	2.573^{c}	0.517^{def}	0.691^{def}	1.627^{b}
L_2	0.477^{ab}	0.450^{ab}	0.153^{e}	0.240^{de}	0.33^{ab}	2.945^{abc}	2.765^{abc}	0.445^{ef}	0.790^{de}	1.736^{ab}
L_3	0.403^{bc}	0.390^{bc}	0.187^{e}	0.233^{e}	0.30^{ab}	2.887^{abc}	2.631^{bc}	0.521^{def}	0.645^{def}	1.671^{ab}
L_4	0.560^{a}	0.433^{ab}	0.120^{e}	0.260^{cde}	0.34^{a}	3.123^{a}	3.085^{ab}	0.313^{e}	0.970^{d}	1.873^{a}
X	0.45^{a}	0.41^{a}	0.15^{b}	0.22^{b}		2.921^{a}	2.763^{a}	0.449^{c}	0.774^{a}	
CV%					28.34					16.43
LSD_C					0.073					0.237
LSD_L					0.073					0.237
LSD_{CXL}					0.146					0.474

Symbols are as in Table 1a.

4.3 Yield components:

The effect of soil water conservation methods on yield components of sorghum intercropped with cowpea in Elfoula season 2011/13 are summarized as follows:

4.3.1 Panickle length in (cm):

The effects of soil water conservation methods on panickle length in Elfoula season 2011/12 and 2012/13 was shown in Table (11).

Generally, soil water conservation methods L_4 (animal traction with terrace) showed higher panickle length than other methods. As for crop sowing methods, S_1 (sorghum mono crop) gave higher panickle length than S_1(sorghum intercrop).

Statistical analysis shows no significant differences in all result of season 2011/ 12 for soil water conservation methods, crop sowing methods and interaction between them..

Statistical analysis in season 2012/13 revealed significant differences with soil water conservation methods. L_4(animal traction with terrace) shows high panickle length, while no significant differences were observed , although interaction between soil water conservation and crop sowing showed significant differences.

Table 11. The effect of soil water conservation on panickle length(cm) of sorghum intercropped with cowpea in ELfuola season 2011/12 and 2012/2013:

Land preparation	Season 2011/2012			Season 2012/2013		
	S_1	S_2	X	S_1	S_2	X
L_1	19.83^{a}	19.11^{a}	19.47^{a}	24.70^{d}	245.53^{d}	24.61^{b}
L_2	21.66^{a}	19.99^{a}	20.83^{a}	26.63^{abc}	26.63^{abc}	26.63^{ab}
L_3	21.22^{a}	19.66^{a}	20.44^{a}	25.66^{bed}	25.13^{cd}	25.40^{bc}
L_4	22.30^{a}	20.88^{a}	21.59^{a}	27.70^{a}	27.26^{ab}	27.48^{a}
X	21.25^{a}	19.91^{a}		26.17^{a}	25.89^{a}	
CV %			8.75			3.95
$L.S.D_L$			2.160			1.2734
$L.S.D_C$			2.160			0.9004
$L_.$			19.472^{a}			1.8008

Symbols are as in Table 1a.

4.3.2 Sorghum1000 seed weight (gm):

The effects of soil water conservation methods on 1000s seed weight of sorghum intercropped with cowpea in Elfoula seasons during 2011/12 and 2012/13 was presented in Table (12).

Soil water conservation methods L_4 (animal traction with terrace) showed greater seed weight, for the two growing seasons, while S_1 (sorghum mono crop) resulted in high seeds weight than S_2 (sorghum intercrop) sowing methods for the growing seasons.

Statistical analysis shows that there was significant difference between soil water conservation methods for the two season while for sorghum mono crop and intercrop No-significant difference for the two growing season.

Interaction between soil water conservation and crop sowing methods statistical analysis shows significant difference for the two growing season.

Table 12. The effect of soil water conservation methods on 1000 seed weight(g) of sorghum intercrop with cowpea in ELfuola season 2011/12 and 2012/2013:

Land preparation	Season 2011/2012			Season 2012/2013		
	S_1	S_2	X	S_1	S_2	X
L_1	29.66[b]	27.66 [b]	28.66 [b]	36.00[ab]	31.63[b]	33.81[b]
L_2	38.33[a]	38.00 [a]	38.16 [a]	37.16[a]	36.80[a]	36.98[ab]
L_3	30.0 [b]	27.33 [b]	28.66 [b]	36.83[a]	35.96[ab]	36.40[ab]
L_4	40.33 [a]	38.00 [a]	39.16 [a]	38.43[a]	37.23[a]	37.83[a]
X	34.58 [a]	32.75 [a]		37.10[a]	35.40[a]	
CV %			8.88			7.52
$L.S.D_L$			3.7001			3.3775
$L.S.D_C$			2.6164			2.3883
L_1			5.2327			4.7765

Symbols are as in Table 1a.

4.3.3 Number of seeds /pod:

The effects of soil water conservation methods on number of seeds / pod in Elfoula season 2011/12 and 2012/13 are shown in Table(13).

Soil water conservation methods L_4 (animal traction with terrace) resulted in higher number of seeds/ pod for the two growing seasons and C2 (cowpea monocrop) gave higher number of seeds/ /pods than C1(cowpea intercrop) methods for the two growing seasons.

Statistical analysis showed that there were significant differences between soil moisture conservation for the two seasons; L_1(Geria) gave the lowest number of seed/pod, while for crop sowing methods, there were no. significant differences between sorghum mono crop and intercrop for the two seasons.

Interaction between soil water conservation methods and crop sowing methods revealed significant differences for the two growing seasons and L_4 C_2(animal traction with terrace and cowpea mono crop) showed the highest number of seeds/pod.

Table 13. The effect of soil water conservation methods on number of seeds/pod of sorghum intercrop with cowpea in ELfuola season 2011/12- 2012/2013:

Land preparation	Season se_1			Season se_2		
	C1	C2	X	C1	C2	X
L_1	7.99^{b}	9.44^{ab}	8.71^{b}	8.00c	9.10bc	8.55b
L_2	9.53^{ab}	11.44^{ab}	10.48^{ab}	9.96ab	10.10ab	10.03a
L_3	9.44^{ab}	9.99^{aab}	9.72^{ab}	9.40ab	9.80ab	9.60a
L_4	11.88^{a}	12.44^{a}	12.16^{a}	10.20ab	10.53a	10.36a
X	9.71^{a}	10.83^{a}		9.39a	9.88a	
CV %			19.50			7.15
$L.S.D_L$			2.4806			0.8538
$L.S.D_C$			1.7540			0.6037
$L.S.D_{LXE}$			3.5081			1.2075

Symbols are as in Table 1a.

4.3.4 Cowpea 100 seed weight:

The effects of soil water conservation methods on cowpea 100,s seed weight in Elfoula during season 2011/12 and 2012/13 was representative in Table(14).

Generally soil water conservation methods L_4 (animal traction with terrace) showed a higher seed weight L_1 (hand hoe) gave the lowest seed weight for the two growing seasons, while crop sowing methods C_2(cowpea mono crop) had a higher 100 seeds weight thanC1(cowpea intercrop) sowing method, for the two seasons.

Statistical analysis shows that there were significant differences between soil water conservation methods for the two seasons while for crop sowing method there were no significant differences in season 2011/12, but the difference was significant in season 2012/ 13.

Table 14. The effect of soil water conservation methods on 100 seed weight of Cowpea intercropped with sorghum in ELfuola season 2011/12- 2011/13

Land preparation	Season 1			Season 2		
	Cowpea 100 seeds weight in (gm)			Cowpea 100 seeds weight in (gm)		
	C1	C2	X	C1	C2	X
L_1	19.50^{c}	20.00^{c}	19.75^{c}	25.50^{c}	26.37^{bc}	25.93^{b}
L_2	24.17^{ab}	24.17^{ab}	24.17^{ab}	27.93^{ab}	23.43^{a}	28.18^{a}
L_3	22.33^{b}	23.00^{b}	22.67^{b}	26.47^{bc}	28.10^{ab}	27.28^{a}
L_4	24.5^{a}	25.47^{a}	24.98^{a}	27.90^{ab}	28.90^{a}	23.40^{a}
X	22.63^{a}	23.16^{a}		26.95^{b}	27.95^{a}	
CV %			2.77			3.76
$L.S.D_{L}$			1.6370			1.2768
$L.S.D_{C}$			1.1575			0.9028
$L.S.D_{LXC}$			2.3150			1.8057

Symbols are as in Table 1a.

4.4 The effect of soil water conservation methods on yield components of sorghum intercrop with cowpea in Babanousa seasons 2011/12 and 2012/13 was summarized as follows:

4.4.1 Panicles length (cm):

The effect of soil water conservation methods on panickle length in Babanousa season 2011/ 13 and 2012/13 are presented in Table(15) .

Soil water conservation method L_4 (animal traction with terrace) showed taller panickle length, while L_1 (hand hoe) gave shorter panickle length for the two seasons. S_1 (sorghum monocrop) gave taller panickle length than S_2(sorghum intercrop sowing) for the two growing seasons.

Statistical analysis shows that there were no-significant differences between soil water conservation in the first season but for the second season there were significant differences between soil water conservation methods, but not for crop sowing methods, in the first season, but it was significantly different in season two.

Interaction between soil water conservation methods and crop sowing method was not significant in first the season and it was significantly different in second season.

Table 15. The effect of soil water conservation methods on panickle length of intercropped with sorghum inBabanousa season 2011/12- 2011/13

Land preparation	Season 2011/2012			Season 2012/2013		
	S1	S2	X	S1	S2	X
L_1	25.00a	24.33a	24.665a	25.30bc	24.40c	24.85c
L_2	26.31a	25.58a	25.95a	26.667ab	25.70bc	26.18ab
L_3	25.56a	25.06a	25.31a	25.9333b	25.40bc	25.66bc
L_4	26.68a	25.59a	26.13a	27.633a	26.46ab	27.05a
X						
CV %			7.15			3.02
$L.S.D_L$			2.2582			0.9710
$L.S.D_C$			1.5968			0.6866
$L.S.D_{LXE}$			3.1936			2.8316

Symbols are as in Table 1a.

4.4.2 Sorghum 1000seed weight:

The effects of soil water conservation methods on sorghum 1000's seed weight in Babanousa seasons 2011/12 and 2012/13 are shown in Table (16).

Soil water conservation methods L_4 (animal traction with terrace) gave the highest 1000 seed weight compared with other methods, while S_1 (sorghum mono crop) showed a higher 1000 seed weight the S_2 (sorghum intercrop) for the two seasons. Statistical analysis showed that there were significant differences between soil water conservation methods, crop sowing methods and the interaction between them in the first, but not the second season means..

Table 16. The effect of soil water conservation methods on 1000 seeds (g)weight of sorghum intercrop with cowpea in Babanousa season 2011/12 and 2012/2013:

Land preparation	Season 2011/12			Season 2012/13		
	S_1	S_2	X	S_1	S_2	X
L_1	29.70^{c}	26.80^{d}	28.25^{b}	25.23^{a}	23.86^{a}	24.55^{a}
L_2	34.00^{ab}	33.36^{b}	33.68^{b}	26.13^{a}	25.96^{a}	26.05^{a}
L_3	30.36^{c}	29.16^{c}	29.76^{b}	26.10^{a}	25.93^{a}	26.01^{a}
L_4	36.16^{a}	34.33^{ab}	35.25^{a}	27.86^{a}	26.16^{a}	27.01^{a}
X	32.55^{a}	30.91^{b}		26.33^{a}	25.48^{a}	
CV %			4.22			8.83
$L.S.D_L$			1.6576			2.8316
$L.S.D_C$			1.1721			2.0022
$L_{S.D.\ Lxc}$			2.3442			4.0045

Symbols are as in Table 1a.

4.4.3 Cow pea number of seeds/pod:

The effects of soil water conservation method on number of seeds/pod in Babanosa season 2011/13 and 2012/13 are shown in Table (17).

The soil water conservation methods L_4 (animal traction with terrace) showed the highest number of seeds/pod for the two growing seasons, and C_2(cow pea mono crop) gave higher number of seeds/pod than C_1(cow pea inter sowing method).

Statistical analysis revealed that there was asignificant difference between soil water conservation method in the two growing seasons, while for crop methods of sowing season it was significant different in first season but second season show no significant difference between crop sowing methods.

Interaction between soil water conservation methods and crop sowing methods show significant difference in the two growing seasons.

Table 17. The effect of soil water conservation methods on number of seeds/pod of cowpea intercropped with sorghum in Babanousa season 2011/12 and 2012/13

Land preparation	Season 2011/12			Season 2012/13		
	C_1	C_2	X	C_1	C_2	X
L_1	5.42^{c}	7.93^{ab}	6.67^{b}	8.66^{b}	10.20^{a}	9.43^{b}
L_2	7.66^{b}	7.80^{b}	7.73^{a}	10.36^{a}	10.73^{a}	10.55^{a}
L_3	6.22^{bc}	7.56^{b}	6.89^{ab}	10.13^{a}	10.40^{a}	10.26^{ab}
L_4	7.78^{b}	9.76^{a}	8.77^{a}	10.76^{a}	11.06^{a}	10.91^{a}
X	6.77^{b}	8.26a		9.98^{a}	10.60^{a}	
CV %			13.96			7.34
$L.S.D_L$			1.3000			0.9348
$L.S.D_C$			0.9193			0.6610
$L_{.S>D.}$ LxC			1.8385			1.3221

Symbols are as in Table 1a.

4.4.4 Cow pea 100 seed weight:

The effects of soil water conservation methods on cow pea 100's seed weight in Babanousa during season 2011/13 and 2012/13 are presented in Table (18).

Soil water conservation methods L_4 (animal traction with terrace) showed the highest 100 seed weight for the two seasons than other soil water conservation methods, and C_2 (cow pea mono crop sowing) resulted in a high 100 seed weight than C_1(cow pea intercrop) sowing methods for the two growing seasons.

Statistical analysis showed that there were significant differences between soil water conservation methods for both growing seasons, but for crop sowing methods no significant difference observed in the first season, but there were significant difference in the second season.

Interaction between soil water conservation methods and crop sowing methods show significant difference for the two seasons.

Table 18. The effect of soil water conservation methods on 100 seeds weight of sorghum intercropped with cowpea in Babanousa season 2012/13

Land preparation	Season 2011/12			Season 2012/13		
	C_1	C_2	X	C_1	C_2	X
L_1	17.16^{ab}	17.00^{b}	17.08^{b}	22.66^{c}	25.23^{bc}	23.95^{b}
L_2	21.00^{ab}	21.33^{ab}	21.16^{a}	25.76^{ab}	27.80^{ab}	26.78^{a}
L_3	18.66^{ab}	19.00^{ab}	18.83^{ab}	26.13^{ab}	26.96^{ab}	26.55^{a}
L_4	21.00^{ab}	22.50^{a}	21.75^{a}	27.66^{ab}	27.96^{a}	27.81^{a}
X	19.45^{a}	19.95^{a}		25.55^{a}	26.99^{b}	
CV %			15.65			5.67
$L.S.D_L$			3.8182			1.8444
$L.S.D_C$			2.6999			1.3042
$L_{.S.D.\ LxC}$			5.3992			3.950

Symbols are as in Table 1a.

4.5 locations x season comparison:

The effects of soil water conservation methods on location x season are summarized as fellow:

4.5.1 Panickle length:

The effect of location x season on pancikle length was shown on Table (19).

Statistical analysis showed that there was a significant difference between location.Location one (Elfoula) showed long panickle length than location two (Babanousa), and season one gave longer panickles length than season two, the difference was significant, also the interaction location x season, had significant difference lo_2xse_1 was better than lo_1xse_1.

Table 19. The effect of locations X seasons on panickle(cm) length of sorghum intercrop with cowpea

Location	Panickle length		
	Se1	Se2	X
Lo_1	20.50[b]	25.51[a]	23.27[b]
Lo_2	26.03[a]	25.93[a]	25.72[a]
X	23.01[b]	25.98[a]	
CV %			6.21
LSD_{LO}			1.986
LSD_{SE}			1.986
$LSD_{LO\ X\ SE}$			1.986

Symbols are as in Table 1a.

4.5.2 Sorghum 1000 seed weight:

The effects of location x season on sorghum 1000 seed weight are shown on Table(20).

Statistical analysis showed that there were significant difference between locations, seasons and the interaction between them.

Table 20. The effect of locations X seasons on 1000(g) seeds weight of sorghum intercropped with cowpea:

Location	1000 seeds weight in (gm)		
	Se1	Se2	X
Lo_1	33.66^{b}	31.75^{b}	34.96^{a}
Lo_2	36.25^{a}	25.90^{c}	28.82^{b}
X	32.70^{a}	31.08^{b}	
CV %			11.94
LSD_{LO}			1.5396
LSD_{SE}			1.5396
$LSD_{LO\ X\ SE}$			2.1773

Symbols are as in Table 1a.

4.5.3 Number of seeds/ pod:

The effects of locations x seasons on number of seeds /pod are presented in Table (21).

The result showed that Lo_1 (Elfoula) had a higher number of seeds /pod than Lo_2(Babanousa), Se_2(season two) gave a higher number of seeds /pod than Se_1(season one). Statistical analysis showed significant differences between locations, season and their interaction.

Table 21. The effect of locations X seasons on number of seeds/pod of cowpea intercropped with sorghum:

Location	Seeds/ pod		
	Se1	Se2	X
Lo_1	10.27^{a}	9.63^{a}	9.955^{a}
Lo_2	7.52^{b}	10.29^{a}	8.905^{b}
X	8.896^{b}	9.964^{a}	
CV %			16.25
LSD_{LO}			0.6216
LSD_{SE}			0.6216
$LSD_{LO\ X\ SE}$			0.8791

Symbols are as in Table 1a.

4.5.4 Cow pea 100 seed weight:

The effects of locations x seasons on cowpea 100 seed weight are shown in Table (22).

The results showed that Lo_1(Efoula) gave higher 100 seed weight than Lo_2(Babnousa), Se_2(season two)gave higher 100 seed weight than Se_1(season one. The interaction Lo_1 x Se_2 and Lo_2 x Se_2 gave the highest 100 seed weight and Lo_2 x Se_1 gave the lowest 100 seed weight.

Statistical analysis showed significant difference for all means.

Table 22. The effect of location X seasons on 100 seed weight(g) of cowpea intercrop with sorghum:

Location	1000 seeds weight in (gm)		
	Se1	Se2	X
Lo_1	22.89[b]	27.45[a]	25.17[a]
Lo_2	19.70[c]	26.27[a]	22.99[b]
X	21.30[b]	26.86[a]	
CV %			9.82
LSD_{LO}			0.9594
LSD_{SE}			0.9594
$LSD_{LO\ X\ SE}$			1.3568

Symbols are as in Table 1a.

4.6 The comparison between interaction of locations and seasons on yield parameters.

4.6.1 Final hay yield (t/ha):

The results presented in Table(23), showed that Lo2x se1 gave highest final hay yield than other treatments.

Statistical analysis showed significant differences between means.

Table 23. The effect of location X seasons on final hay yield(t/ha.) in Elfoula and Babanous of sorghum intercropped with cowpea season2011/12 and 2012/13:

Location	Final hay production t/ha		
	Se1	Se2	X
Lo_1	2.68c	3.02c	2.88b
Lo_2	4.83a	3.65b	4.24a
X	3.76a	3.63a	
CV %			39.14
LSD $_{LO}$			0.397
LSD $_{SE}$			0.397
LSD $_{LO\ X\ SE}$			0.561

Symbols are as in Table 1a.

4.6.2 Seed yield (t/ha):

The effects of interaction between locations and seasons on seed yield in Elfoula and Babanousa are represented in Table(24).The results showed that L02xse1 showed higher seed yield than the other treatment. Statistical analysis showed significant differences among means.

Table (24) The effect of location X seasons on seed yield(t/ha.) in Elfoula and Babanousaof

sorghum intercropped with cowpea season 2011/12and 2012/13.

Location	Seeds yield		
	Se1	Se2	X
Lo_1	1.12a	1.17a	1.01a
Lo_2	0.90b	0.69c	0.93b
X	1.01a	0.97a	
CV %			27.25
LSD $_{Lo}$			0.1512
LSD $_{Se}$			0.1512
LSD $_{Lo\ X\ Se}$			0.1069

Symbols are as in Table 1a.

4.6.3 Harvest index (H.I):

The effects of interaction between locations and seasons on harvest index of Elfoula and Babanousa are presented in Table (25).

The result showed that Lo1 xSe1(Elfoula locations season one) gave high harvest index. Statistical analysis showed significant differences in all means.

Table (25) The effect of location X seasons on harvest index in Elfoula and Babanousaof sorghum intercropped with cowpea season 2011/12and 2012/13.

Location	Seeds yield		
	Se1	Se2	X
Lo_1	21.05a	18.84a	19.9a
Lo_2	14.79b	9.61c	12.21b
X	17.92a	14.29b	
CV %			60.81
LSD $_{LO}$			2.7833
LSD $_{SE}$			2.7833
LSD $_{LO\ X\ SE}$			3.9362

Symbols are as in Table 1a.

4.6 Yield parameters (Elfoula):

The effect of soil water conservation methods on yield parameters of sorghum intercropped with cowpea in Elfoula are summarized as follows:

4.6.1 Final hay yield (t /ha):

The effects of soil water conservation on final hay yield in Elfoula season 2011/12 and 2012 /13 are shown in Table(26a and 26b).

The soil water conservation L_4(animal traction with terrace), gave a higher final hay yield than other methods. S_1(sorghum monocrop) sowing methods resulted in high hay yield compared with the other methods of sowing, and L_4 x S_1(animal traction with terrace) x sorghum mono crop gave the highest hay yield among treatment for the two growing seasons.

Statistical analysis showed that there are significant difference among soil water conservation methods within the two seasons, sowing methods also showed significant difference for the two growing seasons. Interaction between soil water conservation methods and crop sowing methods also relealed significant differences in the two seasons.

Table 26a. The effect of soil water conservation methods on final hay(t/ha.) yield of sorghum intercrop with cowpea ELfoula season 2011/12:

Land preparation	Hay yield t/ha				
	S1	S2	C1	C2	X
L_1	8.45^{abcd}	6.11^{cdef}	2.22^{def}	3.00^{def}	4.95^{b}
L_2	11.93^{abc}	11.00^{abc}	1.79^{ef}	4.11^{def}	7.21^{ab}
L_3	7.85^{abcde}	7.05^{abef}	1.37^{f}	3.50^{def}	4.94^{b}
L_4	13.72^{a}	13.22^{ab}	1.04^{f}	5.84^{cdef}	8.46^{a}
X	10.49^{a}	9.35^{a}	1.61^{b}	4.11^{b}	
CV %					58.61
$L.S.D_L$					3.121
$L.S.D_C$					3.121
$L.S.D_{LXE}$					6.243

Symbols are as in Table 1a.

Table 26b. The effect of soil water conservation methods on hay yield(t/ha.) of sorghum intercrop with cowpea ELfoula season 2012/13:

Land preparation	Final hay yield t/ha				
	S1	S2	C1	C2	X
L_1	9.25^{bed}	8.30^{de}	4.35^{hi}	5.63^{gh}	6.94^{b}
L_2	9.98^{abc}	9.06^{cd}	3.47^{ij}	6.74^{fg}	7.31^{ab}
L_3	9.70^{abc}	9.38^{bcd}	3.81^{fj}	5.92^{g}	7.20^{b}
L_4	10.56^{a}	10.29^{a}	2.87^{j}	7.61^{ef}	7.85^{a}
X	9.91^{a}	9.26^{b}	3.67^{d}	6.42^{c}	
CV %					9.49
$L.S.D_L$					0.579
$L.S.D_C$					0.579
$L.S.D_{LXE}$					1.159

Symbols are as in Table 1a.

4.6.2 Seed yield (t / ha):

The effects of soil water conservation methods on seed yield in Elfoula season 2011/12 and 2012 /13 was represented in Tables (27a and 27b).

Soil water conservation method L_4 (animal traction) showed the highest seed yield in season 2011 / 12. S_1 (sorghum mono crop), gave high seed yield for the two growing seasons while interaction L_4 x s_1(animal plough traction x sorghum mono crop), gave the highest seed yield for the two seasons.

Statistical analysis showed that there were significant differences between soil water conservation methods, crop sowing methods and interaction between them for the two growing seasons.

Table 27a. The effect of soil water conservation methods on seed yield(t/ha.) of sorghum intercrop with cowpea ELfoula season 2011/12:

Land preparation	Seed yield t/ha				
	S1	S2	C1	C2	X
L_1	1.52[a]	1.46 [a]	0.58[d]	0.70 [cd]	1.06[b]
L_2	1.61 [a]	1.53 [a]	0.52 [d]	0.90[bc]	1.14[ab]
L_3	1.53 [a]	1.53 [a]	0.57 [d]	0.71[cd]	1.08 [b]
L_4	1.67 [a]	1.62 [a]	0.50 [d]	1.12 [b]	1.23 [a]
X	1.58 [a]	1.53 [a]	0.54 [d]	0.86[b]	
CV %					14.72
$L.S.D_L$					0.138
$L.S.D_C$					0.138
$L.S.D_{LXE}$					0.277

Symbols are as in Table 1a.

Table 27b. The effect of soil water conservation methods on seed yield(t/ha.) of sorghum intercrop with cowpea ELfoula season 2011/13:

Land preparation	Seed yield t/ha				
	S1	S2	C1	C2	X
L_1	1.46 ^{ba}	1.36 ^{ab}	0.17^{c}	0.20 ^{c}	0.798 ^{a}
L_2	1.54^{a}	1.47 ^{ab}	0.14 ^{c}	0.26c	0.888 ^{a}
L_3	1.48 ^{a}	1.45 ^{ab}	0.19 ^{c}	0.97^{b}	1.021 ^{a}
L_4	1.66 ^{a}	1.59 ^{a}	0.147 ^{c}	0.30 ^{c}	0.923 ^{a}
X	1.54 ^{a}	1.47 ^{a}	0.16 ^{c}	0.43^{b}	
CV %					33.34
$L.S.D_L$					0.250
$L.S.D_C$					0.250
$L.S.D_{LXE}$					0.500

Symbols are as in Table 1a.

4.6.3 Harvest index (H.I%):

The effects of soil water conservation methods on harvest index in Elfoula for season 2011/12 and 2012/ 13 are shown in Tables (28a and 28b).

The soil water conservation method L_1 (hand hoe) gave ahigher harvest index in season 2011/12, and L_3 (animal plough traction) gave the highest harvest index in season 2102/ 13, while C_1(cow pea intercrop) showed a high harvest index in season 2011 /12, and C_2(cow pea mono crop) showed highest harvest index in season 2012/13.

Statistical analysis showed that there were no significant difference between soil water conservation in season 2011 /2012, but there were significant differences in season 2012/13. On than other hands crop sowing methods and interaction between soil water conservation methods and sowing methods showed significant differences for the two growing seasons.

Table 28a. The effect of soil water conservation on harvest index (H.I %) in ELfoula season 2011/12:

Land preparation	Harvest index (H.I%)				
	S1	S2	C1	C2	X
L_1	19.34^{abc}	21.57^{abc}	27.47^{abc}	24.50^{abc}	23.24^{a}
L_2	15.73^{abc}	13.33^{bc}	27.70^{abc}	21.40^{abc}	19.54^{a}
L_3	17.70^{abc}	19.80^{abc}	29.87^{ab}	23.03^{abc}	22.60^{a}
L_4	12.50^{bc}	11.30^{c}	31.17^{a}	20.40^{abc}	28.84^{a}
X	16.34^{b}	16.50^{b}	29.05^{a}	22.33^{ab}	
CV %					49.49
$L.S.D_L$					8.688
$L.S.D_C$					8.688
$L.S.D_{LXE}$					17.373

Symbols are as in Table 1a.

Table 28b. The effect of soil water conservation on harvest index (H.I%) in ELfoula season 2011/13:

Land preparation	Harvest index (H.I%)				
	S1	S2	C1	C2	X
L_1	14.37^{b}	15.67^{d}	3.57^{e}	25.60^{d}	14.80^{ab}
L_2	13.53^{d}	13.90^{d}	4.03^{e}	22.20^{c}	13.41^{b}
L_3	13.97^{d}	13.33^{d}	4.87^{e}	31.53^{a}	15.90^{a}
L_4	13.47^{d}	13.30^{d}	5.17^{e}	28.27^{ab}	15.05^{ab}
X	13.81^{b}	14.05^{b}	4.41^{c}	26.90^{a}	
CV %					
$L.S.D_L$					2.176
$L.S.D_C$					2.176
$L.S.D_{LXE}$					4.351

Symbols are as in Table 1a.

4.6.4 Final hay land equivalent ratio (L.E.R):

The effects of soil water conservation methods on final hay land equivalent ratio in Elfoula during season 2011/12 and 2012/13 are shown in Table (29).

The soil water conservation method L_1 (hand hoe) showed a higher L.E.R than the others method for the two seasons, while sorghum showed higher land equivalent ratio than cow pea for the two seasons.

Statistical analysis showed that there was no significant difference between soil water conservation in season 2011/12 but in season 2012/13 showed significant difference between soil water conservation methods, and there were significant differences between crop growing for the two seasons and interaction between soil water conservation methods and crop showed significant difference for the two seasons

Table 29. The effect of soil water conservation methods of final hay land equivalent ratio (L.E.R) in ELfoula season 2011/12 and 2012/ 2013:

Soil water conservation	Season 2011/2012			Season 2012/2013		
	S	C	X	S	C	X
L_1	0.8838^{ab}	0.8292^{abc}	0.8565^{a}	0.9284^{a}	1.0391^{a}	0.9338^{a}
L_2	1.2683^{a}	0.4031^{bc}	0.8331^{a}	0.9381^{a}	0.6728ab	0.8055^{ab}
L_3	0.9191^{ab}	0.7129^{abc}	0.8160^{a}	0.9781^{a}	0.0720^{b}	0.5251^{b}
L_4	1.1031^{a}	0.2151^{c}	0.6591^{a}	0.9612^{a}	0.4991^{ab}	0.7301^{ab}
X	1.0423^{a}	0.5401^{b}		0.9515^{a}	0.5707^{b}	
CV %			45.69			44.16
$L.S.D_L$			0.4476			0.4162
$L.S.D_C$			0.3165			0.2943
$L.S.D_{LXE}$						0.5886

Symbols are as in Table 1a.

4.6.5 Seed land equivalent ratio (L.E.R):

The effects of soil water conservation methods on seed land equivalent ratio in Elfoula seasons 2011/2012 and 2012/2013,are shown in Table (30) .

The soil water conservation methods L_3 (animal traction plough) showed ahigh seed land equivalent ratio in season 2011/12 while L_1(hand hoe)

showed high seed land equivalent ratio in season 2012/13 and L_4(animal traction with terrace) gave the lowest seed land equivalent ratio for the two growing seasons. Sorghum crop showed a higher land equivalent ratio for the two growing seasons.

Statistical analysis showed that there were no significant differences between soil water conservation in season 2011/12 but season 2012/13 showed significant different. The land equivalent ratio between crops was significantly differences in season 2011/12, but season 2012/13 showed no significant differences. Interaction between soil water conservation methods and crops showed significant difference for the two growing seasons.

sTable 30. The effect of soil water conservation methods of seed land equivalent ratio (L.E.R) in ELfoula season 2011/12 and 2012/ 13:

Land preparation	Season 2011/12			Season 2012/13		
	S	C	X	S	C	X
L_1	0.97^{ab}	0.85^{abc}	0.913^{a}	0.90^{a}	0.83^{ab}	0.86^{a}
L_2	0.94^{ab}	0.57^{bc}	0.76^{a}	0.90^{a}	0.52^{cd}	0.71^{ab}
L_3	0.93^{a}	0.85^{abc}	0.94^{a}	0.96^{a}	0.64^{bc}	0.80^{ab}
L_4	0.96^{ab}	0.46^{c}	0.71^{a}	0.96^{a}	0.37^{d}	0.66^{a}
X	0.93^{a}	0.68^{b}		0.93^{a}	0.59^{b}	
CV %			29.20			18.53
$L.S.D_L$			0.3022			0.1757
$L.S.D_C$			0.2137			0.1243
$L.S.D_{LXE}$			0.4274			0.2485

Symbols are as in Table 1a.

4.7 yield parameters Babanousa:

The effects of soil water conservation methods on yield parameters in Babanousa for seasons 2011/12 and 2012/13 are summarized as follows:

4.7.1 Final hay yield (t/ha):

The effects of soil water conservation methods on hay yield in Babanousa seasons 2011/12 and 2012/13 are shown in Table(31) .

Soil water conservation method L_4 (animal traction plough with terrace) showed the higher hay yield and L_1 (hand hoe) gave lowest hay yield for the two seasons, while S_1 (sorghum mono crop) showed the highest hay yield for the two seasons, and L_4x S_1 (animal traction with terrace x sorghum mono crop) showed highest hay yield for the two seasons.

Statistical analysis showed that there were significant difference between soil water conservation methods, crop sowing methods, and interaction between them for the two growing seasons.

Table 31. The effect of soil moisture conservation on final hay yield (t/ha.)of sorghum intercrop with cowpea Babanousa season 2011/12 and 2012/13:

Land preparation	Season 2011/12					Season 2012/13				
	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	17.33^{c}	16.64^{c}	0.42^{f}	5.07^{e}	9.87^{c}	9.42^{de}	8.64^{ef}	5.48^{g}	8.05^{f}	7.91^{b}
L_2	21.33^{ab}	18.11^{bc}	0.39^{f}	7.11^{de}	11.74^{b}	11.06^{ab}	10.70^{abc}	4.44^{h}	9.87^{cd}	9.021^{a}
L_3	17.84^{bc}	17.17^{c}	0.41^{f}	6.06^{de}	10.37^{bc}	10.34^{bed}	20.18^{bcd}	6.03^{gh}	9.67^{d}	8.80^{a}
L_4	23.67^{a}	22.92^{a}	0.30^{f}	9.28^{e}	14.04^{a}	11.29^{a}	11.08^{ab}	3.60^{i}	10.18^{bcd}	9.00^{a}
X	20.04^{a}	19.71^{a}	0.38^{c}	6.88^{b}		10.54^{a}	10.15^{a}	4.60^{e}	9.44^{b}	
CV %					19.08					6.52
$L.S.D_L$					1.829					0.472
$L.S.D_C$					1.829					0.472
$L.S.D_{LXE}$					3.659					0942

Symbols are as in Table 1a.

4.7.2 Seed yield (t/ha):

The effects of soil water conservation methods on seed yield in Babanousa during seasons 2011/12 and 2012/13 are shown in Table(32).

The effect of soil water conservation methods L_1(hand hoe) gave the highest seed yield in season 2011/12 and L_4(animal traction with terrace) gave the highest seed yield in season 2012/13, where as S_1(sorghum mono crop) sowing method gave the highest seed yield for the two seasons.

Statistical analysis showed that there were no significant difference between soil water conservation in season 2011/12 the differences were significant during season 2012/2013. Crop sowing methods showed significant differences for the two seasons.

The interaction between soil water conservation methods and crop sowing methods showed significant differences for the two growing seasons.

Table 32. The effect of soil moisture conservation methods on seed yield(t/ha.) of sorghum intercropped with cowpea in Babanousa season2011/12 and 2012/13:

Land preparation	Season 2011/12					Season 2012/13				
	S_1	S_2	C_1	C_2	X	S_1	S_2	C_1	C_2	X
L_1	1.76^{ab}	1.68^{ab}	0.42^{c}	1.27^{b}	1.28^{a}	1.22^{ab}	1.09^{b}	0.04^{d}	0.05^{d}	0.60^{b}
L_2	1.85^{ab}	1.77^{ab}	0.40^{c}	0.54^{c}	1.14^{a}	1.38^{a}	1.17^{ab}	0.40^{d}	0.07^{d}	0.69^{ab}
L_3	1.76^{ab}	1.82^{ab}	0.42^{c}	0.48^{c}	1.11^{a}	1.33^{a}	1.30^{ab}	0.04^{d}	0.06^{d}	0.68^{ab}
L_4	1.92^{a}	1.86^{a}	0.27^{c}	0.58^{c}	1.16^{a}	1.42^{a}	1.42^{a}	0.03^{d}	0.32^{c}	0.78^{a}
X	1.82^{a}	1.78^{a}	0.38^{c}	0.72^{b}		1.33^{a}	1.27^{a}	0.03^{b}	0.12^{b}	
CV %					29.77					19.31
$L.S.D_L$					0.291					0.112
$L.S.D_C$					0.291					0.112
$L.S.D_{LXE}$					0.582					0.603^{b}

Symbols are as in Table 1a.

4.7.3 Harvest index (H.I %):

The effects of soil water conservation methods on harvest index in Babanousa for seasons 2011/12 and 2012/13 are shown in Table (33a-33b) .

The soil water conservation methods L_1 (hand hoe) showed a high harvest index in season2011/12, and L_4 (animal traction with terrace) gave the highest harvest index during season 2012/13, while S_1(cow pea intercrop)showed ahigh harvest index in season 2012/13,and interaction of L_4xC_1(animal traction with terrace x cow pea mono crop) gave the highest harvest index in season 2011/12 and L_1xS_1(Geria x sorghum mono crop) gave a higher harvest index in season 2012/13.

Statistical analysis showed that there was a significant difference between soil water conservation in season 2011/12 but not in season 2012/13, and crop sowing methods showed significant differences in the two growing seasons.

Interaction between soil water conservation methods and crop sowing methods showed significant difference for the two growing seasons.

Table 33a. The effect of soil water conservation methods on harvest index (H. I%) Babanousa season 2011/12:

Land preparation	Harvest index (H. I%)				
	S1	S2	C1	C2	X
L_1	10.33^{c}	10.30^{c}	54.10^{a}	8.87^{c}	20.90^{a}
L_2	8.77^{c}	9.73^{c}	35.90^{b}	2.27^{c}	15.42^{b}
L_3	9.80^{c}	9.97^{c}	50.93^{a}	7.33^{c}	19.51^{ab}
L_4	8.10^{c}	8.60^{c}	54.73^{a}	6.13^{c}	19.39^{ab}
X	9.25^{b}	9.56^{b}	48.82^{a}	7.40^{b}	
CV %					34.40
$L.S.D_L$					5.394
$L.S.D_C$					5.394
$L.S.D_{LXE}$					10.737

Symbols are as in Table 1a.

Table 33b. The effect of soil water conservation methods on harvest index (H. I%) Babanousa season 2012/13:

Land preparation	Harvest index (H. I%)				
	S1	S2	C1	C2	X
L_1	11.933^{a}	11.570^{a}	7.63^{de}	7.13^{e}	9.56^{a}
L_2	11.10^{ab}	10.67^{abc}	9.73^{abced}	6.93^{e}	9.60^{a}
L_3	11.77^{a}	11.13^{ab}	8.53^{cde}	6.60^{e}	9.50^{a}
L_4	11.13^{ab}	11.37^{ab}	8.97^{bcde}	7.57^{de}	9.75^{a}
X	11.883^{a}	11.183^{a}	8.717^{b}	7.058^{c}	
CV %					15.32
$L.S.D_L$					1.227
$L.S.D_C$					1.227
$L.S.D_{LXE}$					2.455

Symbols are as in Table 1a.

4.7.4 Final hay yield land equivalent ratio (L.E.R):

The effects of soil water conservation methods on final hay yield in Babanousa for season 2011/12 and 2102/13 are presented in Tables (34a and34).

The soil water conservation method L_1 (hand hoe) showed the highest final hay yield land equivalent ratio during the first season, and sorghum crop showed high land equivalent ratio for the two seasons.

Statistical analysis showed that there were no-significant differences between soil water conservation in season 2011/2012 but season 2012/2013 showed significant differences, and there were significant differences between sorghum and cow pea for the two growing seasons.

Interaction between soil water conservation methods and crops showed significant differences for the two growing seasons.

Table 34a. The effect of soil water conservation methods on final hay land equivalent ratio (L.E.R) in Babanousa season 2011/12.

Land preparation	L.E.R		
	S	C	X
L_1	0.95^{a}	0.43^{b}	0.69^{a}
L_2	0.86^{a}	039^{b}	0.62^{a}
L_3	0.96^{a}	0.37^{b}	0.66^{a}
L_4	0.96^{a}	0.30^{b}	0.61^{a}
X	0.93^{a}	0.37^{b}	
CV %			20.31
$L.S.D_L$			0.1253
$L.S.D_C$			0.0887
$L.S.D_{LXE}$			0.1775

Symbols are as in Table 1a.

Table 34b. The effect of soil water conservation methods on final hay land equivalent ratio (L.E.R) in Babanousa season 2012/13.

Land preparation	L.E.R		
	S	C	X
L_1	0.91^{a}	0.69^{b}	0.80^{a}
L_2	0.96^{a}	0.44^{cd}	0.70^{ab}
L_3	0.98^{a}	0.53^{c}	0.76^{ab}
L_4	0.98^{a}	0.33^{d}	0.65^{b}
X	0.96^{a}	0.50^{b}	
CV %			11.71
$L.S.D_L$			0.1064
$L.S.D_C$			0.0752
$L.S.D_{LXE}$			0.1504

Symbols are as in Table 1a.

4.7.5 Seed land equivalent ratio:

The effects of soil water conservation methods on seed land equivalent ratio in Babanousa season 2011/12 and 2012/13 are presented in Tables (35a and 35b).

The soil water conservation method L_3(animal traction plough) showed high seed land equivalent ratio in season2011/12 and L_1(hand hoe) showed high seed land equivalent ratio in season 2012/13, and sorghum crop showed the highest seed land equivalent ratio than cow pea crop for the two growing season.

Statistical analysis showed that there were significant differences between soil water conservation methods in season 2011/12, but not in season 2012/13, , while the methods of crop sowing showed significant differences for the two growing seasons.

The interaction was significant difference for the two growing season.

Table 35a. The effect of soil water conservation methods on seed yield land equivalent ratio (L.E.R) in Babanousa season 2011/12.

Land preparation	L.E.R		
	S	C	X
L_1	0.95^{a}	0.63^{be}	0.79^{ab}
L_2	0.95^{a}	0.74^{abc}	0.84^{ab}
L_3	$.94^{a}$	0.88^{ab}	0.96^{a}
L_4	0.97^{a}	0.46^{c}	0.72^{a}
X	0.98^{a}	0.68^{a}	
CV %			20.78
$L.S.D_L$			0.2144
$L.S.D_C$			0.1574
$L.S.D_{LXE}$			0.3028

Symbols are as in Table 1a.

Table 35b. The effect of soil water conservation methods on seed yield land equivalent ratio (L.E.R) in Babanousa season 2012/13.

Land preparation	L.E.R		
	S	C	X
L_1	0.89^{abc}	0.74^{bcd}	0.87^{a}
L_2	0.92^{ab}	0.54^{de}	0.73^{a}
L_3	0.97^{a}	0.67^{cd}	0.82^{a}
L_4	0.99^{a}	0.40^{e}	0.71^{a}
X	0.95^{a}	0.58^{b}	
CV %			18.55
$L.S.D_L$			0.1339
$L.S.D_C$			0.1339
$L.S.D_{LXE}$			0.2669

Symbols are as in Table 1a.

4.8 comparison of interaction of season x soil water conservation method and crop sowing methods:

The effects of season x soil water conservation methods and crop sowing method in Elfoula are summarized as follows:

4.8.1 The interaction of season x soil water conservation methods and crop sowing methods on final hay yield in ELfoula were presented in Table (36):

The results showed that season (2012/13) gave higher values than season (season 2011/12).

The interaction between Se_1x L_4 (season 2011/12 and animal traction) with terrace showed higher final hay yield than the other interactions, and also se1(season2011/12)/ with sorghum mono crop sowing methods(s1) showed a high final hay yield than other crop sowing method interactions with season.

Statistical analysis showed that there were no significant between seasons, but the interaction between seasons and soil water conservation method showed significant differences, and interaction between seasons and crop

sowing methods also showed significant differences for the two growing seasons.

Table 36. The interaction between seasons and soil water conservation methods of hay yield in ELfoula season 2011/12 and 2012/13.

Land preparation	Hay yield		Hay yield		
	Se1	Se2		Se1	Se2
L1	4.94[b]	6.9367[ab]	S1	10.48[a]	9.90[a]
L2	7.20[a]	7.3152[a]	S2	9.34[a]	9.25[a]
L3	4.94[b]	7.2050[a]	C1	1.60[d]	3.67[cd]
L4	8.45[a]	7.8542[a]	C2	4.11[c]	6.47[b]
X	6.38[a]	7.3271[a]			
CV %					38.79
LSD_{SE}					1.0806
LSD_{SEXL}					2.1611
LSD_{SEXL}					2.1611

Symbols are as in Table 1a.

4.8.2 Comparison of seed yield in Elfoula season 2011/12 and 2012/13:

The resuls of interaction between seasons, conservation methods and crop sowing on seed yield in Elfoula season for 2011/12 and 2012/13 comparisons are shown in Table (37).

The Se_1(season 2011/12) showed a higher seed yield than Se_2 (season 2012/13) and $L_4xSe_{1,}$ L_4(soil water conservation method in season 2011/12, showed high seed yield compared to other interaction and S_1xSe_1 in season 2011/12 gave the highest seed yield in both seasons.

Statistical analysis showed that there were no significant differences between seasons, interaction between season and soil water conservation methods and also with seasons and crop sowing methods.

Table 37. The interaction between seasons and soil water conservation methods on seed yield(t/ha.) in ELfoula season 2011/12 and 2012/13

Land preparation	Interaction bet. season and seed production		Interaction bet. season and seed production		
	Se1	Se2		Se1	Se2
L1	1.06abc	0.79e	S1	1.58a	1.54a
L2	1.14ab	0.85de	S2	1.53a	1.46a
L3	1.08abc	1.02bcd	C1	0.54a	0.16d
L4	1.22b	0.92cde	C2	0.85b	0.43c
X	1.12a	0.90b			
CV %					24.65
LSD_{SE}					0.1016
LSD_{SEXL}					0.2023
LSD_{SEXL}					0.2023

Symbols are as in Table 1a.

4.9 The effects of seasons x soil water conservation methods and crop sowing methods in Babanousa are summarized as follows:

4.9.1 The interaction of season x soil water conservation methods and crop sowing method on final hay yield in Babanousa for season 2011/12 and 2012/13 was shown on Table(38).

Se_1 (season 2011/12) showed a higher final hay yield than season se_2 (2011/13), and L_4 in season2011/12showed a higher hay yield than other treatments , while C_1(cowpea intercrop) in season 2011/12 gave the lowest hay yield.

Statistical analysis showed that there were significant differences between seasons, and between soil water conservation methods and crop sowing methods

Table 38. The interaction between seasons and soil water conservation methods on final hay yield (t/ha.)in ELfoula season 2011/12 and 2012/13

Land preparation	Hay yield		Hay yield		
	Se1	Se2		Se1	Se2
L1	9.86cd	7.91e	S1	20.0a	10.54b
L2	11.73b	9.02cde	S2	18.7a	10.15b
L3	10.37bc	8.80de	C1	3.7e	4.60d
L4	14.01a	9.00cde	C2	6.9c	9.44b
X	11.50a	8.68b			
CV %					17.53
LSD_{SE}					0.7187
LSD_{SEXL}					1.438
LSD_{SEXL}					1.438

Symbols are as in Table 1a.

9.2 The effect of interaction on seed yield:

The interactions of season x soil water conservation methods and crop sowing methods on seed yield in Babanousa for season 2011/12 and 2012/13 are showon in Table (39).

Se_1 (season 2011/12) showed a higher seed yield than season se_2 (season2012/13). and L_1 (hand hoe) in season 2012/13 showed the lowest seed yield also S_1(sorghum mono crop) in season 2011/12 showed high seed yield.

Statistical analysis showed that there were significant differences in all means.

Table 39. The interaction between seasons and soil water conservation methods on seed yield(t/ha.) in Babanousa season 2011/12 and 2012/13, comparison:

Land preparation	Interaction bet .land preparation and Season		Crop sowing methods	Interaction bet. Crop sowing and season	
	Se1	Se2		Se1	Se2
L1	1.28a	0.60b	S1	1.81a	1.33b
L2	1.13a	0.69b	S2	1.78a	1.27b
L3	1.11a	0.68b	C1	0.37d	0.08e
L4	1.15a	0.79b	C2	0.71c	0.12e
X	1.17a	0.69b			
CV %					28.68
LSD_{SE}					0.1088
LSD_{SEXL}					0. 2175
LSD_{SEXL}					0.2175

Symbols are as in Table 1a.

4.10 The effect of interaction between location, land preparation and crop sowing methods on vegetative plant growth.

4.10.1 Plant height (cm)

The interaction between locations, land preparations and crop sowing methods on plant height after 30,45and 60 days after sowing for the season 2011/12 and 2012/13 are shown in tables(40a to 40f).Generally Lo2 showed high plant height for the two season ,animal plough traction with terrace gave the highest plant height also sorghum mono crop gave a higher plant height than other sowing methods. Statistical analysis showed that there were significant differences for all treatments in season 2012/13. The interaction between locations and crop sowing methods showed no significant differences.

Table 40 a. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea plant height {cm},30 days after sowing season 2011/12,

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	33.77efg	30.43fg	31.23fg	27.43g	30.72e
	L_2	40.60def	36.27defg	39.33defg	31.87efg	37.02de
	L_3	36.47defg	31.80fg	37.63defg	33.77efg	34.92de
	L_4	40.700def	37.900defg	41.000def	36.500defg	39.03d
35.419b	X	37.88cd	34.10d	37.300cd	32.392d	
Lo_2	L_1	74.767bc	67.53c	40.20def	42.97def	56.37c
	L_2	84.30ab	80.20b	42.37def	48.07d	63.73ab
	L_3	80.100bc	77.700bc	4o.600def	44.467de	60.72bc
	L_4	95.600a	86.27ab	46.60d	48.80d	69.32a
62.533a	X	83.692a	77.925a	42.442bc	46.075b	
CV %						15.81
$L.S.D._L$						6.3173
$L.S.D_C$						6.3173
$L.S.D_{LXE}$						12.635

Table 40b. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea plant height {cm},45 days after sowing season 2011/12,

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L1	51.17ijk	48.33 k	48.10 k	54.10ijk	50.42 e
	L2	54.53 ijk	53.93 ijk	52.40 ijk	59.80ijk	55.17de
	L3	53.13 ijk	52.10 iik	47.20 k	54.23ijk	51.67 e
	L4	64.07 hij	59.90 igk	50.43 jk	65.93 hi	60.11 d
54.34b	X	55.75 cd	53.57 cd	249.53 d	58.52 c	
Lo_2	L1	112.10 bc	104.30 c	78.97 dh	85.80 efg	95.29 c
	L2	125.80 ab	122.93 ab	97.43 cdef	100.38 cde	111.75 a
	L3	122.63 ab	120.27 ab	82.30 fg	88.97 defg	103.54 b
	L4	131.97 a	128.83 a	98.00 cde	102.97 cd	115.44 a
106.51a	X	123.13 a	119.08 a	98.17 b	94.64 b	
CV %						11.60
$L.S.D._L$						7.6140
$L.S.D_C$						7.6140
$L.S.D_{LXE}$						15.228

Table 40c. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea plant height {cm},60 days after sowing season 2011/12,

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	80.80 kl	75.23 l	90.67 kl	92.67 kl	84.73 e
	L_2	101.83 higkl	92.43 kl	98.63 igkl	105.50 higkl	99.60 be
	L_3	101.60 higkl	81.50 kl	90.33 kl	93.47 kl	91.72 de
	L_4	107.63 ghigk	98.10 gkl	104.03 higkl	105.63 higkl	103.85 d
94.97b	X	97.97.c	86.82 c	95.92 c	99.20 c	191.77 bc
Lo_2	L_1	168.77 cd	128.67 fghi	128067 fghi	132.67 efgh	155.30 c
	L_2	212.00 ab	209.50 ab	141.03 def	136.87 efg	174.85 ab
	L_3	211.43 ab	204.00 ab	126.63 fghig	130.60 efgh	168.07 bc
	L_4	225.57 a	217.77 ab	149.07 def	160.80 de	188.30 a
171.65a	X	210.19 a	200.01 a	136.35 b	140.07 b	
CV %						14.01
$L.S.D._L$						15.242
$L.S.D_C$						15.242
$L.S.D_{LXE}$						30.485

Table 40d. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea plant height {cm},30 days after sowing season. 2012/13.

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	47.467 bcdef	46.333 cdef	42.52 def	40.133 def	44.046 bc
	L_2	55.767 ab	49.333 bcd	42.633 cdef	42.783 def	47.629 ab
	L_3	48.900 bcde	51.833 abc	39.267 f	42.200 def	45.550 bc
	L_4	58.933 a	56.2000 ab	45.8000 cdef	44.267 cdef	51.3000 a
47.131a	X	52.767 a	50.925 a	42.488 g	42.346 b	
Lo_2	L_1	43.843 cdef	39.767 ef	43.800 cdef	42.067 def	42.369 c
	L_2	44.767 cdef	42.033 def	43.367 cdef	41.800 def	42.992 c
	L_3	43.733 cdef	41.267 def	44.133 cdef	43.400 cdef	43.033 bc
	L_4	47.900 bcdef	45.100 cdef	43.267 cdef	43.433 def	44.925 bc
43.355b	X	45.061 b	42.042 b	43.642 b	42.675 b	
CV %						12.48
$L.S.D._L$						4.6070
$L.S.D_C$						4.6070
$L.S.D_{LXE}$						9.2139

Symbols are as in Table 1a.

Table 40e. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea plant height {cm},45 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	89.40 hi	85.00 i	87.10 I	91.47 ghi	88.24 d
	L_2	101.23 abcdefghi	97.13 defehi	93.07 efghi	101.87 abcdefghi	98.32 bc
	L_3	98.50 cdefghi	87.00 i	86.13 i	91.73 fghi	90.84 cd
	L_4	124.07 a	116.20 abc	99.00 cdefghi	107.60 abcdefgh	111.72 a
97.280b	X	103.30 ab	96.33 bc	91.33 c	98.17 bc	
Lo_2	L_1	93.93 efghi	99.33 cdefghi	90.25 hi	94.94 i	92.11 cd
	L_2	114.67 abcd	106.80 abcdefgh	95.63 efghi	100.40 cdefghi	104.29 ab
	L_3	110.40 abcdef	109.80 abcdefg	95.58 efghi	94.27 efghi	102.54 ab
	L_4	120.07 ab	119.07 ab	96.27defghi	111.33 abcde	111.68 a
102.660b	X	109.77a	108.75 a	94.43 bc	97.68 bc	
CV %						11.65
$L.S.D._L$						9.4337
$L.S.D_C$						9.4337
$L.S.D_{LXE}$						18.867

Symbols are as in Table 1a.

Table 40f. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea plant height {cm},60 days after sowing season 2012/13,

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	208.50 ab	171.67 b	193.20 ab	202.45 ab	193.96 a
	L_2	198.45 ab	186.53 ab	202.07 ab	193.33 ab	195.10 a
	L_3	183.18 ab	181.73 ab	202.87 ab	215.20 a	195.75 a
	L_4	214.87 a	207.42 ab	183.13 ab	222.44 a	206.97 a
197.380a	X	201.25 ab	186.84 b	195.32 ab	208.36a	
Lo_2	L_1	191.33 ab	183.33 ab	186.93 ab	193.73 ab	188.80 a
	L_2	2017.67a	214.70 ab	189.40 ab	198.00 ab	201.22 a
	L_3	206.58 ab	201.28 ab	189.67 ab	197.31 ab	198.71 a
	L_4	216.80 a	211.93 ab	200.07 ab	202.75 ab	207.89 a
199.150a	X	206.84 ab	200.30 ab	191.52 ab	197.95 ab	
CV %						12.62
$L.S.D._L$						20.56
$L.S.D_C$						20.56
$L.S.D_{LXE}$						40.912

Symbols are as in Table 1a.

4.10.2 Stem diameter (mm)

The effects of interaction between locations , land preparations and crop sowing methods on stem diameter in the sampling occasions(30,45 and 60 days after sowing) for the two seasons are showed in Tables (41a to 41f). The general result was that the stem diameter was different within locations and seasons, L4 (animal traction with terrace) showed a high stem diameter and sorghum intercrop gave a higher stem diameter than sorghum monocrop. Statistical analysis showed that there were significant differences in all treatment expect in season 2011/12.30 days after sowing showed no significant differences.

Table 41a. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea stem diameter {mm},30 days after sowing season 2011/12,

Location		Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	0.84kl	1.00ghijkl	0.80kl	1.04fghijkl	0.92e
	L_2	1.25deghi	1.48abcd	0.94ijkl	1.18deghij	1.21bc
	L_3	1.37cde	1.20 befghig	1.92gkl	1.06 efghigkl	1.14 cd
	L_4	1.44 bcd	1.68 abc	1.07 efehghi gk	1.35def	1.39 a
1.1642a	X	1.23 ed	1.34 bc	0.93 e	1.16d	
Lo_2	L_1	1.263 defghi	1.300 delg	0.733 l	0.770 kl	1.02de
	L_2	1.47 abcd	1.73 ab	0.79 kl	0.89 gkl	1.22 bc
	L_3	1.28defgh	1.33def	0.74 L	0.84kl	1.05 de
	L_4	1.73 ab	1.78a	0.81 kl	0.96higkl	1.32ab
1.1506a	X	1.43 ab	1.53 a	0.77 f	0.66 ef	
CV %						17.27
$L.S.D._L$						0.163
$L.S.D_C$						0.163
$L.S.D_{LXE}$						0.326

Symbols are as in Table 1a.

Table 41b. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea stem diamter {mm},45 days after sowing season 2011/12,

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	1.46 efg	1.55 def	0.98 ig	1.20fghi	1.28 f
	L_2	1.62 de	1.83 d	1.13 ghig	1.36efgh	1.48de
	L_3	1.53 def	1.59de	0.99 hig	1.35efgh	1.36 ef
	L_4	1.69de	1.87 d	1.33 efghi	1.54ef	1.61cd
1.433b	X	1.57 b	1.71 b	1.11 d	1.34 c	2.34 c
Lo_2	L_1	2.34 c	2.45 bc	0.90j	1.20ghig	1.72 bc
	L_2	2.60 abc	2.81ab	0.96 ig	0.56 def	1.98 a
	L_3	2.41 abc	2.63 abc	0.93 g	1.20 fghij	1.79 b
	L_4	2.69 abc	2088a	0.96 j	1.56 def	2.02 a
1.880a	X	2.51 a	2.69 a	0.94 d	1.38 c	
CV %						13.72
$L.S.D._L$						0.186
$L.S.D_C$						0.186
$L.S.D_{LXE}$						0.371

Table 41 c. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea stem diamter {mm},60 days after sowing season 2011/12,

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	2.47 c	2.53 bc	0.98 g	1.28fg	1.81 c
	L_2	2.71 abc	3.00 a	1.07 fg	1.65 de	2.11 ab
	L_3	2.57 bc	2.78 abc	1.01 g	1.37ef	1.93bc
	L_4	2.85ab	3.03 a	1.40 ef	1.77 d	2.27 a
2.030a	X	2.65 b	2.83 a	1.12 d	1.58 c	
Lo_2	L_1	2.463 c	2.527 bc	0.977 g	1.277 fg	1.81 c
	L_2	2.700 abc	3.000 a	1.067 fg	1.653 de	2.12 ab
	L_3	2.570 bc	2.777 abc	1.013 g	1.370 ef	1.93bc
	L_4	2.85 ab	3.03 a	1.40 ef	1.77 d	2.27 a
2.029a	X	2.68 b	2.83 a	1.12d	1.52 c	
CV %						10.64
$L.S.D._L$						0.165
$L.S.D_C$						0.165
$L.S.D_{LXE}$						0.329

Table (41d) Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea stem diamter {cm},30 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	1.02 bcd	1.12 bc	0.72 e	0.71 e	0.89 c
	L_2	1.25 b	0.44 f	0.78 de	0.85 cde	0.83 c
	L_3	1.26 b	1.26 b	0.78 de	0.84de	1.03 b
	L_4	1.63a	1.75a	0.79 de	0.84 be	1.26 a
1.002b	X	1.29b	1.39 c	0.77 d	0.81d	
Lo_2	L_1	1.60 a	1.68 a	0.85cde	0.813	1.24a
	L_2	1.69 a	1.80 a	0.86 cbe	0.89 cde	1.31 a
	L_3	1.71a	1.72a	0.88 cde	0.86 cde	1.28 a
	L_4	1.75 a	1.82 a	0.77 be	0.88 cde	1.31 a
1.284a	X	1.69 a	1.76 a	0.83 d	0.86d	
CV %						14.02
$L.S.D._L$						1.308
$L.S.D_C$						1.308
$L.S.D_{LXE}$						2.617

Table 41e. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea stem diamter {mm},45 days after sowing season 2012/13,

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	1.50 i	1.56 hi	0.95 kl	0.93 kl	1.23 c
	L_2	1.75 ghi	1.81 fgh	1.01 jkl	1.13 jkl	1.43 b
	L_3	1.79 fgh	1.82 efg	0.97 jkl	1.10 jkl	1.42 b
	L_4	1.87 defg	2.05 cdef	1.18 gk	1.22 j	1.58a
1.414b	X	1.73b	1.81 b	1.03 c	1.09 c	
Lo_2	L_1	2.02 cdef	2.08 cde	1.10 gkl	0.95 kl	1.54 ab
	L_2	2.20abc	2.35 a	1.01 jkl	1.0 jkl	1.65a
	L_3	2.04 cdef	2.09 bcd	0.97 jkl	1.03 jkl	1.53 ab
	L_4	2.18 abc	2.34 ab	0.92	1.17 jkl	1.65 a
1.593a	X	2.11 a	2.21 a	1.00 c	1.05 c	
CV %						10.67
$L.S.D._L$						0.139
$L.S.D_C$						0.319
$L.S.D_{LXE}$						02698

Table (41 f) Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea stem diamter {mm},60 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	1.78 fghi	1.83efgh	1.13 L	1.14 L	1.47 D
	L_2	1.92 EF	1.99def	1.11 l	1.27 kl	1.58cd
	L_3	1.91 efg	2.02 de	1.17 L	1.21 kl	1.58 cd
	L_4	2.04 de	2.17cd	1.22 kl	1.33 kl	1.69^c
1.579b	X	1.91 b	2.00 b	1.16 e	1.24 de	
Lo_2	L_1	2.00def	2.21 bcd	1.43 jk	1.58 ij	1.81 b
	L_2	2.35abc	2.34 abc	1.26 kl	1.22kl	1.89 ab
	L_3	2.22bcd	2.31abc	1.31 kl	1.58 ij	1.85 ab
	L_4	2.43 ab	2.47 a	1.26 kl	1.69 ghi	1.96a
1.877a	X	2.25a	2.33 a	1.32 d	1.61 c	
CV %						8.17
$L.S.D._L$						0.1152
$L.S.D_C$						0.1152
$L.S.D_{LXE}$						0.2304

Symbols are as in Table 1a.

4.10.3 Leaf area (mm2)

The effects of interaction between location , land preparation and crop sowing methods on leaf area index in the three sampling occasions (30. 45 and 60 days after sowing) for the two seasons are shown in Tables(42a to 42f)

The general trend was that always Lo2(Babanousa) showed a higher leaf area than Lo1(Elfoula), expect in season 2012/13 , 30 after sowing Lo1 (Elfoula) gave ahigher leaf area i. Statistical analysis showed that there were significant differences among means.

Table 42a. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea leaf area {mm2},30 days after sowing season 2011/12

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	1.76cd	1.43d	0.29e	0.26e	0.94d
	L_2	2.30bc	1.84e	0.40e	0.27e	1.20cd
	L_3	1.87cd	1.76cd	0.36e	0.27e	1.06cd
	L_4	2.68b	1.98cd	0.42e	0.32e	1.35bc
1.139b	X	2.16b	1.75c	0.37d	0.28d	
Lo_2	L_1	2.45bc	2.39bc	0.29e	0.41e	1.38bc
	L_2	3.51a	2.86ab	0.31e	0.48e	1.79a
	L_3	2.77b	2.81b	0.39e	0.42e	1.59ab
	L_4	3.52a	2.87ab	0.56e	0.61e	1.89a
1.665a	X	3.059a	2.732a	0.39d	0.48d	
CV %						30.37
$L.S.D._L$						0.3474
$L.S.D_C$						0.3474
$L.S.D_{LXE}$						0.6949

Table 40 b. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea leaf area {mm2},45 days after sowing season 2011/12

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	3.20gh	3.09h	0.51i	0.42i	1.81d
	L_2	4.57cdef	3.56fgh	0.57i	0.53i	2.31cd
	L_3	3.20gh	3.13h	0.39i	0.45i	1.79d
	L_4	4.70bcde	3.98efgh	0.531i	0.66i	2.47bc
2.093b	X	4.00c	3.44c	0.50i	0.52i	
Lo_2	L_1	4.73bcde	4.22defg	0.36d	0.46d	2.44bc
	L_2	5.66ab	5.15bcd	0.47i	0.52i	300ab
	L_3	5.14bcd	4.37def	0.43i	0.42i	2.59bc
	L_4	6.38a	5.42abc	0.56i	0.65i	3.25a
2.809a	X	5.477a	4.793b	0.454d	0.520d	
CV %						14.98
$L.S.D._L$						0.5195
$L.S.D_C$						0.5195
$L.S.D_{LXE}$						1.0390

Table 42c. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea leaf area i {mm2},60 days after sowing season 2011/12

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	4.13hi	4.00i	0.49j	0.65j	2.32e
	L_2	5.18defg	4.89fg	0.52j	0.70j	2.82cd
	L_3	4.82fgh	4.52ghi	0.46j	0.56j	2.59de
	L_4	6.55ab	5.00efg	0.61j	0.71j	3.22ab
2.736b	X	5.17b	4.60c	0.52d	0.66d	
Lo_2	L_1	5.37cdef	4.97efg	0.37j	0.50j	2.80cd
	L_2	5.98bc	5.46cdef	0.52j	0.54j	3.13bc
	L_3	5.42cdef	5.67cde	0.47j	0.47j	3.00bc
	L_4	6.78ab	5.79cd	0.77j	0.86j	
3.121a	X	5.89a	5.47b	0.53d	0.60d	
CV %						25.97
$L.S.D._L$						0.3579
$L.S.D_C$						0.3579
$L.S.D_{LXE}$						0.7159

Table 42d. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea leaf area {mm2},30 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	2.96def	2.59f	0.32g	0.28g	1.54c
	L_2	3.36cde	2.91def	0.34g	0.32g	1.73bc
	L_3	3.79bc	3.56cd	0.31g	0.32g	2.00b
	L_4	4,55a	4.37ab	0.32g	0.34g	2.40a
1.917a	X	3.67a	3.36ab	0.32d	0.32d	
Lo_2	L_1	2.99def	2.82ef	0.25g	0.28g	1.58c
	L_2	3.05def	2.97def	0.22g	0.29g	1.63c
	L_3	2.99def	2.87def	0.24g	0.30g	1.60c
	L_4	3.53cde	3.27cdef	0.21g	0.31g	
1.661b	X	3.14bc	2.98c	0.23d	0.30d	
CV %						24.30
$L.S.D._L$						0.3547
$L.S.D_C$						0.3547
$L.S.D_{LXE}$						0.7095

Table (42 e) Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea leaf area {mm2},45 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	4.59cde	4.01de	0.28f	0.27f	2.29cd
	L_2	5.55abc	4.91abcd	0.36f	0.35f	2.79ab
	L_3	4.61cde	4.50de	0.29f	0.32f	2.43bcd
	L_4	5.89a	5.78ab	0.43f	0.40f	3.123a
2.658a	X	5.16a	4.80ab	0.34c	0.34c	
Lo_2	L_1	4.00de	3.64e	0.32f	0.30f	2.06d
	L_2	4.79bcd	4.61cde	0.33f	0.38f	2.53bcd
	L_3	4.49de	4.48def	0.33f	0.37f	2.42bcd
	L_4	4.95abcd	4.77cd	0.32f	0.40f	2.61bc
2.404b	X	4.56b	4.37b	0.32c	0.36c	
CV %						24.14
$L.S.D._L$						0.4986
$L.S.D_C$						0.4986
$L.S.D_{LXE}$						0.9972

Table (42 f) Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea leaf area {mm2},60 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	4.91h	4.77h	0.32i	0.32i	2.58d
	L_2	5.92fg	5.29gh	0.36i	0.36i	2.98cd
	L_3	5.32gh	4.84h	0.38i	0.35i	2.72d
	L_4	6.42cdef	5.93fg	0.36i	0.37i	3.27bc
2.7888b	X	5.64c	5.21d	0.35e	0.35e	
Lo_2	L_1	6.03efg	6.11defg	0.39i	0.39i	3.23c
	L_2	7.57ab	6.85bcde	0.37i	0.39i	3.79a
	L_3	7.133abc	6.73cdef	0.36i	0.39i	3.65ab
	L_4	7.72a	6.90abcd	0.34i	0.46i	3.85a
3.631a	X	7.112a	6.65b	0.36e	0.41e	
CV %						15.52
$L.S.D._L$						0.4127
$L.S.D_C$						0.4127
$L.S.D_{LXE}$						0.8254

4.10.4. Fresh weight (t/ha):

The effects of interaction between location , land preparation and crop sowing methods on fresh weight in the three sampling occasions (30, 45,60 days after sowing) for the two locations is showed on Tables(43 to 43f). The general trend of result was that , there were significant differences between locations,Lo2

showed high fresh weight expect in 2011/12,30days sampling. Other means were also significantly different.

Table 43a. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea fresh weight {t/ha. },30 days after sowing season 2011/12

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	2.54bcde	2.31e	1.05ghij	0.99ghij	1.72cd
	L_2	2.88abcd	2.85abcd	1.00ghij	1.42fg	1.05ab
	L_3	2.85abcd	2.73abcd	1.04ghij	1.22fgh	1.96abc
	L_4	3.15a	2.94ab	0.84hij	1.66f	2.12a
1.970a	X	2.86a	2.71ab	0.98d	1.33c	
Lo_2	L_1	2.50bcde	2.36de	0.74hij	1.10ghi	1.67d
	L_2	2.77abcde	2.63abcde	0.64ij	1.19fgh	1.81bcd
	L_3	2.54abcde	2.40cde	0.65ij	1.13fghi	1.68d
	L_4	2.93abc	2.65abcde	0.52j	1.41fg	1.88abcd
1.759b	X	2.68ab	2.51b	0.63e	1.21cd	
CV %						17.76
$L.S.D._L$						0.2702
$L.S.D_C$						0.2702
$L.S.D_{LXE}$						0.5404

Table 43b. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea fresh weight {t/ha. },45 days after sowing season 2011/12

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	3.36hi	3.05ij	2.04kl	3.34i	2.95d
	L_2	4.29fgh	3.96ghi	1.90kl	3.46hi	3.40bcd
	L_3	3.96ghi	3.40efg	2.10jk	3.54hi	3.25cd
	L_4	4.70efg	4.64efg	1.72klm	3.84ghi	3.72abc
3.331a	X	4.08c	3.76cd	1.94e	3.55d	
Lo_2	L_1	5.11def	4.64efg	1.24klm	1.31klm	3.08d
	L_2	6.32b	5.96bcd	1.15lm	1.62klm	3.76ab
	L_3	5.56bcde	5.30cde	1.10lm	1.29klm	3.31bcd
	L_4	7.44a	6.19bc	0.92m	1.62klm	4.04a
3.548a	X	6.12a	5.52b	1.10f	1.46e	
CV %						16.84
$L.S.D._L$						0.4728
$L.S.D_C$						0.4728
$L.S.D_{LXE}$						0.9455

Table 43c. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea fresh weight {t/ha },60 days after sowing season 2011/12

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	4.54cd	3.81de	2.75efgh	3.58defgh	3.67c
	L_2	4.98cd	4.62cd	2.60efgh	3.74defg	3.98c
	L_3	4.59cd	4.39cd	2.70efgh	3.63degh	3.83c
	L_4	5.14cd	4.92cd	2.01h	3.82de	3.97c
3.863b	X	4.81b	4.44bc	2.52d	3.69	
Lo_2	L_1	8.19b	8.03b	2.19fgh	4.66cd	5.77b
	L_2	10.28a	10.00a	2.12gh	5.81c	7.05a
	L_3	10.05a	9.87a	2.18fgh	4.53cd	6.66a
	L_4	10.48a	10.15a	2.08gh	5.87c	7.14a
6.655a	X	9.75a	9.51a	2.14d	5.22b	
CV %						18.39
$L.S.D._L$						0.7891
$L.S.D_C$						0.7891
$L.S.D_{LXE}$						1.5783

Table 43d. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea fresh weight {t/ha },30 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	0.97bcdef	0.54fghijkl	0.37kl	0.45ijkl	0.58c
	L_2	0.91bcdefgh	0.85cdefghi	0.36 l	0.48ghijkl	0.65c
	L_3	0.82cdefghijk	067defghijkl.	0.41ijkl	0.47hijkl	0.59c
	L_4	1.04bcde	0.91bcdefgh	0.39jkl	0.52fghijkl	0.72bc
0.634b	X	0.94bc	0.74c	0.38d	0.48d	
Lo_2	L_1	1.04bcde	0.98bcdef	0.41ijkl	0.53fghijkl	0.74bc
	L_2	1.32ab	1.21abc	0.54fghijkl	0.83cdefghij	0.98a
	L_3	1.12abcd	1.08bcd	0.60efghijkl	0.79cdefghijkl	0.90ab
	L_4	1.54a	1.18abc	0.44ijkl	0.93bcdefg	1.02a
0.908a	X	1.25a	1.11ab	0.50d	0.77c	
CV %						36.37
$L.S.D._L$						0.229
$L.S.D_C$						0.229
$L.S.D_{LXE}$						0.458

Table 43e. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea fresh weight {t/ha },45 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	1.63hi	1.31hi	1.60hi	2.17ghi	1.68b
	L_2	2.31ghi	2.11gh	1.51hi	2.69fgh	2.17b
	L_3	2.11ghi	1.24hi	1.55hi	2.23ghi	1.78b
	L_4	2.28ghi	2.05ghi	1.04i	2.80fgh	2.04b
1.915b	X	2.09bcd	1.68cd	1.42d	2.47bc	
Lo_2	L_1	4.87bcde	4.52 cde	1.48hi	2.10ghi	3.24a
	L_2	6.19ab	5.64abcd	1.46hi	2.69fgh	3.99a
	L_3	5.97abc	5.34abcd	1.58hi	2.13ghi	3.76a
	L_4	4.15def	6.64a	1.05i	3.31efg	3.79a
3.696a	X	5.30a	5.54a	1.39d	2.56b	
CV %						35.39
$L.S.D._L$						0.8103
$L.S.D_C$						0.8103
$L.S.D_{LXE}$						1.6206

Table 43f. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea fresh weight {t/ha },60 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	2.83hijk	1.96jklm	1.96jklm	3.50ghi	2.56d
	L_2	3.95efgh	3.40ghi	1.52klm	3.53ghi	3.10cd
	L_3	2.91hij	2.53ijkl	1.58klm	3.50ghi	2.63d
	L_4	4.73deg	4.35efg	1.12m	4.55efg	3.69c
2,995b	X	3.61cd	3.06d	1.55e	3.77c	
Lo_2	L_1	7.77ab	7.20bc	2.06jklm	3.67fghi	5.18b
	L_2	8.78a	8.58a	1.66jklm	5.20de	6.05a
	L_3	8.53a	8.16ab	1.82jklm	4.96def	5.87a
	L_4	9.02a	8.76a	1.51m	5.89cd	6.30a
5.848a	X	8.53a	8.17a	1.76e	4.93b	
CV %						18.32
$L.S.D._L$						0.6610
$L.S.D_C$						0.6610
$L.S.D_{LXE}$						1.3221

4.10.5.Dry weight(t/ha):

The effects of interaction between location ,land preparation and crop sowing methods on dry weight in the three sampling occasions (30,45,60 days after sowing) are shown in Tables(44a to 44f).

The general trend was that location two(lo2) showed a higher dry weight in all means expect season 2011/12,30 days after sowing. Statistical analysis showed that there wera significant differences in all means.

Table 44a. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea dry weight {t/ha },30 days after sowing season 2011/12

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	0.59efg	0.51ghij	0.15nop	0.17nop	0.35d
	L_2	0.78abc	0.68cde	0.17nop	0.23lmn	0.47b
	L_3	0.72bcd	0.63def	0.17nop	0.18nop	0.425bc
	L_4	0.860a	0.801ab	0.142nop	0.311kl	0.53a
0.442a	X	0.74a	0.66b	0.16e	0.23e	
Lo_2	L_1	0.46hij	0.41ijk	0.11op	0.18nop	0.29ef
	L_2	0.55fgh	0.51ghi	0.11op	0.21mno	0.35de
	L_3	0.47hij	0.40jk	0.10op	0.19mnop	0.29e
	L_4	0.61defg	0.53efgh	0.09p	0.31klm	0.38cd
0.328b	X	0.52c	0.46d	0.10e	0.22e	
CV %						18.47
$L.S.D._L$						0.0582
$L.S.D_C$						0.0582
$L.S.D_{LXE}$						0.1164

Table 44b. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea dry weight {t/ha },45 days after sowing season 2011/12

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	0.80	0.67	0.32	0.60	0.60e
	L_2	1.22	1.11	0.37	0.66	0.84bc
	L_3	1.13	0.95	0.34	0.62	0.76cd
	L_4	1.37	1.34	0.34	0.78	0.96a
0.789a	X	1.13c	1.02d	0.34f	0.67e	
Lo_2	L_1	1.15	1.03	0.24	0.24	0.67de
	L_2	1.44	1.35	0.24	0.35	0.85bc
	L_3	1.35	1.18	0.22	0.27	0.75cd
	L_4	1.73	1.42	0.21	0.38	0.94ab
0.800a	X	1.42a	1.25b	0.23g	0.31fg	
CV %						16.56
$L.S.D._L$						0.11158
$L.S.D_C$						0.11158
$L.S.D_{LXE}$						0.11206

Table 44c. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea dry weight {t/ha },60 days after sowing season 2011/12

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	1.27efg	1.05fgh	0.61ijkl	0.73hijkl	0.92d
	L_2	1.46e	1.33efg	0.57jkl	0.84hijk	1.05d
	L_3	1.33efg	1.26efg	0.57jkl	0.82hijkl	0.99d
	L_4	1.56e	1.48e	0.45 l	0.87hij	1.09d
1.012b	X	1.40b	1.28b	0.55d	0.81c	
Lo_2	L_1	2.05d	2.01d	0.46kl	1.01gh	1.38c
	L_2	2.83abc	2.63bc	0.50jkl	1.39ef	1.84ab
	L_3	2.76abc	2.47bc	0.47kl	0.98ghi	1.61b
	L_4	3.03a	2.92ab	0.49jkl	1.50e	1.99a
1.718a	X	2.67a	2.50a	0.48d	1.22b	
CV %						17.20
$L.S.D._L$						0.1916
$L.S.D_C$						0.1916
$L.S.D_{LXE}$						0.3832

Table 44d. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea dry weight {t/ha },30 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	0.13cdefg	0.11defg	0.05hijk	0.04ijk	0.08d
	L_2	0.16bcdef	0.25a	0.03k	0.04jk	0.12abc
	L_3	0.15bcdef	0.13bcdef	0.04hijk	0.05hijk	0.09cd
	L_4	0.19abc	0.16bcdef	0.03k	0.04jk	0.10cd
0.010b	X	0.16b	0.16ab	0.04d	0.04d	
Lo_2	L_1	0.15bcdef	0.15bcdef	0.07ghijk	0.07ghijk	0.11bcd
	L_2	0.20ab	0.19abc	0.06ghijk	0.10efghij	0.14ab
	L_3	0.17bcd	0.17bcde	0.08fghijk	0.10fghij	0.13abc
	L_4	0.24a	0.18abc	0.05hijk	0.11defghi	0.145a
0.130a	X	0.19a	0.17ab	0.06cd	0.09c	
CV %						36.00
$L.S.D._L$						0.0337
$L.S.D_C$						0.0337
$L.S.D_{LXE}$						0.0674

Table 44e. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea dry weight {t/ha },45 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	0.35bcde	0.28bcdef	0.21cdef	0.33bcde	0.29b
	L_2	0.49b	0.38bcd	0.19def	0.30bcdef	0.34b
	L_3	0.44bc	0.27bcdef	0.21cdef	0.33bcde	0.31b
	L_4	0.43bcd	0.40bcd	0.09f	0.32bcdef	0.31b
0.313b	X	0.43b	0.33b	0.17c	0.32b	
Lo_2	L_1	1.15a	1.08a	0.22cdef	0.29bcdef	0.68a
	L_2	1.24a	1.16a	0.19def	0.33bcde	0.73a
	L_3	1.21a	1.11a	0.22cdef	0.27bcdef	0.70a
	L_4	1.31a	1.30a	0.13ef	0.41bcd	0.79a
0.725a	X	1.23a	1.16a	0.19c	0.33b	
CV %						28.31
$L.S.D._L$						0.1199
$L.S.D_C$						0.1199
$L.S.D_{LXE}$						0.2398

Table 44f. Comparison of locations, soil water conservation and crop sowing methods on sorghum and cowpea dry weight {t/ha}, 60 days after sowing season 2012/13

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	0.63defg	0.45fghij	0.30hijkl	0.55defgh	0.48c
	L_2	0.85bcd	0.74cdef	0.23jkl	0.52efghij	0.58bc
	L_3	0.64defg	0.56defgh	0.25ijkl	0.53efghi	0.50c
	L_4	0.99bc	1.14b	0.15 l	0.56defgh	0.71b
0.568b	X	0.78b	0.72b	0.23d	0.54c	
Lo_2	L_1	1.87a	1.77a	0.35ghijkl	0.61deg	1.15a
	L_2	1.82a	1.80a	0.22kl	0.70cdef	1.14a
	L_3	1.817a	1.76a	0.30hijkl	0.68def	1.14a
	L_4	1.7a	1.75a	0.19kl	0.77cde	1.12a
0.136a	X	1.82a	1.77a	0.27d	0.69b	
CV %						21.45
$L.S.D._L$						0.1492
$L.S.D_C$						0.1492
$L.S.D_{LXE}$						0.2983

4.11 The effect of interaction between location x land preparation methods x crop sowing methods on yield parameters:

4.11.1 final hay yield season 2011/12:

The effects of interaction of location soil water conservation methods and crop sowing methods on final hay yield in Elfoula and Babanousa season 2011/2012 and 2012/13 are presented in Table s(45a to 45b).

The results showed that Lo_2 (Babanousa) gave ahigherr final hay yield the Lo_1(Elfoula) and L_4x Lo_2(animal traction with terrace) in Babnousa gave the highest final hay yield, and S_1(sorghum monocrop) in Lo_2(Babanousa) showed the highest final hay yield.

Statistical analysis showed that there were significant differences for all means.

Table (45a) Comparison of final hay yield (t/ha) ELfoula and Babanousa season on 2011/2012 interaction between location and treatment:

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	3.55^{fghij}	$2.57^{hijktmn}$	0.93^{lmno}	1.26^{klmno}	2.08^{e}
	L_2	5.01^{efg}	4.62^{fgh}	0.75^{mno}	1.73jklmn	3.02^{de}
	L_3	3.30^{ghdr}	$2.96^{ghijklm}$	0.57^{no}	1.47^{klmno}	2.08^{e}
	L_4	5.76^{def}	5.55^{def}	0.44no	$2.46^{hijklmn}$	3.55^{cd}
	X	4.40^{b}	3.93^{bc}	0.67^{no}	1.73^{d}	
Lo_2	L_1	7.28^{ed}	6.99^{cde}	0.18^{de}	$2.13^{ijklmno}$	4.14^{bc}
	L_2	8.96^{abc}	7.61^{bed}	0.17^{o}	2.99^{ghijkl}	4.93^{ab}
	L_3	7.50^{bcd}	7.21^{cde}	0.17^{o}	$2.55^{hijklmn}$	4.36^{bc}
	L_4	9.94^{a}	9.63^{ab}	0.13^{o}	3.90^{fghi}	5.90^{a}
	X	8.42^{a}	7.86^{a}	0.16^{e}	2.89^{c}	
CV %						36.20
$L.S.D._{L}$						1.1099
$L.S.D_{C}$						1.1098
$L.S.D_{LXE}$						2.2199

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Table (45b) Comparison of final hay yield (t/ha) ELfoula and Babanousa season 2012/13 interaction of location soil water conservation X crop sowing:

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	3.90^{opg}	3.49^{ijk}	1.90^{opa}	2.36^{n}	2.91^{c}
	L_2	4.19^{cdefg}	3.30^{ghij}	1.46^{ghij}	2.33^{lm}	3.07^{c}
	L_3	4.08^{cdefg}	3.94^{efgh}	1.60^{ers}	2.49^{mn}	3.03^{c}
	L_4	4.47^{abcd}	4.32^{abcdef}	1.20^{s}	3.19^{kl}	3.30^{b}
	X	4.16^{bc}	3.89^{d}	1.54^{g}	2.72^{e}	
Lo_2	L_1	3.98^{efgh}	3.6^{hij}	2.30^{no}	3.38^{jk}	3.33^{b}
	L_2	4.65^{ab}	4.50^{abc}	1.87^{per}	4.15^{cdefg}	3.79^{a}
	L_3	4.32^{abcde}	4.28^{bcdef}	2.12^{nop}	4.06^{defgh}	3.70^{a}
	L_4	4.74^{a}	4.65^{ab}	1.45^{rg}	4.28^{abcdef}	3.78^{a}
	X	4.43^{a}	4.26^{ab}	1.93^{f}	3.97^{ed}	
CV %						7.86
$L.S.D._{L}$						0.2156
$L.S.D_{C}$						0.2156
$L.S.D_{LXE}$						0.4312

4.11.2 seed yield season:

The effects of interaction of location soil water conservation methods and crop sowing on seed yield in Elfoula and Babanousa season 2011/2012 was represented in table (46a—46b).

The result showed that Lo_1 (Elfoula) gave ahigher seed yield than Lo_2 (Babanousa), and L_4 (animal traction with terrace), in Lo_1 (Elfoula), showed the highest seed yield, also S_1 (sorghum mono crop) in Lo_2 (Babanousa) had the highest seed yield for sowing methods.

Statistical analysis showed no-significant differences in soil water conservation x location, but the was significant difference between locations x crop sowing methods although interaction of location x soil conservation x crop sowing method showed significant difference.

Table (46a) Comparison of seed yield (t/ha) ELfoula and Babanousa season 2011/12:

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	0.64^{abed}	0.61^{abcd}	0.25^{gh}	0.29fgh	0.45^{a}
	L_2	0.68abc	0.64^{abcd}	0.22^{gh}	0.38fgh	0.42^{a}
	L_3	0.64^{abed}	0.64^{abc}	0.24^{gh}	0.30fgh	0.46^{a}
	L_4	0.70^{abe}	0.68^{abc}	0.21^{gh}	0.47def	0.52^{a}
0.493a	X	0.66^{bc}	0.64^{c}	0.23^{ef}	0.36d	
Lo_2	L_1	0.74^{ab}	0.71^{abe}	0.18h	0.53cde	0.54^{a}
	L_2	0.78^{ab}	0.74^{ab}	0.17h	0.23gh	0.48^{a}
	L_3	0.73^{ab}	0.76^{ab}	0.18h	0.20gh	0.49a
	L_4	0.81^{a}	0.78^{ab}	0.16h	0.24gh	0.487^{a}
0.474a	X	0.76^{a}	0.75^{ab}	0.16^{f}	0.30de	
CV %						23.78
$L.S.D._L$						0.0938
$L.S.D_C$						0.0938
$L.S.D_{LXE}$						0.1876

Table (46b) Comparison of seed yield (t/ha) ELfoula and Babanousa season 2012/13:

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	0.61abc	0.57abc	0.07e	0.08e	0.34bc
	L_2	0.66ab	0.62abc	0.06e	0.10e	0.36abc
	L_3	0.62ab	0.61abc	0.08e	0.41e	0.43a
	L_4	0.79a	0.67ab	0.06e	0.13e	0.39ab
0.379a	X	0.65a	0.62ab	0.07e	0.18d	
Lo_2	L_1	0.51bcd	0.46cd	0.02e	0.02e	0.25d
	L_2	0.58abc	0.54abcd	0.02e	0.03e	0.29cd
	L_3	0.56abcd	0.55abcd	0.02e	0.03e	0.29cd
	L_4	0.60bc	0.60abc	0.01e	0.14e	0.34bc
0.292b	X	0.56bc	0.53c	0.02e	0.05e	
CV %						29.55
$L.S.D._L$						0.210
$L.S.D_C$						0.210
$L.S.D_{LXE}$						0.4312

4.11.3 Harvest index (H.I)

The effects of interaction between location, land preparation and crop sowing methods on harvest index in Elfoula and Babanusa for seaeon 2011/12 and 2012/13are shown on Tables(47a to 47b).

Generally, Lo2 gave the highest harvest index , L1 (hand hoe plough) and C1(cowpea intercrop) gave the highest harvest index for interaction.

Statistical analysis showed significant differences for all means expect season 2011/12 did not significant differences between locations.

Table (47a) Comparison of harvest index ELfoula and Babanousa season 2011/12 interaction of location soil water conservation and crop sowing

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	19.4cdefghij	21.6cdef	27.5bcd	24.5bcde	23.242a
	L_2	15.7deffghij	13.3efghij	27.7bcd	21.4cdefgh	19.542ab
	L_3	17.7cdefghij	19.8cdeghij	29.9bc	23.0bcdef	22.600a
	L_4	12.5efghij	11.3efghij	31.2bc	20.4cdefghij	18.842ab
21.06aa	X	16.3cd	16.5cd	29.1b	22.3bc	
Lo_2	L_1	10.33fghij	10.30ghij	54.1a	8.9ghij	20.900ab
	L_2	8.80ghij	9.70ghij	35.9b	7.26ij	15.417b
	L_3	9.80fghij	10.00ghij	50.9a	7.33hij	19.508b
	L_4	8.10ghij	8.60ghij	54.7a	6.1j	19.390ab
18.80a	X	9.30e	9.70de	48.9a	7.4e	
CV %						43.35
$L.S.D._L$						7.0508
$L.S.D_C$						7.0508
$L.S.D_{LXE}$						14.102

Table (47b) Comparison of harvest index ELfoula and Babanousa season 2012/13 interaction of location soil water conservation and crop sowing

Location	Soil water conservation	Crop sowing method				
		S_1	S_2	C_1	C_2	X
Lo_1	L_1	14.37de	15.67d	33.57m	25.60bc	14.80ab
	L_2	13.53def	13.90def	4.03 lm	22.20c	13.42b
	L_3	13.87def	13.33def	4.87klm	31.53a	15.05ab
	L_4	13.47def	13.00def	5.17jklm	28.27b	15.05ab
14.792a	X	13.81b	14.05b	4.41e	26.90a	
Lo_2	L_1	11.93efg	11.57efg	7.63hijk	7.13ijkl	9.57c
	L_2	11.10eefg	10.67fgh	9.73ghi	6.93ijklm	9.61c
	L_3	11.77efg	11.13efg	8.53ghij	6.60ijklm	9.51c
	L_4	11.13efg	11.37efg	8.97ghi	7.57hijk	9.76c
9.610b	X	11.48c	11.18c	8.72d	7.06d	
CV %						17.21
$L.S.D._L$						1.7136
$L.S.D_C$						1.1736
$L.S.D_{LXE}$						3.4272

CHAPTER FIVE

DISCUSSION

5.1 Growth parameters:

In this study the trend of vegetative growth was that L_4 (land prepared with animal traction with terrace) gave high plant height, stem diameter, leaf area index, fresh and dry weight. While for crop sowing method of sorghum mono crop showed high growth parameters (plant height, leaf area index, fresh and dry weight), except stem diameter which increased with sorghum intercrop. This agreed with the findings of Odo (1991), Ntare and Williams (1992), Lesoing and Francis (1999), and Ajeigbe et al (2006). Similarly, Mead and Willey (1980) had earlier reported that in a sorghum/cowpea intercrop, not only was the yield of cowpea was depressed by sorghum but cowpea also depressed the yield of sorghum. However, Chui and Shibles (1983) attributed the depression in yield of cereal/legume mixtures to shading by cereal of the legume thereby reducing yield. Pal et al (1993) also reported yield reduction in intercropped cereal/legume compared to sole cereal and legume in the Nigerian savanna and that yield reduction due to intercropping depended on the crop component ratios. The highest grain yield of sorghum.

Voluminous literature has accumulated to prove that water stress (resulting from adequate rains or prolonged irrigation) have depressed most parameters (if not all) of vegetative and/or productive growth.

Reduction in growth had been found to vary in degree depending on the duration, magnitude of water stress and stage of crop growth during which the crop suffered from water stress.

This fact had been demonstrated for different crops, including legumes, fibers, cereals and various other crops.

Example for such finding can be presented by the work of Slatyer (1967), Kramer (1969), El Nadi (1970 and 1975), Saeed and El Nadi (1997), Abdelazim (1988), Mingcaiz *et al* (2004), Ali and Ahmed (2006) and Abu Elgasim and El Nadi (2009).

5.2 Yield components:

The general trend of yield components this study as affected by land preparation and crop sowing methods was that, the panicle length and 1000 seed weight of sorghum crop, also number of seeds per pods and 100 seed weight of cowpea, showed high length and yield for L_4 (animal traction with terrace) and S_1 (sorghum mono crops).This finding was similar to Abd Elrahman,and Hago.. (2005). Mohamed et al.,(2011),studied the effect of tillage and farm yard manure on yield and yields components of grain sorghum in rain-fed condition and reported that tillage depth of 15cm and cow manure of 24 t/ha are effective and are recommended to improve yield of grain sorghum in gardoud soil of North Kordofan. Also reduction in this parameter was supported by the findings of several workers on different crops e.g .,broad beans(Elnadi 1970),haricot beans(Elnadi 9175),soybean (Mingcai etal 2004) and cowpeas (Abu Elgasim and Elnadi 2009).

5.3 Interaction between location and season:

The general trend of interaction between location and season on yield components and yield parameters was that, they vary from location to another and within the season. This was due to fluctuations in rain fall (Appendix 1and 2) . This finding is similar to Makinde, *et al.*,(2011)studied of the seasonality and crop combination effects on growth and yield of two sorghum cultivars in sorghum/maize/okra intercrop in a forest-savanna transition zone of Nigeria , and reported that the 2010 season crops had relatively longer growth duration, received more rainfall than season 2009. Jana Kholova *et al.*, (2013) reported

that most severe droughts were when stress began before flowering and resulted in failure of grain production in most cases, although biomass production was not affected so severely. The frequency of drought stress types were analyzed for selected locations through rabi tract and showed different zones had different predominating stress patterns. This knowledge can help better focusing research for adaptive traits and management practices to specific stress situations and accelerate improvement of rabi sorghum via targeted specific adaptation. The case study presented here is applicable to other sorghum growing environments.

5.4 Yield parameters:

The general trend in study of the effect of land preparation and crop sowing methods on yield parameter was that, the final hay yield (t/ha) and seed yield (t/ha) were high with L_4 (animal traction plough with terrace and mono crop sowing methods) while harvest index and land equivalent ratio were high with L_1 (hand hoe) land preparation and C_1 cowpea intercrop sowing method. This similar to findng of the (Lewis *et al*., 1974) final yield of sorghum crop is decreased when the plant exposed to water stress during the late vegetative to blown stage Stont. Darryl G. *et al*., (1988) reported that water stress influenced both rate and period of growth of sorghum bicolor L. Moench plants. Change in growth rate is one of the most sensitive plant responses to water stress (Hgiao, 1973). Also Stont and Simpson, (1978) reported the effect of water stress on sorghum yield. Prabhjot Kanr Gill *et al*., (2001) studied the effect of various a biotic stresses on growth, soluble sugars and water relation of sorghum seedlings grown in light and darkness and hey reported that under these stress conditions relative water content and water potential of seedlings decreased dramatically subsequently. This reduction resulted in remark able decrease in fresh weight and a substantial increase in dry weight of stressed seedlings.

5.5 The effect of interaction between season, land preparation and crop sowing methods:

The trend of the effect in this study was that always with L_4 (animal traction plough with terrace and mono crop sowing methods) showed the highest yield for both final hay yield and seed yield and this yield varied from season to another, this is similar to .Other researcher finding that(Semenov, 2009; Butterworth et al., 2009) Seasonal weather variability has a direct influence on the quantity and quality of agricultural production in tropical Africa. Specifically in Nigeria, Agricultural production is at the mercy of weather which had been providing the opportunities to use agriculture for economic means most importantly for the rural dwellers. It is for this reason among others that the farmers in the forest-savanna transition zone of Nigeria mostly practice intercropping since, there is more regular pattern of water availability in the zone. Intercropping which has been associated with such advantages as better utilization of environmental factors, greater yield stability, soil protection, variability of food supply increasing the return per unit area and insurance against crop failure. Vogel, 1993 found that maize yield was directly related to the yearly presumable amount and distribution, also tillage treatment influence was significant at both sites because of the variable effect on yield, improved soil drainage , topsoil water content and rooting depth.

5.6 The effect of interaction between location, land preparation and crop sowing method on vegetative growth:

The general trend in this study is that LO2 (Babanousa) gave high growth parameter of plant height, leaf area index, fresh and dry weight. Also L_4 (animal traction plough with terrace and mono crop sowing methods) showed higher parameters .. This similar to Azadi *et al*., (2013) evaluated the effect of planting season and crop density on yield and yield density of lentil (ghachsaran variety)

in the dry land condition and Analysis of variance showed that the effect of planting date was significant on all traits. Seed yield, biological yield, harvest index, and number of seeds per unit area in autumn sowing were significantly higher than spring planting. The effect of planting density was significant on seed yield, seed number per unit area single seed pod. The maximum seed yield with 1600 kg/ha related to winter planting. Treatment of 350 seeds per square meter had the highest seed yield (1575 kg/ha).Kkarra,(2012). Studied the effects of some in-situ water harvesting techniques on soil moisture and sorghum production in Northern Gedaref state. The study revealed the potential advantages off in-situ water harvesting for semi-arid zones and particular for Gedaref,Sudan.

5.7 The effect of interaction between location, land preparation and crop sowing method on yield parameters:

Lo_2 and L_4 (animal traction plough with terrace and mono crop sowing methods) gave high final hay yield and high seed yield: generally, the yield varied with location, for harvest index Geria (L_1) and C_1 (cowpea intercrop) showed the highest harvest index. This shows that the effect of water stress was more severe on vegetative growth than on seed production. This agreed with Aikins and Afuakwa(2010), who studied the effects of four different tillage practices on cowpea performance, then reported that, there were significant difference, in *Asontem* cowpea growth, dry matter yield and yield components between tillage practices. Disc plough followed by disc harrow gave the best results producing the highest percentage of seedling emergence, tallest plant, biggest stem girth and greatest number of leaves. Furthermore, disc plough followed by disc harrow resulted in the longest root length, highest dry matter yield, highest number of pods per plant, highest number of seeds per pod and highest 1000 seed-weight. The no tillage plots produced the shortest planst, smallest stem girth and smallest number of leaves. In addition, the no tillage

plots gave the shortest root length, lowest dry matter yield, smallest number of pods per plant, smallest number of seeds per pod and smallest 1000 seed-weight. Therefore, considering the soil and weather conditions of the experiment the best tillage practice for *Asontem* cowpea growth and yield is disc plough followed by disc harrow. In this study harvest index was high in land preparation with terrace and inter crop sowing methods this indicated that the prepared with terrace was more favorable for vegetative growth than reproductive growth.

5.9 Land Equivalent Ratio:

Growth parameters and yield parameters of both sorghum and cowpea were higher in sole cropping than in intercropped mixtures, presumably due to absence of competition from companion crops, in this study. This agreed with the findings of Oda (1991), Natr and Williams (1992), Lesoing and Francis (1999) and Willey (1980) who earlier reported that in a sorghum/ cowpea intercrop, not only by sorghum but cowpea also depressed the yield of sorghum.

However, Chui and Shibles (1983) attributed the depression in yield of cereal/ legume mixtures to shading by cereal of legume., Pal *et al* (1993) also reported reduction in intercropped cereal and legume compared to sole cereal and legume in the Nigerian Savanna. The highest reduction of cowpea yield in this study was found in L_4 (animal traction plough with terrace and inter crop sowing methods).

Conclusion:

(1) The soil water conservation with terrace (animal traction plough and Geria) showed high yield of vegetative growth , final hay yield and seed yield.

(2) Cowpea intercropped gave low yield for both vegetative growth , yield compound, final hay and seed yield

(3) The trend of crop growth and yield fluctuated within seasons and location.

Recommendation:

(1) Land preparation with animal traction plough with terrace and Geria with terrace showed high yield , so its recommend to be used in this area .

(2) Cowpea intercropped with sorghum Zanire showed low yield, so studies of cowpea intercrop with other sorghum types is important to select the better intercropping types with cowpea.

(3) Study of moisture content within land preparation is essential.

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APPENDICES

Appendix (1): The average rainfall season 2011/ 2012

Location / Month	Alfoula	Rainy days/ month	Babanous	Rainy days/ month
May	42	3	14.4	3
June	34	3	136.7	5
July	147	8	118.8	10
August	269	10	313.8	10
September	354	8	69.0	7
October	-	-	20	1
November	-	-	-	-
Total	905	32	675.9	36

Appendix (2): The average rainfall season 2012/ 2013

Location / Month	Alfoula	Rainy days/ month	Babanous	Rainy days/ month

May	77	5	28.6	7
June	55	5	135.1	5
July	139	7	110.7	10
August	322	12	93.4	10
September	130	8	133.3	10
October	31	1	19.2	1
November	-	-	3.6	2
Total	754	38	523.9	50

ELfoula season 2011/2012

Analysis of Variance Table for P (plant height 30 days)

Source	DF	SS	MS	F	P
rep	2	204.69	102.346	1.80	0.1823
land	3	455.04	151.680	2.67	0.0653
treat	3	246.19	82.062	1.45	0.2493
land*treat	9	56.48	6.275	0.11	0.9992
Error	30	1703.60	56.787		
Total	47	2665.99			

Grand Mean 35.419 CV 21.28

Analysis of Variance Table for PL(plant height45 days)

Source	DF	SS	MS	F	P
rep	2	36.25	18.125	0.16	0.8560
land	3	677.17	225.724	1.95	0.1433
treat	3	517.62	172.539	1.49	0.2377
land*treat	9	165.81	18.423	0.16	0.9967
Error	30	3478.01	115.934		
Total	47	4874.86			

Grand Mean 54.342 CV 19.81

Analysis of Variance Table for PLA60(plant height60 days)

Source	DF	SS	MS	F	P
rep	2	19.2	9.593	0.05	0.9534
land	3	2589.4	863.125	4.30	0.0123
treat	3	1130.9	376.983	1.88	0.1546
land*treat	9	508.2	56.471	0.28	0.9749
Error	30	6022.1	200.735		
Total	47	10269.8			

Grand Mean 94.975 CV 14.92

Analysis of Variance Table for L(L.A.I 30 days)

Source	DF	SS	MS	F	P
rep	2	0.1539	0.0769	0.63	0.5411
land	3	1.1350	0.3783	3.08	0.0422
treat	3	32.9896	10.9965	89.59	0.0000
land*treat	9	0.9535	0.1059	0.86	0.5670
Error	30	3.6821	0.1227		
Total	47	38.9140			

Grand Mean 1.1389 CV 30.76

Analysis of Variance Table for LA (L.A.I 60 days)

Source	DF	SS	MS	F	P
rep	2	0.231	0.1153	0.70	0.5030
land	3	5.211	1.7369	10.59	0.0001
treat	3	223.919	74.6396	455.18	0.0000
land*treat	9	5.992	0.6658	4.06	0.0017
Error	30	4.919	0.1640		
Total	47	240.272			

Grand Mean 2.7359 CV 14.80

Analysis of Variance Table for Lai45 (L.A.I. 45 days)

Source	DF	SS	MS	F	P
rep	2	0.910	0.4548	0.90	0.4173
land	3	4.313	1.4376	2.84	0.0543
treat	3	122.096	40.6988	80.53	0.0000
land*treat	9	3.612	0.4013	0.79	0.6242
Error	30	15.162	0.5054		
Total	47	146.092			

Grand Mean 2.0933 CV 33.96

Analysis of Variance Table for(plant stem diameter 30 days)

Source	DF	SS	MS	F	P
rep	2	0.00478	0.00239	0.11	0.8966
land	3	0.76072	0.25357	11.63	0.0000
treat	3	5.49392	1.83131	83.96	0.0000
land*treat	9	0.32012	0.03557	1.63	0.1513
Error	30	0.65435	0.02181		
Total	47	7.23390			

Grand Mean 1.1498 CV 12.84

Analysis of Variance Table for (plant stem diameter 45 days)

Source	DF	SS	MS	F	P
rep	2	0.0387	0.01933	0.27	0.7619
land	3	0.7050	0.23500	3.34	0.0324
treat	3	26.8019	8.93396	126.84	0.0000
land*treat	9	0.2228	0.02476	0.35	0.9490
Error	30	2.1130	0.07043		
Total	47	29.8813			

Grand Mean 1.8873 CV 14.06

Analysis of Variance Table for (plant stem diameter 60 days)

Source	DF	SS	MS	F	P
rep	2	0.0453	0.02266	0.47	0.6324
land	3	1.4110	0.47034	9.66	0.0001
treat	3	25.5248	8.50826	174.75	0.0000
land*treat	9	0.1645	0.01828	0.38	0.9378
Error	30	1.4607	0.04869		
Total	47	28.6063			

Grand Mean 2.0298 CV 10.87

Analysis of Variance Table for(dry weight/ha. 30 days)

Source	DF	SS	MS	F	P
rep	2	0.0760	0.03798	0.98	0.3876
land	3	1.1182	0.37273	9.60	0.0001
treat	3	17.7274	5.90913	152.23	0.0000
land*treat	9	0.5305	0.05894	1.52	0.1867
Error	30	1.1645	0.03882		
Total	47	20.6165			

Grand Mean 1.0575 CV 18.63

Analysis of Variance Table for(dry weight/ha. 45 days)

Source	DF	SS	MS	F	P
rep	2	0.1253	0.06267	1.14	0.3336
land	3	4.6628	1.55425	28.25	0.0000
treat	3	26.2107	8.73690	158.78	0.0000
land*treat	9	2.7714	0.30794	5.60	0.0002
Error	30	1.6507	0.05502		
Total	47	35.4209			

Grand Mean 1.8781 CV 12.49

Analysis of Variance Table for (dry weight/ha. 60 days)

Source	DF	SS	MS	F	P
rep	2	0.0130	0.0065	0.08	0.9211
land	3	1.1453	0.3818	4.86	0.0072
treat	3	32.5170	10.8390	137.94	0.0000
land*treat	9	1.7054	0.1895	2.41	0.0341
Error	30	2.3574	0.0786		
Total	47	37.7381			

Grand Mean 2.4106 CV 11.63

Analysis of Variance Table for (fresh weight t/ha.30 days)

Source	DF	SS	MS	F	P
rep	2	0.911	0.4553	0.60	0.5567
land	3	6.800	2.2666	2.97	0.0474
treat	3	184.399	61.4665	80.64	0.0000
land*treat	9	5.291	0.5879	0.77	0.6433
Error	30	22.866	0.7622		
Total	47	220.267			

Grand Mean 4.6896 CV 18.62

Analysis of Variance Table for final hay production t/ha

Source	DF	SS	MS	F	P
rep	2	90.55	45.276	3.23	0.0537
land	3	109.55	36.515	2.60	0.0701
treat	3	643.24	214.414	15.29	0.0000
land*treat	9	78.16	8.685	0.62	0.7710
Error	30	420.60	14.020		
Total	47	1342.10			

Grand Mean 6.3885 CV 58.61

Analysis of Variance Table for (fresh weight t/ha.45 days)

Source	DF	SS	MS	F	P
rep	2	1.798	0.8991	0.99	0.3833
land	3	21.391	7.1304	7.85	0.0005
treat	3	184.968	61.6561	67.92	0.0000
land*treat	9	23.552	2.6169	2.88	0.0140
Error	30	27.235	0.9078		
Total	47	258.945			

Grand Mean 7.9312 CV 12.01

Analysis of Variance Table for (fresh weight t/ha.60 days)

Source	DF	SS	MS	F	P
rep	2	0.034	0.0169	0.01	0.9854
land	3	4.409	1.4697	1.28	0.2988
treat	3	208.831	69.6104	60.67	0.0000
land*treat	9	17.802	1.9780	1.72	0.1268
Error	30	34.419	1.1473		
Total	47	265.496			

Grand Mean 9.1977 CV 11.65

ELfoula season 2011/2012

Analysis of Variance Table for seed production t/ha.

Source	DF	SS	MS	F	P
rep	2	0.0847	0.04234	1.53	0.2322
land	3	0.1901	0.06335	2.30	0.0980
treat	3	9.4438	3.14794	114.04	0.0000
land*treat	9	0.2643	0.02937	1.06	0.4162
Error	30	0.8281	0.02760		
Total	47	10.8110			

Grand Mean 1.1285 CV 14.72

Analysis of Variance Table for harvesting index 2011/2012

Source	DF	SS	MS	F	P
rep	2	225.57	112.786	1.04	0.3663
land	3	172.29	57.430	0.53	0.6659
treat	3	1302.21	434.071	4.00	0.0166
land*treat	9	186.00	20.667	0.19	0.9936

Error	30	3257.74	108.591
Total	47	5143.82	

Grand Mean 21.056 CV 49.49

Analysis of Variance Table for panickle length(cm).

Source	DF	SS	MS	F	P
rep	2	0.9045	0.4523	0.14	0.8712
land	3	12.6069	4.2023	1.29	0.3179
treat	1	10.0732	10.0732	3.10	0.1016
land*treat	3	0.8080	0.2693	0.08	0.9681
Error	13	42.1923	3.2456		
Total	22				

Note: SS are marginal (type III) sums of squares

Grand Mean 20.585 CV 8.75

Analysis of Variance Table for 1000,seeds weight

Source	DF	SS	MS	F	P
rep	2	24.333	12.167	1.36	0.2879
land	3	603.000	201.000	22.51	0.0000
treat	1	20.167	20.167	2.26	0.1551
land*treat	3	4.833	1.611	0.18	0.9079
Error	14	125.000	8.929		
Total	23	777.333			

Grand Mean 33.667 CV 8.88

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Analysis of Variance Table for seed/pod.

Source	DF	SS	MS	F	P
rep	2	24.115	12.0575	3.00	0.0821
land	3	38.055	12.6851	3.16	0.0580
treat	1	7.459	7.4593	1.86	0.1943
land*treat	3	2.056	0.6854	0.17	0.9143
Error	14	56.181	4.0130		
Total	23	127.867			

Grand Mean 10.273 CV 19.50

Analysis of Variance Table for 100 sees weight

Source	DF	SS	MS	F	P
rep	2	5.581	2.7904	1.60	0.2373
land	3	95.528	31.8428	18.22	0.0000
treat	1	1.707	1.7067	0.98	0.3398
land*treat	3	0.737	0.2456	0.14	0.9340
Error	14	24.466	1.7476		
Total	23	128.018			

Grand Mean 22.892 CV 5.77

EL foula season 2012/2013

a **Analysis of Variance Table for Plant height(cm) 30 days**

Source	DF	SS	MS	F	P
rep	2	2142.46	1071.23	46.16	0.0000
land	3	355.76	118.59	5.11	0.0056
treat	3	1087.38	362.46	15.62	0.0000
land*treat	9	161.92	17.99	0.78	0.6400
Error	30	696.21	23.21		
Total	47	4443.73			

Grand Mean 47.131 CV 10.22

Analysis of Variance Table for (Plant height(cm) 45days)

Source	DF	SS	MS	F	P
rep	2	3506.6	1753.30	20.17	0.0000
land	3	3991.8	1330.61	15.31	0.0000
treat	3	880.6	293.54	3.38	0.0311
land*treat	9	683.2	75.91	0.87	0.5587
Error	30	2607.6	86.92		
Total	47	11669.9			

Grand Mean 97.281 CV 9.58

Analysis of Variance Table for (Plant height(cm) 60 days)

Source	DF	SS	MS	F	P
rep	2	1777.7	888.86	0.82	0.4495
land	3	1322.8	440.94	0.41	0.7487
treat	3	2995.5	998.51	0.92	0.4417
land*treat	9	4717.1	524.13	0.48	0.8735
Error	30	32462.7	1082.09		
Total	47	43275.9			

Grand Mean 197.94 CV 16.62

Analysis of Variance Table for L.A.L 30 days

Source	DF	SS	MS	F	P
rep	2	1.541	0.7707	4.82	0.0154
land	3	4.981	1.6602	10.37	0.0001
treat	3	122.774	40.9246	255.68	0.0000
land*treat	9	4.759	0.5288	3.30	0.0065
Error	30	4.802	0.1601		
Total	47	138.857			

Grand Mean 1.9165 CV 20.88

Analysis of Variance Table for L.A.L 60 days

Source	DF	SS	MS	F	P
rep	2	2.438	1.219	5.70	0.0080
land	3	3.308	1.103	5.16	0.0054
treat	3	310.100	103.367	483.62	0.0000
land*treat	9	3.200	0.356	1.66	0.1423
Error	30	6.412	0.214		
Total	47	325.458			

Grand Mean 2.8875 CV 16.01

Analysis of Variance Table for L.A.L 45 days

Source	DF	SS	MS	F	P
rep	2	9.080	4.5400	9.32	0.0007
land	3	5.083	1.6943	3.48	0.0280
treat	3	259.298	86.4327	177.42	0.0000
land*treat	9	3.941	0.4379	0.90	0.5384
Error	30	14.615	0.4872		
Total	47	292.016			

Grand Mean 2.6580 CV 26.26

Analysis of Variance Table for plant stem diameter 30 days

Source	DF	SS	MS	F	P
rep	2	0.33049	0.16524	4.40	0.0211
land	3	1.27724	0.42575	11.33	0.0000
treat	3	2.30308	0.76769	20.43	0.0000
land*treat	9	2.00981	0.22331	5.94	0.0001
Error	30	1.12710	0.03757		
Total	47	7.04772			

Grand Mean 1.0024 CV 19.34

Analysis of Variance Table for plant stem diameter 45days

Source	DF	SS	MS	F	P
rep	2	0.37946	0.18973	6.42	0.0048
land	3	0.72477	0.24159	8.17	0.0004
treat	3	6.09514	2.03171	68.74	0.0000
land*treat	9	0.10494	0.01166	0.39	0.9281
Error	30	0.88667	0.02956		
Total	47	8.19098			

Grand Mean 1.4144 CV 12.16

Analysis of Variance Table for plant stem diameter 60 days

Source	DF	SS	MS	F	P
rep	2	0.07464	0.03732	1.77	0.1879
land	3	0.27321	0.09107	4.32	0.0121
treat	3	7.00301	2.33434	110.63	0.0000
land*treat	9	0.08264	0.00918	0.44	0.9051
Error	30	0.63303	0.02110		
Total	47	8.06653			

Grand Mean 1.5788 CV 9.20

Analysis of Variance Table for harvesting index

Source	DF	SS	MS	F	P
rep	2	5.82	2.91	0.43	0.6561
land	3	38.23	12.74	1.87	0.1557
treat	3	3071.31	1023.77	150.35	0.0000
land*treat	9	120.68	13.41	1.97	0.0794
Error	30	204.28	6.81		
Total	47	3440.32			

Grand Mean 14.792 CV 17.64

Analysis of Variance Table for dry weight t/ha.30 days

Source	DF	SS	MS	F	P
rep	2	0.08747	0.04373	4.38	0.0214
land	3	0.04824	0.01608	1.61	0.2073
treat	3	0.93664	0.31221	31.30	0.0000
land*treat	9	0.17768	0.01974	1.98	0.0779
Error	30	0.29926	0.00998		
Total	47	1.54929			

Grand Mean 0.2374 CV 42.07

Analysis of Variance Table for dry weight t/ha. 45 days

Source	DF	SS	MS	F	P
rep	2	6.1589	3.07944	33.53	0.0000
land	3	0.0722	0.02406	0.26	0.8522
treat	3	2.2014	0.73380	7.99	0.0005
land*treat	9	0.5209	0.05788	0.63	0.7621
Error	30	2.7550	0.09183		
Total	47	11.7083			

Grand Mean 0.7446 CV 40.70

Analysis of Variance Table for dry weight t/ha.60 days.

Source	DF	SS	MS	F	P
rep	2	8.8929	4.44644	18.59	0.0000
land	3	2.2331	0.74437	3.11	0.0410
treat	3	12.4046	4.13487	17.28	0.0000
land*treat	9	4.2645	0.47383	1.98	0.0777
Error	30	7.1770	0.23923		
Total	47	34.9720			

Grand Mean 1.3528 CV 36.15

Analysis of Variance Table for fresh weight t/ha.30 days

Source	DF	SS	MS	F	P
rep	2	3.1593	1.57963	4.59	0.0182
land	3	0.7842	0.26139	0.76	0.5253
treat	3	12.9866	4.32885	12.59	0.0000
land*treat	9	1.2282	0.13646	0.40	0.9268
Error	30	10.3151	0.34384		
Total	47	28.4733			

Grand Mean 1.5104 CV 38.82

Analysis of Variance Table for final hay production t/ha

Source	DF	SS	MS	F	P
rep	2	0.859	0.4297	0.89	0.4216
land	3	5.336	1.7787	3.68	0.0228
treat	3	293.832	97.9439	202.66	0.0000
land*treat	9	15.212	1.6902	3.50	0.0046
Error	30	14.499	0.4833		
Total	47	329.738			

Grand Mean 7.3264 CV 9.49

Analysis of Variance Table for fresh weight t/ha.45 days

Source	DF	SS	MS	F	P
rep	2	234.713	117.356	40.41	0.0000
land	3	10.464	3.488	1.20	0.3262
treat	3	43.189	14.396	4.96	0.0065
land*treat	9	14.721	1.636	0.56	0.8158
Error	30	87.114	2.904		
Total	47	390.200			

Grand Mean 4.5608 CV 37.36

Analysis of Variance Table for fresh weight t/ha.60 days

Source	DF	SS	MS	F	P
rep	2	201.494	100.747	25.03	0.0000
land	3	55.138	18.379	4.57	0.0095
treat	3	209.328	69.776	17.33	0.0000
land*treat	9	62.383	6.931	1.72	0.1273
Error	30	120.755	4.025		
Total	47	649.097			

Grand Mean 7.1317 CV 28.13

Analysis of Variance Table for seed production t/ha.

Source	DF	SS	MS	F	P
rep	2	0.2286	0.11428	1.27	0.2960
land	3	0.3290	0.10967	1.22	0.3206
treat	3	17.9624	5.98748	66.44	0.0000
land*treat	9	0.9908	0.11009	1.22	0.3190
Error	30	2.7036	0.09012		
Total	47	22.2144			

Grand Mean 0.9004 CV 33.34

Analysis of Variance Table for panickle length (cm)

Source	DF	SS	MS	F	P
rep	2	1.0758	0.53792	0.51	0.6120
land	3	29.2233	9.74111	9.21	0.0013
treat	1	0.4817	0.48167	0.46	0.5107
land*treat	3	0.2683	0.08944	0.08	0.9673
Error	14	14.8042	1.05744		
Total	23	45.8533			

Grand Mean 26.033 CV 3.95

Analysis of Variance Table for 1000 seeds weight(gm.)

Source	DF	SS	MS	F	P
rep	2	5.866	2.9329	0.39	0.6815
land	3	53.928	17.9761	2.42	0.1098
treat	1	17.340	17.3400	2.33	0.1491
land*treat	3	14.750	4.9167	0.66	0.5896
Error	14	104.154	7.4396		
Total	23	196.038			

Grand Mean 36.258 CV 7.52

Analysis of Variance Table for 100-seed weight cow pea fula S2

Source	DF	SS	MS	F	P
rep	2	11.6425	5.82125	5.48	0.0175
land	3	22.6100	7.53667	7.09	0.0039
treat	1	6.0000	6.00000	5.64	0.0323
land*treat	3	1.0033	0.33444	0.31	0.8146
Error	14	14.8842	1.06315		
Total	23	56.1400			

Grand Mean 27.450 CV 3.76

Analysis of Variance Table for seeds/pod.

Source	DF	SS	MS	F	P
rep	2	0.6775	0.33875	0.71	0.5073
land	3	11.2346	3.74486	7.88	0.0025
treat	1	1.4504	1.45042	3.05	0.1026
land*treat	3	0.7979	0.26597	0.56	0.6504
Error	14	6.6558	0.47542		
Total	23	20.8162			

Grand Mean 9.6375 CV 7.15

Babnousa season 2011/2012

Analysis of Variance Table for L.A.I 30 days

Source	DF	SS	MS	F	P
rep	2	0.2621	0.1311	0.52	0.5989
land	3	1.8071	0.6024	2.40	0.0877
treat	3	73.4134	24.4711	97.38	0.0000
land*treat	9	1.5074	0.1675	0.67	0.7320
Error	30	7.5392	0.2513		
Total	47	84.5293			

Grand Mean 1.6646 CV 30.12

Analysis of Variance Table for L.A.I 60 days

Source	DF	SS	MS	F	P
rep	2	0.336	0.168	0.72	0.4932
land	3	3.552	1.184	5.10	0.0057
treat	3	315.010	105.003	452.23	0.0000
land*treat	9	2.030	0.226	0.97	0.4825
Error	30	6.966	0.232		
Total	47	327.893			

Grand Mean 3.1208 CV 15.44

Analysis of Variance Table for L.A.I 45 days

Source	DF	SS	MS	F	P
rep	2	0.857	0.4287	1.56	0.2263
land	3	4.788	1.5960	5.81	0.0029
treat	3	262.553	87.5178	318.87	0.0000
land*treat	9	3.023	0.3359	1.22	0.3178
Error	30	8.234	0.2745		

Total	47	279.455

Grand Mean 2.8088 CV 18.65

Analysis of Variance Table for Plant height (cm)30 days.

Source	DF	SS	MS	F	P
rep	2	33.6	16.80	0.27	0.7624
land	3	1065.4	355.13	5.79	0.0030
treat	3	16309.6	5436.52	88.62	0.0000
land*treat	9	335.3	37.25	0.61	0.7809
Error	30	1840.4	61.35		
Total	47	19584.2			

Grand Mean 62.533 CV 12.53

Analysis of Variance Table for Plant height (cm)45 days.

Source	DF	SS	MS	F	P
rep	2	273.0	136.50	2.46	0.1029
land	3	2902.7	967.58	17.41	0.0000
treat	3	10506.1	3502.03	63.01	0.0000
land*treat	9	254.9	28.32	0.51	0.8559
Error	30	1667.5	55.58		
Total	47	15604.2			

Grand Mean 106.51 CV 7.00

Analysis of Variance Table for Plant height (cm)60 days.

Source	DF	SS	MS	F	P
rep	2	1576.4	788.2	1.58	0.2224
land	3	6803.0	2267.7	4.55	0.0096
treat	3	54399.0	18133.0	36.38	0.0000
land*treat	9	1927.0	214.1	0.43	0.9085
Error	30	14954.1	498.5		
Total	47	79659.5			

Grand Mean 171.65 CV 13.01

Analysis of Variance Table for stem diameter(cm)60 days.

Source	DF	SS	MS	F	P
rep	2	0.0453	0.02266	0.47	0.6310
land	3	1.4253	0.47510	9.80	0.0001
treat	3	25.5118	8.50392	175.47	0.0000
land*treat	9	0.1607	0.01786	0.37	0.9412
Error	30	1.4539	0.04846		
Total	47	28.5970			

Grand Mean 2.0285 CV 10.85

Analysis of Variance Table for plant stem diameter(cm)30 days

Source	DF	SS	MS	F	P
rep	2	0.0232	0.01160	0.17	0.8405
land	3	0.7586	0.25285	3.81	0.0200
treat	3	26.3370	8.77899	132.25	0.0000
land*treat	9	0.2075	0.02306	0.35	0.9508
Error	30	1.9915	0.06638		
Total	47	29.3177			

Grand Mean 1.8798 CV 13.71

Analysis of Variance Table for plant stem diameter(cm)45 days

Source	DF	SS	MS	F	P
rep	2	0.00620	0.00310	0.14	0.8695
land	3	0.73479	0.24493	11.10	0.0000
treat	3	5.45704	1.81901	82.42	0.0000
land*treat	9	0.33572	0.03730	1.69	0.1353
Error	30	0.66213	0.02207		
Total	47	7.19588			

Grand Mean 1.1506 CV 12.91

Analysis of Variance Table for harvesting idex(%)

Source	DF	SS	MS	F	P
rep	2	8.6	4.30	0.10	0.9026
land	3	200.5	66.83	1.60	0.2108
treat	3	14542.8	4847.59	115.83	0.0000
land*treat	9	527.4	58.60	1.40	0.2320
Error	30	1255.5	41.85		
Total	47	16534.8			

Grand Mean 18.804 CV 34.40

Analysis of Variance Table for dry weight t/ha 30 days

Source	DF	SS	MS	F	P
rep	2	0.14728	0.07364	3.64	0.0385
land	3	0.43774	0.14591	7.21	0.0009
treat	3	7.99824	2.66608	131.68	0.0000
land*treat	9	0.22934	0.02548	1.26	0.2990
Error	30	0.60739	0.02025		
Total	47	9.41999			

Grand Mean 0.7804 CV 18.23

Analysis of Variance Table for dry weight t/ha 45 days

Source	DF	SS	MS	F	P
rep	2	0.3208	0.1604	1.14	0.3340
land	3	2.9377	0.9792	6.95	0.0011
treat	3	76.0945	25.3648	179.92	0.0000
land*treat	9	2.2001	0.2445	1.73	0.1245
Error	30	4.2293	0.1410		
Total	47	85.7824			

Grand Mean 1.8903 CV 19.86

Analysis of Variance Table for dry weight t/ha 60 days.

Source	DF	SS	MS	F	P
rep	2	1.250	0.6252	1.14	0.3320
land	3	13.660	4.5533	8.33	0.0004
treat	3	224.070	74.6899	136.69	0.0000
land*treat	9	6.656	0.7395	1.35	0.2525
Error	30	16.392	0.5464		
Total	47	262.028			

Grand Mean 4.0916 CV 18.07

Analysis of Variance Table for fresh weight t/ha 30 days

Source	DF	SS	MS	F	P
rep	2	3.329	1.6646	3.27	0.0521
land	3	2.060	0.6868	1.35	0.2776
treat	3	203.292	67.7641	132.96	0.0000
land*treat	9	2.623	0.2915	0.57	0.8091
Error	30	15.290	0.5097		
Total	47	226.595			

Grand Mean 4.1877 CV 17.05

Analysis of Variance Table for final hay production t/ha.

Source	DF	SS	MS	F	P
rep	2	23.31	11.65	2.42	0.1061
land	3	125.47	41.82	8.68	0.0003
treat	3	3239.93	1079.98	224.22	0.0000
land*treat	9	58.84	6.54	1.36	0.2508
Error	30	144.50	4.82		
Total	47	3592.04			

Grand Mean 11.503 CV 19.08

Analysis of Variance Table for fresh weight t/ha 45 days

Source	DF	SS	MS	F	P
rep	2	6.28	3.142	1.13	0.3370
land	3	38.76	12.920	4.64	0.0088
treat	3	1414.40	471.467	169.25	0.0000
land*treat	9	41.67	4.630	1.66	0.1427
Error	30	83.57	2.786		
Total	47	1584.68			

Grand Mean 8.4469 CV 19.76

Analysis of Variance Table for fresh weight t/ha 60days

Source	DF	SS	MS	F	P
rep	2	23.85	11.927	1.27	0.2966
land	3	80.59	26.862	2.85	0.0539
treat	3	2732.39	910.796	96.67	0.0000
land*treat	9	53.39	5.932	0.63	0.7626
Error	30	282.66	9.422		
Total	47	3172.88			

Grand Mean 15.846 CV 19.37

Analysis of Variance Table for panickle length(cm)

Source	DF	SS	MS	F	P
rep	2	3.4916	1.74578	0.52	0.6028
land	3	8.0583	2.68611	0.81	0.5104
treat	1	3.3451	3.34507	1.01	0.3329
land*treat	3	0.2798	0.09327	0.03	0.9934
Error	14	46.5598	3.32570		
Total	23	61.7345			

Grand Mean 25.517 CV 7.15

Analysis of Variance Table for 1000 seeds weight

Source	DF	SS	MS	F	P
rep	2	11.447	5.7237	3.19	0.0720
land	3	193.025	64.3415	35.91	0.0000
treat	1	16.170	16.1704	9.02	0.0095
land*treat	3	4.248	1.4160	0.79	0.5192
Error	14	25.086	1.7918		
Total	23	249.976			

Grand Mean 31.738 CV 4.22

Analysis of Variance Table for seeds/pod.

Source	DF	SS	MS	F	P
rep	2	3.6103	1.8052	1.64	0.2295
land	3	16.2923	5.4308	4.93	0.0153
treat	1	13.3803	13.3803	12.14	0.0036
land*treat	3	4.7236	1.5745	1.43	0.2763
Error	14	15.4307	1.1022		
Total	23	53.4372			

Grand Mean 7.5200 CV 13.96

Analysis of Variance Table for 100 seeds weight

Source	DF	SS	MS	F	P
rep	2	1.896	0.9479	0.10	0.9057
land	3	83.708	27.9028	2.93	0.0701
treat	1	1.500	1.5000	0.16	0.6972
land*treat	3	2.250	0.7500	0.08	0.9704
Error	14	133.104	9.5074		
Total	23	222.458			

Grand Mean 19.708 CV 15.65

Babanousa season 2012/2013

Analysis of Variance Table for Plant height (cm) 30 days.

Source	DF	SS	MS	F	P
rep	2	7.413	3.7064	0.54	0.5903
land	3	43.415	14.4717	2.09	0.1219
treat	3	62.151	20.7172	3.00	0.0461
land*treat	9	44.308	4.9232	0.71	0.6931
Error	30	207.284	6.9095		
Total	47	364.572			

Grand Mean 43.355 CV 6.06

Analysis of Variance Table for Plant height (cm) 45 days.

Source	DF	SS	MS	F	P
rep	2	987.28	493.638	5.81	0.0074

land	3	2343.53	781.177	9.19	0.0002
treat	3	2160.98	720.328	8.47	0.0003
land*treat	9	566.52	62.947	0.74	0.6694
Error	30	2550.00	85.000		
Total	47	8608.31			

Grand Mean 102.66 CV 8.98

Analysis of Variance Table for Plant height (cm) 60 days.

Source	DF	SS	MS	F	P
rep	2	558.8	279.379	1.33	0.2786
land	3	2255.2	751.727	3.59	0.0250
treat	3	1442.9	480.976	2.30	0.0978
land*treat	9	642.5	71.385	0.34	0.9536
Error	30	6283.2	209.439		
Total	47	11182.5			

Grand Mean 199.15 CV 7.27

Analysis of Variance Table for L.A.I 30 days.

Source	DF	SS	MS	F	P
rep	2	1.588	0.7941	5.87	0.0070
land	3	0.464	0.1547	1.14	0.3474
treat	3	94.086	31.3619	231.96	0.0000
land*treat	9	0.514	0.0572	0.42	0.9124
Error	30	4.056	0.1352		
Total	47	100.708			

Grand Mean 1.6610 CV 22.14

Analysis of Variance Table for L.A.I 60 days.

Source	DF	SS	MS	F	P
rep	2	1.197	0.599	3.01	0.0643
land	3	2.840	0.947	4.76	0.0079
treat	3	507.383	169.128	850.45	0.0000
land*treat	9	3.578	0.398	2.00	0.0750
Error	30	5.966	0.199		
Total	47	520.965			

Grand Mean 3.6314 CV 12.28

Analysis of Variance Table for L.A.I 45days.

Source	DF	SS	MS	F	P
rep	2	0.295	0.1475	1.81	0.1817
land	3	2.065	0.6882	8.43	0.0003
treat	3	204.121	68.0404	833.16	0.0000
land*treat	9	1.775	0.1972	2.42	0.0338
Error	30	2.450	0.0817		
Total	47	210.706			

Grand Mean 2.4036 CV 11.89

Analysis of Variance Table for plant stem diameter(cm) 30 days.

Source	DF	SS	MS	F	P
rep	2	0.0190	0.00951	0.49	0.6182
land	3	0.1685	0.05616	2.88	0.0520

treat	3	15.5828	5.19426	266.84	0.0000
land*treat	9	0.2469	0.02744	1.41	0.2281
Error	30	0.5840	0.01947		
Total	47	16.6012			

Grand Mean 1.5929 CV 8.76

Analysis of Variance Table for plant stem diameter(cm) 45 days.

Source	DF	SS	MS	F	P
rep	2	0.02814	0.01407	2.19	0.1291
land	3	0.03948	0.01316	2.05	0.1279
treat	3	9.21820	3.07273	478.90	0.0000
land*treat	9	0.05794	0.00644	1.00	0.4588
Error	30	0.19249	0.00642		
Total	47	9.53625			

Grand Mean 1.2842 CV 6.24

Analysis of Variance Table for plant stem diameter(cm) 60 days.

Source	DF	SS	MS	F	P
rep	2	0.03332	0.01666	0.86	0.4326
land	3	0.15127	0.05042	2.61	0.0698
treat	3	8.74681	2.91560	150.84	0.0000
land*treat	9	0.35127	0.03903	2.02	0.0722
Error	30	0.57988	0.01933		
Total	47	9.86255			

Grand Mean 1.8773 CV 7.41

Analysis of Variance Table for harvesting index.

Source	DF	SS	MS	F	P
rep	2	7.195	3.5977	1.66	0.2071
land	3	0.411	0.1369	0.06	0.9789
treat	3	159.526	53.1752	24.54	0.0000
land*treat	9	10.975	1.2195	0.56	0.8162
Error	30	65.018	2.1673		
Total	47	243.125			

Grand Mean 9.6104 CV 15.32

Analysis of Variance Table for dry weight 30 days.

Source	DF	SS	MS	F	P
rep	2	0.00722	0.00361	0.47	0.6291
land	3	0.04962	0.01654	2.16	0.1138
treat	3	0.75867	0.25289	32.99	0.0000
land*treat	9	0.05395	0.00599	0.78	0.6344
Error	30	0.22998	0.00767		
Total	47	1.09945			

Grand Mean 0.3090 CV 28.34

Analysis of Variance Table for dry weight 45 days.

Source	DF	SS	MS	F	P
rep	2	0.2406	0.1203	1.50	0.2404
land	3	0.4121	0.1374	1.71	0.1866
treat	3	60.5128	20.1709	250.72	0.0000

land*treat	9	0.5694	0.0633	0.79	0.6307
Error	30	2.4135	0.0805		
Total	47	64.1484			

Grand Mean 1.7268 CV 16.43

Analysis of Variance Table for dry weight 60 days.

Source	DF	SS	MS	F	P
rep	2	0.050	0.0252	1.63	0.2120
land	3	0.024	0.0080	0.52	0.6723
treat	3	123.914	41.3046	2677.94	0.0000
land*treat	9	0.537	0.0596	3.87	0.0024
Error	30	0.463	0.0154		
Total	47	124.988			

Grand Mean 2.7056 CV 4.59

Analysis of Variance Table for fresh t/ha. weight 30 days.

Source	DF	SS	MS	F	P
rep	2	0.6102	0.30511	0.65	0.5294
land	3	3.2099	1.06995	2.28	0.0997
treat	3	23.7592	7.91974	16.87	0.0000
land*treat	9	1.8838	0.20932	0.45	0.8986
Error	30	14.0871	0.46957		
Total	47	43.5502			

Grand Mean 2.1631 CV 31.68

Analysis of Variance Table for final hay t/ha.

Source	DF	SS	MS	F	P
rep	2	0.693	0.3466	1.08	0.3524
land	3	9.848	3.2828	10.23	0.0001
treat	3	274.171	91.3903	284.74	0.0000
land*treat	9	21.587	2.3986	7.47	0.0000
Error	30	9.629	0.3210		
Total	47	315.929			

Grand Mean 8.6879 CV 6.52

Analysis of Variance Table for fresh t/ha. weight 45 days.

Source	DF	SS	MS	F	P
rep	2	37.16	18.580	2.72	0.0822
land	3	20.85	6.950	1.02	0.3989
treat	3	852.92	284.308	41.60	0.0000
land*treat	9	84.40	9.378	1.37	0.2441
Error	30	205.02	6.834		
Total	47	1200.35			

Grand Mean 8.7983 CV 29.71

Analysis of Variance Table for fresh t/ha. weight 60 days.

Source	DF	SS	MS	F	P
rep	2	1.72	0.861	1.44	0.2519
land	3	47.10	15.702	26.34	0.0000
treat	3	2049.40	683.134	1145.83	0.0000
land*treat	9	39.28	4.364	7.32	0.0000

Error	30	17.89	0.596		
Total	47	2155.39			

Grand Mean 13.923 CV 5.55

Analysis of Variance Table for seed production t/ha.

Source	DF	SS	MS	F	P
rep	2	0.0238	0.01191	0.66	0.5233
land	3	0.2279	0.07596	4.22	0.0133
treat	3	17.9949	5.99830	333.17	0.0000
land*treat	9	0.1515	0.01683	0.93	0.5101
Error	30	0.5401	0.01800		
Total	47	18.9382			

Grand Mean 0.6948 CV 19.31

Analysis of Variance Table for panicle length(cm).

Source	DF	SS	MS	F	P
rep	2	7.1175	3.55875	5.79	0.0147
land	3	15.3246	5.10819	8.31	0.0020
treat	1	4.7704	4.77042	7.76	0.0146
land*treat	3	0.3146	0.10486	0.17	0.9145
Error	14	8.6092	0.61494		
Total	23	36.1363			

Grand Mean 25.938 CV 3.02

Analysis of Variance Table for 1000 seeds weighr

Source	DF	SS	MS	F	P
rep	2	4.441	2.22042	0.42	0.6622
land	3	18.632	6.21056	1.19	0.3501
treat	1	4.335	4.33500	0.83	0.3780
land*treat	3	2.885	0.96167	0.18	0.9056
Error	14	73.206	5.22899		
Total	23	103.498			

Grand Mean 25.908 CV 8.83

Analysis of Variance Table for seeds/pod.

Source	DF	SS	MS	F	P
rep	2	1.8808	0.94042	1.65	0.2273
land	3	7.1683	2.38944	4.19	0.0259
treat	1	2.2817	2.28167	4.00	0.0652
land*treat	3	1.6883	0.56278	0.99	0.4270
Error	14	7.9792	0.56994		
Total	23	20.9983			

Grand Mean 10.292 CV 7.34

Analysis of Variance Table for 100 seeds weight

Source	DF	SS	MS	F	P
rep	2	5.447	2.7237	1.23	0.3226
land	3	48.698	16.2328	7.32	0.0035
treat	1	12.327	12.3267	5.56	0.0335
land*treat	3	4.933	1.6444	0.74	0.5450

Error	14	31.059	2.2185	
Total	23	102.465		

Grand Mean 26.275 CV 5.67

ELfoula seas on 1--2comparison

Analysis of Variance Table for final hay production t/ha.

Source	DF	SS	MS	F	P
rep	2	9.487	4.7437	3.80	0.0265
season	1	3.725	3.7253	2.99	0.0879
season*land	6	20.274	3.3789	2.71	0.0191
season*treat	6	165.291	27.5485	22.08	0.0000
Error	80	99.833	1.2479		
Total	95	298.610			

Grand Mean 2.8801 CV 38.79

Analysis of Variance Table for harvesting index

Source	DF	SS	MS	F	P
rep	2	80.10	40.051	0.82	0.4452
season	1	941.88	941.880	19.22	0.0000
season*land	6	210.52	35.087	0.72	0.6377
season*treat	6	4373.52	728.920	14.88	0.0000
Error	80	3919.99	49.000		
Total	95	9526.01			

Grand Mean 17.924 CV 39.05

Analysis of Variance Table for seed production t/ha.

Source	DF	SS	MS	F	P
rep	2	0.01727	0.00863	0.78	0.4617
season	1	0.22253	0.22253	20.12	0.0000
season*land	6	0.09159	0.01527	1.38	0.2329
season*treat	6	4.83110	0.80518	72.78	0.0000
Error	80	0.88502	0.01106		
Total	95	6.04751			

Grand Mean 0.4259 CV 24.69

Babanousa season 1—2 comparison

Analysis of Variance Table for final hay production t/ha.

Source	DF	SS	MS	F	P
rep	2	9.487	4.7437	3.80	0.0265
season	1	3.725	3.7253	2.99	0.0879
season*land	6	20.274	3.3789	2.71	0.0191
season*treat	6	165.291	27.5485	22.08	0.0000
Error	80	99.833	1.2479		
Total	95	298.610			

Grand Mean 2.8801 CV 38.79

Analysis of Variance Table for harvesting index.

Source	DF	SS	MS	F	P
rep	2	80.10	40.051	0.82	0.4452
season	1	941.88	941.880	19.22	0.0000
season*land	6	210.52	35.087	0.72	0.6377
season*treat	6	4373.52	728.920	14.88	0.0000
Error	80	3919.99	49.000		
Total	95	9526.01			

Grand Mean 17.924 CV 39.05

Analysis of Variance Table for seed production t/ha.

Source	DF	SS	MS	F	P
rep	2	0.01727	0.00863	0.78	0.4617
season	1	0.22253	0.22253	20.12	0.0000
season*land	6	0.09159	0.01527	1.38	0.2329
season*treat	6	4.83110	0.80518	72.78	0.0000
Error	80	0.88502	0.01106		
Total	95	6.04751			

Grand Mean 0.4259 CV 24.69

Location and seasonal analysis

Analysis of Variance Table for final hay production t/ha.

Source	DF	SS	MS	F	P
rep	2	3.45	1.726	0.89	0.4128
location	1	88.79	88.786	45.74	0.0000
season	1	7.46	7.462	3.84	0.0515
location*season	1	29.83	29.826	15.36	0.0001
location*land	6	30.17	5.028	2.59	0.0198
location*treat	6	612.84	102.141	52.61	0.0000
Error	174	337.79	1.941		
Total	191	1110.33			

Grand Mean 3.5601 CV 39.14

Analysis of Variance Table for harvesting index.

Source	DF	SS	MS	F	P
rep	2	46.7	23.34	0.24	0.7833
location	1	663.1	663.05	6.95	0.0092
season	1	2867.5	2867.52	30.04	0.0000
location*season	1	103.0	102.96	1.08	0.3004
location*land	6	243.8	40.63	0.43	0.8612
location*treat	6	8462.4	1410.40	14.78	0.0000
Error	174	16609.2	95.46		
Total	191	28995.6			

Grand Mean 16.066 CV 60.81

Analysis of Variance Table for seed production t/ha.

Source	DF	SS	MS	F	P
rep	2	0.0259	0.01294	1.04	0.3552
location	1	0.0547	0.05471	4.40	0.0373
season	1	1.0625	1.06252	85.52	0.0000
location*season	1	0.1322	0.13225	10.64	0.0013
location*land	6	0.0672	0.01121	0.90	0.4948
location*treat	6	11.2966	1.88277	151.53	0.0000
Error	174	2.1619	0.01242		
Total	191	14.8011			

Grand Mean 0.4090 CV 27.25