Effect of Phosphorousand Intercroppingon The Nutritive Value of Maize *(Zea mays)***and** Lablab bean**(***Lablab purpureus)*

By

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DEDICATION

First of all I thank Allah our creator above for giving me the courage, ability and strength to accomplish this work.

My special love goes to my father and my mother for their trust and endless love.

To my two sisters and my brother, with my all love.

To all my friends, thanks for the endearing friendship, for every beautiful moment we spent together, Allah keep us...

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Abstract

A field experiment was conducted at the Demonstration Farm of the University of Khartoum to determine the effect ofphosphorous fertilization and intercropping on the nutritive value of*Zea mays*and *Lablab purpureus*. The field experiment was arranged as split plot design with four replications. The main plots were (*Lablab purpureus* as sole crop, *Zea mays*as sole crop, *Lablab purpureus* mixture and*Zea mays* mixture). The sub plot treatments were phosphorous fertilization at the rate of (0, 50 and 75 kg P_2O_5 / ha) which were then referred to as P_0, P_1 and P_2 respectively. Samples of 45 days cut from sowing were used to asses the ash, Crude protein (CP), Ether Extract (EE), Crude Fiber (CF), Neutral Detergent Fiber (NDF) and dry matter digestibility.

The results revealed that intercropping and phosphorous fertilization caused a significant increased on the CP content and dry matter digestibility (P>0.05) of all crops under estimated. Intercropping and phosphorous fertilization caused non–significant effect (P<0.05) on the ash content for all crops in this study. Moreover, Intercropping and phosphorous fertilization caused a decrease on the CF and NDF content of all crops under estimated but with no significant difference. However, Intercropping caused non–significant effect (P<0.05) on the EE content of *Zea mays*while, intercropping had a positive influence (P>0.05) on the EE content of *Lablab purpureus*. The data obtained indicated that phosphorous fertilization caused non–significant effect on the EE content of all crops in this study (P<0.05) except *Lablab purpureus* in the mixture which increased (P>0.05) by increasing phosphorous level. It can be concluded that Intercropping and phosphorous fertilization improved the nutritive value of both *Zea mays* and *Lablab purpureus*.

خلاصة الاطروحه

اجريت هذه التجربه في المزرعة التجريبيه فى جامعة الخرطوم لمعرفة تاثير التسميد بالفسفور والزراعه في خليط علي القيمه الغذائيه لمحصولى الذره الشاميه واللوبيا العفن . صممت التجربه في شكل تصميم قطاعات منشطره باربعه تكرارات .

القطاعات الرئيسيه كانت لمحاصيل العلف على النحو التالى (لوبيا عفن منفرد ، ذره شاميه منفرد، لوبيا عفن في الخليط وذره شاميه في الخليط) القطاعات الفرعيه كانت للتسميد بالفسفور و ذلك باستخدام ثلاثه مستويات (0, 50و 75) كجم P_2O_5واشير اليها لاحقا (P_0 P_1 وP_2) على التوالي.تم أخذ عينات من النباتات عند عمر 45 يوم من الزراعه ، استخدمت هذه العينات لتقدير نسبة الرماد الخام ، البروتين الخام ، المستخلص الايثرى ، الالياف الخام ، الالياف الذائبه في المحاليل المتعادله و هضمية الماده الجافه .

اظهرت النتائج ان الزراعه في خليط والتسميد بالفسفور اثرا تاثير معنوى علي نسبة البروتين الخام ومعدل الهضميه لكل المحاصيل تحت الاختبار. كما و أن الزراعه في خليط والتسميد بالفسفور لم ياثرا معنويا فى نسبة الرماد الخام لكل المحاصيل في هذه الدراسه. كذلك فان الزراعه في خليط والتسميد بالفسفور تسببا بنقصان نسبة الالياف الخام ونسبة الالياف الذائبه في المحاليل المتعادله لكل المحاصيل تحت الاختبار ولكن من غير أن يكون هنالك أثر معنوى . الزراعه في خليط لم تؤثر علي نسبة المستخلص الايثرى لعلف الذره الشاميه بينما نجد ان الزراعه في خليط اثرت بصوره ايجابيه علي نسبة المستخلص الدهني لمحصول اللوبيا العفن . اظهرت النتائج المتحصل عليها ان التسميد بالفسفور لم يؤثر علي نسبة المستخلص الدهني لكل المحاصيل فى هذه الدراسه ماعدا محصول اللوبيا عفن في الخليط حيث اظهرت النتائج زياده في نسبة المستخلص الايثرى عند زيادة نسبة التسميد بالفسفور.

أستنتج من هذه الدراسه أن الزراعه في خليط والتسميد بالفسفور حسنا القيمه الغذائيه لكل من محصول الذره الشاميه ومحصول اللوبيا العفن.

Chapter One

Introduction

Sudan is located in the north-eastern part of Africa; it is characterized by a climate ranging from very arid in the northern parts, to very humid in its most southern parts, while the central parts are occupied by savannah.

Sudan ranks fifth in the world, and as the first richest Arabic country in livestock. The livestock estimated to be 41.6, 51.6, 43.3 and 4.5 million heads of cattle sheep, goats and camels respectively, other animals like asses, horses and mules estimated to be 7.51000, 26.200, and 635 heads respectively (FAO, 2009). This huge livestock numbers play a major role in the livehood of rural population and the agricultural development of Sudan.

The economy of Sudan is based on agricultural products. The total land area amounts to some 251 million hectares. About half of this land is suitable for agriculture, of which about 17 million hectares are actually cultivated, employing some two-thirds of the population and contributing of about 40 percent of gross domestic product (GDP) (FAO, 2003).

About ninety percent of the livestock depend on the rangelands and crop residues, which are low in crude protein and high percent of cell wall component, so grazing animals are often unable to satisfy their nutritional requirements especially during reproductive and most productive phases (Amasaib, 2008). To overcome these problems most breeders tend to supplement their herd with cheaper and affordable protein feed sources like *Zea mays* and *Lablab purpureus* to the available feed resources.

Recently there is mounting interest in intercropping between grasses and legumes. The intercropping is defined as the practice of growing two or more crops in a close proximity (Andrews and Kassam, 1976). The great advantages of intercropping such as higher yield, greater land use efficiency and improvement of soil fertility through addition of nitrogen make this practice is very useful (Amasaib, 2008).

Phosphate deficiency is very common globally (Wild, 1988). Phosphorous fertilization is needed in relatively large amounts by legumes for growth and nitrogen fixation and has been reported to promote leaf area, biomass, yield, nodule numbers in legumes ....etc (Amasaib, 2008). The present study aimed to:

1. Study the effect of intercropping on the nutritive value of *Zea mays* and *Lablab purpureus*.
2. Determine the effect of phosphorous fertilization on the chemical composition of *Zea mays* in pure stand, *Zea mays* in the mixture, *Lablab purpureus* in pure stand and *Lablab purpureus* in the mixture.

Chapter Two

Literature Review

2.1 Intercropping

Intercropping is considered as the most biodiversity mean to sustain the land from degradation (Ghosh, 2004). Andrews and Kassam (1976) mentioned that there are at least four basic spatial arrangements used in intercropping, most practical systems are variations of these:

- *Row intercropping*—growing two or more crops at the same time with at least one crop planted in rows.
- *Strip intercropping*—growing two or more crops together in strips wide enough to permit separate crop production using machines but close enough for the crops to interact.
- *Mixed intercropping*—growing two or more crops together in no distinct row arrangement.
- *Relay intercropping*—planting a second crop into a standing crop at a time when the standing crop is at its reproductive stage but before harvesting.

A combination of a legume with a cereal is the most common type of intercropping that occurs with annual crops, and the majority of successful intercrops grown worldwide are also consist of cereal-legume intercrops (Francis, 1989).

Intercroping has many advantages such as protecting the land from degradation due to it is other benefits like higher yield (Yadar and Yadav, 2000), greater land use efficiency and improvement of soil fertility through addition of nitrogen (Go¨kkus *et al*., 1999). On the other hand Baumann *et al*. (2004) stated that the intercropping gained an increasing interest in an attempt to substantiate functional able biodiversity agricultural production and to reduce pesticide use but, intercropping cereal with legumes may cause a reduction in cereal grain because the competition between two crops (Shehu *et al*., 1999).

According to Eskandari *et al*. (2009), the main criteria used in selecting the species, especially as forage crops, in intercropping are:

- The species should have high protein content.
- The species should have a facilitative effect with each other and no antagonistic interaction, i.e., they should exhibit contrasting morphological and physiological characteristics and there should be some temporal differences between the growths of them. In ecological terms, the morphological and physiological differences among species results in their ability to occupy different niches. Thus, the hypothesis here is that in agriculture, environmental factors could be more efficiently utilized by mixed stands of crops than pure stands.
- The two species in combination with each other should produce maximum yields at the same harvest time.
- The two species should have a same sowing date as much as possible.

The combination of cereals and legumes exhibit most of the above criteria. Thus, the inclusion of a legume in the cereal crop has the potential for improving forage yield and quality. Legumes have been shown to produce high concentration of crude protein depending on cultivar, harvest date and local conditions (Herbert *et al*., 1984).

2.2 Phosphorus fertilization

Fertilizer is any organic or inorganic material of natural or synthetic origin (other than liming materials) that is added to a soil to supply one or more plant nutrients essential to the growth of plants (Erisman *et al*., 2008). A recent assessment found that about 40 to 60% of crop yields are attributable to commercial fertilizer use (Stewart *et al*., 2005). Phosphorus plays an important role in crop maturation, root development, photosynthesis, nitrogen fixation, other vital processes and as a major nutrient and in order of importance, phosphorus is second to nitrogen (Gervey, 1987).

Erisman *et al*. (2008) reported that inorganic fertilizer use has also significantly supported global population growth it has been estimated that almost half the people on the Earth are currently fed as a result of synthetic nitrogen fertilizer use.

The macronutrients are consumed in larger quantities and are present in plant tissue in quantities from 0.15% to 6.0% on (DM) basis (Erisman *et al*., 2008). Micronutrients are consumed in smaller quantities and are present in plant tissue on the order of parts per million (ppm), ranging from 0.15 to 400 ppm DM, or less than 0.04% DM (Mills *et al*., 1996).

The use of phosphate fertilizers has also increased from 9 million tons per year in 1960 to 40 million tons per year in 2000, Maize crop yielding 6-9 tons of grain per hectare requires 31–50 kg of phosphate fertilizer to be applied (Vance *et al*., 2003).

2.3 *Zea mays* (L.) (Maize or Corn)

2.3.1 Origin:

Maize is a Mexican origin (Piperno and Flannery, 2001). The term "Zea" is from the greek "zea" meaning cereal or grain and the term "mays" is thought to derive from the native Arawak word maiz or mahiz used in the Americas to describe the plant (Hyam and Pankhurst, 1995), the word was adopted by the Spanish crew of Columbus who carried maize back to Europe (Desjardins and McCarthy, 2004). Maize spread to the rest of the world due to it is popularity and the ability to grow in varieties of climates especially in temperate zones (Farnham *et al*., 2003; Paliwal, 2000d).

2.3.2 Uses:

Corn is considered an important food crop for humans and a high-energy feed for animals (FAO, 1992). Maize fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid as in case of sorghum or fodders (Dahmardeh *et al*., 2009). It has a multitude of uses, it is used in the preparation of food or drinks, as animal feed (either as grain or silage), for industrial purposes and since the early 1980's a significant amount of grain has also been used for fuel ethanol production (Watson, 1988). Forty percent is used as stock feed in tropical areas and up to 85% in developed countries (Farnham *et al*., 2003; Paliwal, 2000g).

Maize is widely cultivated throughout the world, top producing countries include The United States, China, Brazil, Mexico and Indonesia (Farnham *et al*., 2003). Sudan production was 66 thousand tones in the year 2009 (FAO, 2009).

2.3.3 Nutritive value:

Boyer and Hannah (1994) noted that a typical mature kernel is contained of 70% - 75% starch, 8%-10% protein and 4% - 5% oil however, there are large differences in the relative concentrations of these components between different parts of the kernel. The two major structures of the kernel are the endosperm 80% and the germ 10% of the mature kernel dry weight (Boyer & Hannah, 1994). The endosperm is largely starch approximately 99%, while the germ contains high levels of fat (33%) and protein about eighteen percent (Boyer & Hannah, 1994).

Also Nelson and Pan (1995) revealed that starch in Maize contains two major types of glucose homopolymers, amylase and amylopectin, In amylase the glucose residues are mainly linked via a-1,4 linkages, which results in a linear chain of glucose units, In amylopectin the majority are a-1,4 linkages, with a-1,6 linkages providing branching.

Protein in the endosperm can be divided into prolamins which referred to as zeins, Zeins contain large amounts of amino acids glutamine, proline, leucine and alanine but are very low in lysine and tryptophan (Woo *et al*., 2001). Embryo proteins provide higher levels of lysine and tryptophan (FAO, 1992).

Fatty acids distributed as 14% saturated and 86% unsaturated (Boyer and Hannah, 1994). Maize oil is generally high in linoleic acid and low in linolenic acid (Sammon and Iputo, 2006).

Ranges for proximate analysis of Maize grain are (7-23) % Moisture in fresh weight, (6-12) % Protein, (3.1-5.8) % Lipid, (1.1-3.9) % Ash, (82.2-82.9) % Carbohydrate, (8.3-11.9) % fibre and 55.0% digestibility according to (OECD, 2002).

Phosphorus is a component of energy carrying phosphate compounds such as ATP and ADP (Raven *et al.*, 1999). Phosphorous deficiency reduces the leaf area index of Maize, thus reducing the amount of photosynthetically active radiation absorbed by the canopy and leading ultimately to lower biomass accumulation (Pellerin *et al.*, 2000). Symptoms of phosphorus deficiency are slow growth, late maturity, a reddening of leaves, poorly developed root system and small ear size (Colless, 1992).

2.3.4 Effect of intercropping on the nutritive values of *Zea mays* and some other grasses:

Eskandari *et al*. (2009) reported that protein content in the *Faba bean* was on average 2.1 times that of Wheat, therefore, the addition of *Faba bean* as legume could be improve the quality of Wheat forage, because Wheat contains lower crude protein concentrations of (8.4-10.5) %, and *Faba bean* as whole crop has been shown to produce high concentration of crude protein of (17-18.5) %. Moreover, legumes produce low dry matter and are known to be weak competitors against weeds (Eskandari *et al*., 2009). Therefore, it seems that growing either legumes or cereals in a sole crop is not ideal for forage production. On the other hand, Liu *et al*. (2006) concluded that crude protein of plants in intercropping system was increased by 30.8% when compared with mono-cropping Maize. This was in line with Herbert *et al*. (1984) who reported that all intercrops produced (8-17) % more total protein than Corn monoculture.

In addition, Putnam *et al*. (1986) noted increases of (11-51) % in CP concentrations of Maize -Soyabean intercrops compared with a Maize sole cropping. This is in agreement with the research of Fujita *et al*. (1992) who reported that protein concentration was increased from (69-81) g.kg-1 for Maize sole cropping to (88-108) g.kg-1 for various intercropping pattern.

On the other hand, integration of legumes into the cereal-based farming system may be the key to sustaining soil, crop and livestock production (Caballero *et al*., 1995). Thus, a better alternative might be to grow these species as a mixture. Also the higher total protein yield produced by intercropping was attributed to higher forage production by intercrops and also protein content (Fujita *et al*., 1992). This was in conformity with (Eldessougi *et al*., 2003) who noted that Maize yield was increased by intercropping with Groundnut, mainly because of an enhanced phosphorous uptake.

Other important characteristics for forage quality are the concentration of NDF, CF and Ash. The NDF content is important in ration formulation because it reflects the amount of forage that can be consumed by animals (Bingol *et al*., 2007; Lithourgidis *et al*., 2006). As NDF percentage increases, dry matter intake decreases (Van Soest, 1994). Lauriault *et al*. (2004) noted that intercropping with Pea decreased NDF and CF significantly in all cereal. Thus, addition of legumes to forage Maize can reduce the NDF and CF concentrations, indicating potential for increasing forage intake. In addition, Dahmardeh *et al*. (2009) reported that maximum NDF and CF were recorded by sowing Maize alone. Intercropping of cereal and legume can improve forage quality in terms of Ash. In this connection, Anil *et al*. (2000) reported that Ash content was increased by intercropping of Maize and *Runner bean*. Mason and Pritchard (1987) stated that mineral absorption percent increases due to complementary effects between components of Maize-Soyabean intercropping.

It has been reported that different forage quality was obtained at different harvest date in intercropping. Dahmardeh *et al.* (2009) concluded that maximum crude protein percentage of forage was obtained in the first harvest and minimum crude protein was achieved in the second harvest of Maize growth period in Maize-Cowpea intercropping. Decreasing of CP content with increasing maturity reported by Shepard and Kung (1996), while reduction in NDF and CF concentration of forage from doughty stage compared with milky stage was recorded which can attributed in increasing of grain to whole biomass ratio. In the other word, harvest time affected significantly NDF and CF concentration. A decline in fiber concentration with increasing maturity can be attributed to the dilution effect created by increasing content of grain as Corn matures (Coors *et al*., 1997).

Maize composition with different legumes may results in different forage quality. For example, Javanmard *et al.* (2009) used two Maize hybrids (704 and 301) and four legumes (Vetch, Bitter vetch, Berseem clover and common Bean) intercrops to evaluate the effects of legumes on forage yield and quality. They found that CP yield, dry matter content and ash content of maize forage increased by intercropping as compared with maize sole crop. Also, intercropping of legumes with Maize significantly reduced NDF and ADF content thus, increasing digestibility of the forage. Furthermore, forage quality achieved by intercropping was higher in the composition of Maize with Vetch, bitter Vetch and common Bean, where NDF and ADF content were higher in Maize-Berseem clover intercropping.

Seed proportion of intercropping components is also a factor affecting yield and CP content of forage. For instance, Ibrahim *et al.* (2006) compared the yield and quality of Maize fodder and Cowpea sown alone and in mixture with each other in different proportions. They found that the production of crude protein was affected by seed combinations of Maize and Cowpea in different ratios, where, an increased proportion of Cowpea in seed mixture increased the crude protein contents. The seed combination of (75:25) Maize and Cowpea produced more dry matter (13.26 t/ha) and crude protein (10.45%) than Maize sole crop, suggesting that higher green forage yield and good quality could be attained by mixture of Maize and Cowpea of (75:25) seed ratio. Dawo *et al.* (2007) concluded that CP concentration increased 22% in the mixture when Corn proportion decreased by 50% in the mixture of Corn and Bean. Boufaied *et al*. (2003) noted that intercropping had no effect on concentration of EE content for grasses and legumes.

2.3.5 Effect of phosphorous fertilization on the nutritive values of *Zea mays* and some other grasses:

A lot of investigations have been conducted to examine the effect of phosphorous fertilizer on plant. Abuswar (1997) found positive effect of phosphorous fertilizer on forage yield and dry matter of abu 70. Also Russell (1985) found a significant effect on CP when adding 48 kg phosphorous/ha than when adding 24kg phosphorous/ha. Moreover, Walmsley and Sergeant (1978) reported non-significant effect phosphorous fertilization on fresh weight and dry matter for cereal forages crops. Ayub *et al*. (2002) showed that phosphorus application influenced the DM and Ash content of Maize when intercropped with legumes significantly. The application of phosphate fertilizer decrease the CF and NDF content in Wheat when intercropped with *Lablab bean* (Kulkorni *et al*. 1986).

Phosphorous often increases nodulation and hence increase N or CP content in grasses (Hauque and Mohammed, 1985). On the other hand, (Abusuwar *et al*., 1997; Abusuwar *et al*., 1996; Russel, 1985; Abusuwar, 2001; Ibrahim, 1996) **r**eported significant effect of phosphorous fertilization on cereal forage crops in

NDF and ASH. Also Habib *et al*. (1971) found that application of phosphate had no effect on the percentage of ASH in grain. In contrast Rathore and Kumar (1977) noted that phosphorous has no consistent effect on CF content on Sorghum and Dinanath grass, and that phosphorous fertilization increased digestibility of sorghum in the pure stand and in mixture with legumes while, Boufaied *et al*. (2003) noted that phosphorous fertilizer had no significant effect on concentration of total and individual fatty acids in legumes and grasses.

2.4 *Lablab purpureus (***Bean**, *Lablab bean* **or Dolecous***)*

2.4.1 Origin:

The wild forms of *Lablab purpureus* are believed to have originated in India (Deka and Sarkar, 1990) and were introduced into Africa from south-east Asia during the eighth century (Kay, 1979). Presently, Lablab is common in Africa, extending from Cameroon to Swaziland and Zimbabwe, through Sudan, Ethiopia, Uganda, Kenya and Tanzania (Skerman *et al*., 1991).

Lablab purpureus is commonly known as the *Hyacinth bean* or *Lablab bean* (Kay, 1979). It is widespread as a food crop throughout the tropics, especially in Africa, India and Indonesia, the widespread use of Lablab for animal grazing is more recent (Cameron, 1988). Harricharan *et al*. (1988) stated that forage legumes can be grazed, harvested and fed fresh or stored as hay or silage.

Lablab purpureus belongs to family Leguminosae (Cameron, 1988). On the other hand, Winton (1939) reported that legumes are normally of better nutritive values than grasses because legumes have higher contents of protein, calcium, phosphorus and lower contents of fibers.

2.4.2 Uses:

Forage legumes offer several advantages to tropical farming systems. First, leguminous cover reduces soil erosion and runoff, this cover is able to conserve soil, improve organic matter content and compete with weeds (Humphreys, 1995; Schaaffhausen, 1963a,b). Second, the legume-rhizomal symbiosis converts atmospheric nitrogen (N) to forms of N which plants can take up and cycled within the plant-animal-soil system. The legume-rhizobial symbiosis provides farmers with an inexpensive source of N whose production is environmentally "clean". This symbiosis does not involve the consumption of fossil fuel, as occurs in the production of fertiliser N which contributes to global warming and exacerbates the foreign exchange balance of tropical countries lacking in oil resources (Humphreys, 1995). As a consequence of different biochemical pathways of carbon fixation during photosynthesis, N fixing legumes have higher concentrations of cellular protein than tropical grasses (Bjorkman *et al*., 1976).

Third, an economical method of cultivating Lablab for soil improvement and for cattle feed is to sow the legume as a companion crop for Maize. During the first few months Lablab grows slowly competing with weeds between the Maize rows, but not with the Maize. When the Maize begins to ripen, Lablab vines start to grow more vigorously and obtain their greatest development after the Maize is harvested. At this point cattle may be turned out to graze the Maize stover / Lablab field (Schaaffhausen 1963ab; Sinclair 1996). This technique corrects protein deficiency in the dry season, and leads to a better use of low-protein, high-fibre crop residues. Lablab may be incorporated into pasture systems and under more advanced conditions, it can be used in controlled rotational grazing systems (Jones *et al*., 1991). Another benefit of using Lablab is that it is a viable grain producing legume for human consumption (Wood, 1983). Lablab has tender pods which may be eaten green or the grain may be allowed to mature. Once the mature beans are harvested, they need only be cooked to provide nourishment for humans (Schaaffhausen 1963a; Sinclair 1996).

2.4.3 Nutritive value:

Omole *et al*. (2007) results showed that chemical composition for *Lablab purpureus* are 23.40, 18.18, 15.36, 1.23, 8.94 and 56.29 of DM CP CF EE ASH and NFE respectively.

The levels of crude protein recorded in total plant were (15.3% -19.7) % in DM **(**Herrera *et al*., 1966), also results revealed by Wetherall, (1969) showed (11.8 - 17.5) % in DM. Murphy (1998) reported that there are 27.8% Crude fiber and 43% NDF (in DM) in the whole plant.

Dry matter digestibility of *Lablab purpureus was* 55.5% (Milford and Minson, 1968). Dry matter digestibility of Lablab hay 1st cut for sheep was 43.9% 2nd cut for sheep was 39.4% (Favoretto and Peixoto, 1978). Makembe and Ndlovu 1996 noted that the digestibility of 70:30 Maize:Lablab (in situ) was 53.8 % and 50:50 Maize:Lablab (in situ) was 55.0 %. In studies done by Hamilton *et al*. (1970) in Australia, cattle consuming pure stands of lablab maintained a high level of milk production in contrast to animals eating grasses. This improved milk yield and a slower decline of yield with time was related to a higher intake.

2.4.4 Effect of intercropping on the nutritive values of *Lablab purpureus* and other legumes:

Ibrahim *et al*. (2006) noted that the Cowpea sown alone produced more crude protein (18.10%), but the lowest dry matter with non-significant effect and Ash content with a significant effect while, *Zea maize* sown alone produced minimum crude protein (8.5%)._Subramanian and Rao (1988) found that when Pigeon pea was intercropped with Sorghum, legume dry matter was reduced.

Shehu (1999) studied the effect of intercropping on *Lablab bean* with sorghum and found that the dry matter content of *Lablab bean* was greatest when it was the sole crop and least when it was intercropped in pair rows, he concluded also Lablab in the mixture had the lowest CP content and tends to have high fiber treatment. The results reported by Cabblero *et al.* (1995) showed the mixtures of common Vetch with Oat produced 34% more forage yield than common Vetch alone. *The lower the protein percentage, the more mature the legumes. The higher the protein percentage indicates a less mature plant (*Hendricksen and Minson, 1985b).

Boufaied *et al*. (2003) noted that intercropping had no significant effect on concentration of the EE content for grasses and legumes. Crude fiber and NDF content of legumes generally decrease with intercropping (Minson, 1990). Javanmard *et al*. (2009) observed that intercropping of legumes with Maize reduced NDF and ADF content thus, increasing digestibility of the forage. As with most legumes, the dry matter digestibility of lablab declines with maturity (Milford and Minson, 1968).

A Cuban system based on pasture plus forage rations produced from inter-cropping, showed that animals on which included *Lablab bean* had an increase of milk production of 3 litres/cow/day; the same response in milk production was achieved by using supplementation with soybeans. Besides improving production, the *Lablab bean* system had the lowest cost/tonne of DM (Cino et al., 1994). Similar results were obtained in Honduras (Sinclair, 1996) in a trial comparing two forage systems (Maize stover vs. Maize stover/lablab). The system including *Lablab bean* produced more milk per animal and per hectare than the traditional one. In addition, the cows assigned to the maize/lablab system gained more body weight than the cows in the maize system (Sinclair, 1996).

2.4.5 Effect of phosphorous fertilization on the nutritive values of *Lablab purpureus* and other legumes:

Phosphorus fertilization increase DM in alfalfa when intercropped with *Zea maize* (Colomb *et al*., 2002). Application of phosphate fertilizer increased dry matter in cowpea (Ahmed, 1988). Absuwar and Abdalla (2003) reported that phosphorous applications slightly increased the forage fresh yield but with no significant difference. Ibrahim (1996) found that increased application of phosphorous up to 200 kg P_2O_5 / ha resulted in a significant decrease in the CF, NDF and EE content of Clitoria when intercropped with *Zea maize*. Mohammed (1991) indicated that phosphorous fertilizer increased Clitoria dry matter and fresh yield by about 72%. Abusuwar (2004) who found non-significant effect phosphorous fertilization on fresh weight *of Clitoria ternatea*.

Habib *et al*. (1971) found that application of phosphate increased the percentage of Ash in legumes. Osman (1974) reported that Phosphorous increased nodulation and CP content in Sub clover. Yemane (2003) found that CP content of Dekoko (*Pisum sativum*) when intercropped with grasses increased significantly with the increase in the phosphorous application while total sugar decreased with an increase in phosphorous application rate.

Mustafa (1996) found significant increased in CF and NDF when phosphorous applications increased in Alfalfa. Boufaied *et al*. (2003) noted that phosphorous fertilizer had non-significant effect on concentration of total and individual fatty acids in legumes and grasses. Colomb *et al*. (2002) also noted that phosphorous fertilization increased digestibility for Alfalfa in pure stand and alfalfa in the mixture.

Chapter Three

Material and Methods

3.1 Study site

The study was conducted at the University of Khartoum Demonstration Farm of the faculty of agriculture at Shambat. This area has a semi desert climate with hot summer and short rainy season from July to September between 100 and 200 mm, and a temperature ranges from 12^{o}C to 42^{o}C (Shambat Meteorological Station, 2008).

3.2 Treatments:

Treatments were arranged in split plot designed with four replications. The main were (*Lablab purpureus* as sole crop, *Zea mays* as sole crop, *Lablab purpureus* mixture, *Zea mays* mixture). The sub plot treatments were phosphorous fertilization. The application of super phosphate was in the level of 0, 50 and 75 kg P_2O_5 / ha. Which were denoted as P_0, P_1 and P_2 respectively.

3.3 Chemical analysis:

3.3.1 Proximate analysis:

Samples of 45 days cut from sowing were used to asses the proximate components. The ash, CP, EE, and CF according to (AOAC, 1980). NDF were determined according to Georing and Van Soest (1991).

3.3.2 In vitro digestion:

This method is variously known as the in vitro method or the Tilley and Terry method named after Tilley and Terry (1963) who were the first to use this technique which is a two stage technique. In vitro digestibility was determined according to (Menke and Steingass, 1979). Rumen fluid was collected from local breed calve at the morning before feeding.

Microbial digestibility:

The rumen fluid was strained and mixed with buffer in ratio 1:4. Carbon dioxide was providing in steady over the buffer/ rumen fluid mixture out the mixing and dispensing procedure.

In the second stage (0.5g) of the sample were weighted into test tube which were incubated in water bath 39 degree centigrade for 48 hours after the addition of the buffer / rumen fluid mixture 40 ml of buffer rumen fluid mixture was dispensed into each test tube.

Enzyme digestibility:

Tubes test were filtered and put in them enzyme digestibility after the addition of pepsin (2gm) and HCl (100ml).mixture test tubes were located in water bath 39 degree centigrade for 48 hours. The insoluble residue was filtered off and dried and weighted.

3.4 Statistical Analysis:

The data collected were subjected to analysis of variance technique using split plot design. The differences between means were compared using Duncan's Multiple Range test.

Chapter four

Results

Table (1) Effect of intercropping on the nutritive values of *Lablab purpureus* and *Zea mays*

Crop type	ash gkg^{-1}	CP gkg^{-1}	EE gkg^{-1}	CF gkg^{-1}	NDF gkg^{-1}	Dig. %
Lablab purpureus **Pure stand**	14.45^{a}	18.50^{b}	2.15^{b}	21.04^{b}	58.83^{b}	59.40^{b}
Lablab purpureus **in the mixture**	16.80^{a}	23.50^{a}	4.03^{a}	20.22^{b}	55.30^{b}	66.80^{a}
Zea mays **Pure stand**	13.10^{a}	15.70^{b}	2.93^{b}	27.10^{a}	69.11^{a}	55.01^{b}
Zea mays **in the mixture**	14.50^{a}	21.20^{a}	3.01^{b}	26.50^{a}	67.54^{a}	64.70^{a}
SEM	8.19	5.11	1.02	1.8	8.06	3.73

Means followed by the same super scripts in the same column are not significantly different at (0.05) level of significance.

SEM = Standard Error of Means; Dig. = Digestibility.

Table (1) shows the effect of intercropping on the nutritive values of *Lablab purepureus* as pure stand, *Lablab purepureus* in the mixture, Zea mays in the pure stand and the Zea mays in the mixture. The data showed that intercropping had a significant effect on the CP content (P>0.05), the CP content was higher in the mixture than in the pure stand for both *Zea mays* and *Lablab purepureus*.

Concerning the effect of intercropping on the dry matter digestibility, the data revealed that intercropping had a significant influence (P>0.05). In this connection, *Lablab purpureus* in the mixture and *Zea mays* in the mixture obtained the highest value when compared to the pure stand.

The same trend was observed concerning the effect of intercropping on the EE content, the data revealed that intercropping had a significant effect (P>0.05) on the EE content, with the highest value recorded for *Lablab purpureus* in the mixture. While, intercropping showed non-significant influence on the EE content for *Zea mays* (P<0.05).

Although the effect of intercropping on the CF and the NDF content did not reached the level of significance (P<0.05), but *Zea mays* and *Lablab purpureus* when sown in the mixture recorded the lowest values.

In this regard, *Zea mays* in the mixture and *Lablab purpureus* in the mixture showed the highest value of ash content when compared to the pure stand but with non-significant influence (P<0.05).

Table (2) Effect of phosphorous fertilization on the nutritive values of *Lablab purpureus* in pure stand and *Lablab purpureus* in the mixture

Crop type	Fertilizer	ash gkg^{-1}	CP gkg^{-1}	EE gkg^{-1}	CF gkg^{-1}	NDF gkg^{-1}	Dig. %
Lablab purpureus **in pure stand**	P_0	13.36^a	13.66^c	1.59^d	23.45^a	49.93^a	67.42^b
	P_1	13.88^a	16.89^c	2.26^d	22.94^a	46.95^a	68.16^b
	P_2	15.46^a	21.23^b	2.61^d	22.29^a	46.03^a	75.65^a
Lablab purpureus **in the mixture**	P_0	14.59^a	20.10^b	3.06^c	22.32^a	48.87^a	68.67^b
	P_1	16.01^a	21.62^b	4.75^b	21.90^a	47.92^a	69.70^b
	P_2	16.86^a	26.67^a	6.78^a	21.05^a	47.71^a	77.15^a
	SEM	14.18	8.85	1.77	3.13	13.97	6.46

Means followed by the same super scripts in the same column are not significantly different at (0.05) level of significance.

SEM = Standard Error of Means; Dig. = Digestibility.

P_0= 0 kg /ha P_2O_5; P_1= 50 kg /ha P_2O_5; P_2=75 kg /ha P_2O_5.

Table (2) illustrates the effect of phosphorous fertilization on the nutritive values of *Lablab purpureus* in pure stand and *Lablab purpureus* in the mixture. CP content was found to be positively affected by phosphorous fertilization ($P<0.05$). The rank was found to be as follows $P_2 > P_1 > P_0$ for both in pure stand and the mixture. The same trend was found concerning the effect of phosphorous fertilization on the digestibility for *Lablab purpureus* in pure stand and in the mixture, plots applied with P_2 phosphorous level was found to be significantly higher than plots applied with P_1 and the control.

In respect to the effect of phosphorous fertilization on the CF content and the NDF content for *Lablab purpureus* in the pure stand and the mixture, there were non-significant differences ($P<0.05$) among all phosphorus levels, with the least value attained for the plots applied with P_2 level of fertilization.

The results showed that phosphorous fertilization had non-significant influence on the ash content ($P<0.05$) among all phosphorus levels for both *Lablab purpureus* in pure stand and *Lablab purpureus* in the mixture.

The data revealed non-significant effect ($P<0.05$) on the EE content among all the phosphorous levels for *Lablab purpureus* in pure stand while a significant effect ($P>0.05$) was noted concerning the effect of phosphorous fertilization on the EE content of *Lablab purpureus* in the mixture, the rank of the figures was found to be as follows: $P_2>P_1>P_0$.

Table (3) Effect of phosphorous fertilization on the nutritive values of *Zea mays* in pure stand and *Zea mays* in the mixture

Crop type	Fertilizer	ash gkg^{-1}	CP gkg^{-1}	EE gkg^{-1}	CF gkg^{-1}	NDF gkg^{-1}	Dig. %
Zea mays **in pure stand**	P_0	12.19^{a}	13.96^{c}	1.18^{a}	33.73^{a}	64.09^{a}	60.11^{b}
	P_1	12.90^{a}	14.22^{c}	1.62^{a}	31.50^{a}	62.43^{a}	62.45^{b}
	P_2	13.18^{a}	19.07^{b}	2.23^{a}	30.19^{a}	61.82^{a}	70.51^{a}
Zea mays **in the mixture**	$\mathbf{P_0}$	13.14^{a}	14.93^{c}	1.58^{a}	31.36^{a}	63.09^{a}	62.68^{b}
	$\mathbf{P_1}$	15.09^{a}	15.78^{c}	2.00^{a}	29.90^{a}	62.40^{a}	63.06^{b}
	$\mathbf{P_2}$	15.99^{a}	23.91^{a}	2.20^{a}	29.01^{a}	62.02^{a}	72.52^{a}
	SEM	10.18	6.85	1.09	5.13	11.97	4.46

Means followed by the same super scripts in the same column are not significantly different at (0.05) level of significance.

SEM = Standard Error of Means; Dig. = Digestibility.

P_0= 0 kg /ha P_2O_5; P_1= 50 kg /ha P_2O_5; P_2=75 kg /ha P_2O_5.

The effect of phosphorous fertilization on the nutritive value of *Zea mays* in pure stand and *Zea mays* in the mixture is illustrated in table (3). The data revealed that plots applied with P_2 had a significant influence ($P>0.05$) on the CP content with the highest value recorded for P_2 level of fertilization for *Zea mays* in pure stand and in the mixture.

On the other hand, the effect of phosphorous fertilization on the CF content and the NDF content, the results showed non-significant effect ($P<0.05$) through all the various phosphorous levels for *Zea mays* in pure stand and in the mixture, however, plots applied with 75 kg /ha P_2O_5 showed the lowest value.

DM digestibility for *Zea mays* in pure stand and *Zea mays* in the mixture was affected by the application of phosphorous fertilization, the trend was found to be as follow: $P_2>P_1>P_0$.

The results showed non-significant effect ($P<0.05$) of all various phosphorous levels that were examined on the ash and EE content for *Zea mays* in pure stand and in the mixture. However, a slight increase was found by increasing phosphorous level.

Chapter Five

Discussion

In this study the Nutritive values of *Lablab purpureus* and *Zea mays* as affected by intercropping and phosphorous fertilization was examined in this study. The following parameters were studied: CP, DM digestibility, CF, NDF Ash, and EE. The results indicated that phosphorous fertilization and intercropping contributed significantly to improve the nutritive value for both *Lablab purpureus* and *Zea mays*.

5.1 The CP content attributes:

The CP content of *Zea mays* in the mixture (21.20 **gkg^{-1}**) was significantly higher ($P< 0.05$) than the CP of *Zea mays* in pure stand (15.70 **g kg^{-1}**) Achieving one of the most important roles of biodiversity and mixed cropping. It could be concluded that *Lablab purpureus* as leguminous plant have supplied the grasses with nitrogen in the grass -legume mixtures. This results in the line of Mehdi Dahmarden *et al*. (2009) who stated that *zea mays* when sown in mixture with cow pea secured a higher CP than *zea mays* when sown alone. Same results were obtained by Francisco *et al*. (2009) for sorghum legume mixture in USA. More over, this results were in the harmony with Fujita *et al*. (1992) who reported that protein concentration was increased from 69-81 g.kg-1 for Maize sole cropping to 88-108 g.kg-1 for various intercropping pattern. In this study *Lablab purpureus* in the mixture had recorded the highest value of CP 265 g kg-1. In USA Armstrong *et al*. (2008) found that CP was higher for *Lablab purpureus* when sown in intercropping with *Zea mays* (130 g kg–1 DM),) than sole cropping (61 g kg–1 DM). Contradicting results were found by Ibrahim *et al*. (2006) who noted that the Cowpea sown alone produced more crude protein (18.10%).

Phosphorous fertilization was found to have a positive effect on CP of *Zea mays* in pure stand and the mixture. This result may be attributed to the fact that Phosphorous fertilization often increases nodulation and hence increase nitrogen or CP content in grasses (Hauque and Mohammed, 1985). This result was not in the line of Eltelib *et al*. (2006) who found none significant effect of phosphorous fertilization on the CP content of *Zea mays* fodder. More over in Nigeria, Kombiok and Elemo (2004) found non consistent effect of phosphorous fertilization on *Zea mays*. Based on the results, phosphorous fertilization significantly increased the CP content of *Lablab purpureus* in pure stand and the mixture. Increasing the proportion of the legume particularly the leaves as affected by phosphorous fertilization may increase the CP concentration of the legume. In Turkey Tahir *et al*. (2007) stated that When P fertilization was applied alone, crude protein concentration increased. In contrast Mullenr *et al*. (2000) observed no change in yield or protein for alfalfa when applied with 30 kg P ha-'. In addition, these results were similar to Yemane (2003) who found that CP content of Dekoko (*Pisum sativum*) when intercropped with grasses increased significantly with the increase in the phosphorous application.

5.2 The dry matter digestibility attributes:

Interceding grasses with legumes has a significant effect of DM digestibility of *Zea mays* ranging from 55.01 % for sole seeding to 64.70 % for mixed seeding. The positive effect of intercropping on DM digestibility may be attributed to the higher protein concentration for *Zea mays* and *Lablab purpureus* when sown in the mixture with legumes and grasses respectively. These results were in the line with Javanmard *et al.* (2009) who found that intercropping of legumes with Maize significantly increased digestibility of the forages.

With the increase of phosphorous fertilization level DM digestibility increased for *Zea mays* in pure stand and the mixture. This indicated that phosphorus fertilization has raised the nutritive value of *Zea mays*. These results were in conformity with Rathore and Kumar (1977) who noted that phosphorous fertilization increased digestibility of sorghum in the pure stand and sorghum in the mixture. Moreover, as it was obvious from this study phosphorous fertilization had a positive impact of DM digestibility of *Lablab purpureus* in pure stand and the mixture. This result was in the consistency of Colomb *et al*. (2002) who noted that phosphorous fertilization increased digestibility for Alfalfa in the pure stand and Alfalfa in the mixture.

5.3 The CF and NDF content attributes:

In this study the intercropping grasses with legumes caused both NDF and CF to be reduced for the grasses and the legumes. The NDF and CF content are important in ration formulation because they reflect the amount of forage that can be consumed by animals. These results were consistent with results stated by Minson (1990) who observed that Crude fiber and NDF content of legumes generally decrease with intercropping. In addition to that, these results were in harmony with Lauriault *et al*. (2004) who noted that intercropping with Pea decreased NDF and CF significantly in all cereal. On the other hand Armstrong *et al*. (2008) reported that intercropping climbing beans with corn increased neutral detergent fiber concentration and decreased digestibility compared to monoculture corn.

Phosphorous fertilization caused little reduction on CF and NDF of both *Zea mays* in pure stand and the mixture and *Lablab purpureus* in pure stand and the mixture Dianati Tilaki *et al*. (2010) who stated that Phosphorus fertilization had few effects on forage quality. These results were supported by Kulkorni *et al*. (1986) who observed that the application of phosphate fertilizer decrease the CF and NDF content in Wheat when intercropped with *Lablab purpureus* Also these results were not supported by Mustafa (1996) who found a significant increased in CF and NDF when phosphorous applications increased in Alfalfa. However, these findings were not consistent with Ibrahim (1996) who found that increased application of phosphorous up to 200 kg P_2O_5 / ha resulted in a significant decrease in the CF and NDF content of Clitoria when intercropped with *Zea maize*. On the other hand, these findings were not similar to Rathore and Kumar (1977) who noted that phosphorous has no consistent effect on CF content of Sorghum and Dinanath grass.

5.4 Other quality attributes:

5.4.1 The ash content attributes:

Although intercropping caused non-significant influence on the Ash content for *Lablab purpureus* and *Zea mays* however, slight increase was recorded on the Ash content in the mixtures. These were contradicting with many researchers who reviewed that intercropping can raise the Ash content of the crops. These results may attribute to soil differences between the locations. These findings were not similar to Ibrahim *et al*. (2006) who noted that the Cowpea sown alone produced the lowest Ash content. In addition, these results not confirmed the observation reported by (Javanmard *et al*., 2009) in which they found that Ash content of Maize forage increased by intercropping as compared with Maize sole crop.

The effect of phosphorous fertilization and intercropping on the Ash content was non-significant for all forages under estimated. These results were not confirmed the earlier reports by (Habib *et al*., 1971; Colomb *et al*., 2002; Ayub *et al*., 2002; Russel, 1985) in which Habib *et al*. (1971) found that application of phosphate increased the percentage of Ash in legumes. In addition to that Colomb *et al*.

(2002) stated that phosphorus fertilization increase the Ash content in alfalfa when intercropped with *Zea maize*. Also Ayub *et al*. (2002) showed that phosphorus application influenced the Ash content of Maize when intercropped with legumes significantly and Russel (1985) who reported significant effect of phosphorous fertilization on cereal forage crops in Ash content.

5.4.2 The EE attributes:

The EE content was found to be higher in *Lablab purpureus* in the mixture when compared to *Lablab purpureus*. These results were expected since intercropping improved the nutritive value of the crops in the term of CP and digestibility. These results were not supported by Boufaied *et al*. (2003) who noted that intercropping had no effect on concentration of the EE content for legumes. On the other hand, non-significant effect was observed between *Zea mays* in pure stand and *Zea mays* in the mixture by the influence of intercropping. However, these results were in the line with Boufaied *et al*. (2003) who noted that intercropping had no effect on concentration of EE content for grasses.

Phosphorous fertilization had non-significant effect on concentration of EE content of all crops under estimation except for *Lablab purpureus* in the mixture. These results were not in the line of the earlier report by (Ibrahim, 1996) in which he found that increased application of phosphorous up to 200 kg P_2O_5 / ha resulted in a significant decrease in the EE content of Clitoria when intercropped with *Zea maize*. While these results were in conformity with Boufaied *et al*. (2003) who noted that phosphorous fertilizer had non-significant effect on concentration of total and individual fatty acids in grasses and legumes.

Chapter six

Conclusion and Recommendation

The DM, Ash, CF and NDF content of all forages under estimated were not affected ($P<0.05$) by both intercropping and phosphorous fertilization in contrast, the CP content and digestibility of *Lablab purpureus* and *Zea mays* were highly significantly ($P>0.05$) affected by intercropping.

Intercropping caused non–significant effect ($P<0.05$) on the EE content of *Zea mays* while, Intercropping had a positive influence ($P>0.05$) on the EE content of *Lablab purpureus*.

The CP and digestibility had a positive influence in plots applied with P_2 in this experiment ($P>0.05$). The data obtained indicated that phosphorous fertilization caused non–significant effect on the EE of all crops in this study ($P<0.05$) except *Lablab purpureus* in the mixture which reported a significant differences ($P>0.05$) among all phosphorous levels.

The variability in forage quality detected in this study could be attributed to the soil and environmental factors.

Cereals are high important in feeding ruminant animals for their high dry matter production and low cost. However, cereals forage is poor in protein content which shows their low quality and nutritive value. Regarding to high feed costs of protein supplementations, legumes can be used in livestock nutrition for their high protein content and thus, providing cost saving. Since legumes have low dry matter yield, acceptable forage yield and quality can obtained from intercropping of cereals and legumes compared with their sole crops.

Overall, most of researchers' results reviewed in this thesis showed that cereal-legume intercropping can be used as a suitable management strategy for producing high quality and quantity forage.

Numbers of factors must be considered in selecting cereal-legume intercropping compositions, especially for forage production.

Further studies could be conducted under Sudan conditions to investigate the effect of intercropping and phosphorous fertilization of other crops so as to reach the best feed combination and thus, better animals' products.

Intercropping and phosphorous fertilization improved the CP and dry matter digestibility in both crops therefore intercropping and phosphorous fertilization are highly recommended.

Feeding on intercropping crops is highly recommended because, feeding on only legumes might cause bloat to the animals.

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