CHAPTER ONE

INTRODUCTION

Broad bean (*Vicia faba* .L) is member of the fabaceae it is one of the most important legume crop in the world .It is used as a source of protein for human diets and a feed for animals and boosting nitrogen in biosphere (Duce *et al* .2010).In addition the crop is high contents of protein and carbohydrates, rich in fiber, vitamins and minerals (Ofuya and Akhidue 2005).

There are different varieties of broad bean grown in the world. Consideration in the choice of varieties depends on yield, habit of growth, size of seeds, ability to hold leaves, length of growing season, disease resistance and protein content (kipps .1970). Broad bean is mainly grown in East Asia, North Africa, southern Europe and the Nile valley region under rain fed and irrigated conditions. Globally, the crop is grown during winter and spring and occupies around 2,4million hectors with annual production of 4 million tons (FAO stat.2011) .Broad bean are widely cultivated, and the world production of (4,459,655) million tons (FAO 2016). The main producers of broad bean are ten countries are China (1,608,903) , Ethiopia (878,010) ,Australia (423,527), United kingdom (288,955),France (198,246),Germany(153,700) ,Sudan(121,412) Egypt (119,104) ,Italy(100,013) and Peru(71,919){FAO stat. 2016).

In Sudan, it is the most important food legume. Broad bean constitutes the main dish on the breakfast and dinner tables for large sector of the population. Especially the low income group in the urban areas. In Sudan, faba bean is the most favored legume Food and main source of protein for the Sudanese people and plays a significant role in generating income to farmers.

It is concentrated in northern state latitude 16N where environmental conditions are suitable for production better than other parts of the country. The Northern region of Sudan is considered as one of the main supplier of the crop. The production takes place mainly under farming system of small private pump schemes (Abdalla *et al*, 2015).

The Northern State occupies the distant Northern part of Sudan and lies between latitudes 16-22 Nº and longitudes 20-32 Eº, and lies in the arid and semi -arid zones, where the annual rainfall is less than 100 mm. The total currently cultivated areas in the State is estimated at 199 958 ha, 75% of which is cultivated in winter. Wheat and faba bean cultivated areas are about 43% and 31% on the average of the total winter cultivated area in the State, respectively (NSMA, 2016). Northern state is characterized by good and suitable weather conditions, vast fertile land, and abundant water for irrigation and skilled labor for its production (Elfeil, 1993). The average yield of faba bean in the research station was 4.00 tons/ha (Fagiri, Elrasheed: Director Agricultural Research Corporation Dongola, Norhern Sudan, personal interview (2013)), compared to 2.92 ton/ha and 2.40 ton/ha in the Nile scheme and the Underground scheme respectively. (Abdallah, 2005) and (Elfeil, 1993) attributed the deterioration of crops yields to inefficient allocation of resources. They attributed the farmers' mismanagement of resources to many factors, the most important of them are: high inputs cost especially fuel for irrigation, unavailability of inputs at the right time, and land fragmentation. In the 2000 the area under faba bean in the Sudan was estimated to be (43000 hector) with average yield of (2.20 ton / ha (FAO 2000). In this state more than 70% of the crop is produce, in the Nile state ranks 20% and other parts of Sudan Small amounts is produced in Khartoum state, central Sudan, Jubal Mara and Kabkabia in western Sudan .Farther more crop is also an important source of income for farmer in Northern Sudan (Salih 1996).The most important factor to increase crop yield in Sudan is developing of high yielding cultivars and improving of cultural practices.

The objectives of this research were to:

1. Study effect of intervals of irrigation on growth and yield in broad bean.

2. Detect crop tolerances for drought.

3. Determine the best irrigation interval.

CHAPTER TWO

LITERATURE REVIEW

2.1 History, Origin and Distribution

The genus *Vicia* L. belongs to the family Fabaceae. Knowledge of the wild progenitor and area of origin of the genus, and subsequent steps in the domestication of its most important member species, *V. faba* L., is scarce and disputed (Shiran *et al*., 2014). The Near East is considered a center of origin for faba bean (Cubero, 1974*),* while China seems to be a secondary center of faba bean genetic diversity (Zong *et al*., 2009, 2010). Caracuta *et al*. (2016) have identified seeds of a potential ancestor of faba bean adjacent to Mount Carmel, Israel – the remains were C-dated to 14,000 years BP (before present). Moreover, Caracuta *et al*. (2015) have determined that faba bean was already domesticated about 10,200 years BP in the Lower Galilee, Israel. In any case, faba bean can be considered one of the earliest domesticated crops in light of numerous archeological findings in Eurasia and Africa which date back to the early Neolithic (Duc *et al*., 2015a*). Vicia faba* has a large genetic diversity. According *to Duc et al. (2010, 2015a*), >38,000 accessions of faba bean germplasm are conserved globally in numerous gene banks, as well as at the International Center for Agricultural Research in Dry Areas (ICARDA). Research conducted by the EUROLEGUME consortium has shown that potentially many more genotypes are available locally in Europe assessed, at farms and in breeders' collections (*Lepse et al., 2017***).** The genetic diversity of *V. faba* accessions has been in various studies and marker systems (*Zeid et al., 2003; Zong et al., 2009; Oliveira et al., 2016; Sallam et al., 2016; Göl et al., 2017*).

In practice, however, a continuous variation in most morphological, (eco-) physiological and chemical traits has been observed, making it challenging to achieve a discrete differentiation between varieties. A study by *Martos-*

Fuentes.2017)shows that NGS (next-generation sequencing)-based genotyping of faba bean using multiple bar-coded samples is a feasible method. The author's resulting distance matrix shows that some *V. faba* clades were exclusively formed by accessions from a specific country, while others were interspersed, indicating that genetic and geographic distances do not always correspond. Evolution of the species was accompanied by intensified cultivation, with selection for different traits. The genotypes of *V. faba* are commonly classified into three main botanical varieties according to seed size: (a) *V. faba* var. *major* with large seeds, (b) *V. faba* var. *minor* with small seeds, and (c) *V. faba* var. *equine* with medium seeds *(Cubero, 1974; Crépon et al., 2010; Pietrzak et al., 2016),* the first two of which are relevant in European agriculture.

However, faba bean germplasm is also grouped into spring and winter types, according to frost tolerance, delimiting target climatic zone, and sowing time, and according to the ability to adapt to oceanic or continental (i.e., drought-prone) climates (*Moreno and Martinez, 1980; Link et al., 2010; Flores et al., 2013).* Recently*, Zhao et al. (2018)* have shown that cultivar groups featuring differential root system architectures exist independently of botanical variety within Europe, but that, for example, cultivars from Portugal possess greater and coarser but less frequent lateral roots at the top of the taproot in comparison with Northern European cultivars, potentially enhancing water uptake from deeper soil horizons.

2.2 **Morphological Description and Botanical Characterization**

Faba bean is a cool season annual legume (*Bilalis et al., 2003*) that forms coarse, upright, hollow, and unbanked stems from the base, and grows between 0.1 and 2 m tall (*Bond et al., 1985; Duc et al., 2015a; Heuzé et al., 2016)*. Stem growth is indeterminate, and some cultivars are prone to lodging. The leaves are alternate, pinnate, and consist of two to six leaflets, which are up to 8 cm long without tendrils (*Bond et al., 1985)*. The flowers have a typically papilionaceous structure and are grouped in inflorescences; they are either pure white in color or with diffuse anthocyanin pigmentation on all petals, while black spots are often present on the wing petals (*Bond et al., 1985; Duc et al., 2015a; Heuzé et al., 2016)*. Seeds, which vary considerably in size, are oblong to broadly oval with a prominent hilum at the end; their color can be yellow, green, brown, black, or violet, and sometimes seeds are spotted (*Nozzolillo et al., 1989; McDonald and Copeland, 1997; Duc et al., 2015a)*.

Faba bean plants feature a robust taproot with frequent lateral root branching from the top of the tap root; nitrogen-fixing nodules containing rhizobia occur on both the tap and lateral roots (*Bond et al., 1985*). Root traits of European accessions vary profoundly *(Zhao et al., 2018*), and are largely influenced by the tillage regime (*Muñoz-Romero et al., 2011*).

2.3 Adaptability of broad bean to a biotic stress

Drought and heat are considered major constraints in faba bean growth and production in Europe. The most drought-sensitive growth stages are flowering, early pudding, and grain filling *(Mwanamwenge et al., 1999; Katerji et al., 2011*). However, faba bean varieties differ widely in drought tolerance (*Girma and Haile, 2014)*. One of the mechanisms apparent in drought-tolerant varieties or genotypes is praline accumulation (*Migdadi et al., 2016; Abid et al., 2017*), but a differential root architecture, influencing access to water, which differentiates varieties originating from Northern vs. Southern Europe, has also recently been identified (Zhao et al., 2018).

According to(*Maqbool et al. (2010)*, faba bean is susceptible to frost during its reproductive stages. Recent studies, however, have identified some frost-tolerant genotypes, which could be used in breeding programs ,Stoddard *et al*., 2006; Sallam *et al*., 2015*)*. Hardening seedlings through exposure to low nonfreezing temperatures before the onset of winter may enhance plant tolerance to frost Arbaoui and Link, (2008*)*.

Faba bean is generally considered day-neutral, while some accessions require long-day conditions in order to flower. However, thermal time is the most important contributor to flowering progress in faba bean, with approximately 830–1000°days above 0°C being required; winter faba bean genotypes require vernalization (Patrick and Stoddard, (2010*)*. For northern European cropping systems*, (Bodner et al. 2018)* have recently reported results of 650°days and 0°C base temperature before flowering; this potentially reflects a photoperiodic sensitivity toward long-day conditions in faba bean. In a recent study, *Cao et al. (2017)* found that several potential regulators are implicated in the vernalization process in faba bean.

Faba bean is a self-pollinated plant with significant levels of cross-pollination (*Suso et al., 1996; Chen, 2009*). The main pollinating insects are honeybees (*Apis* spp.) and bumblebees (*Bombus* sp.); the benefits of insect pollination for yield have been well documented *(Stoddard, 1991; Cunningham and Le Feuvre, 2013*; *Bishop et al., 2016*).Water logging, e.g., during flowering, limits faba bean growth and yield (Pampana et al., 2016). The negative effects of water logging on growth and other physiological traits (i.e., chlorophyll a and b) persist even after cessation of soil flooding *(Pociecha et al., 2008*). However, faba bean is considered the most tolerant to water logging of the cool-season grain legumes (*Solaiman et al., 2007).*

Excess soil salinity affects both growth and nitrogen fixation in faba bean plants, which are considered moderately tolerant of soil salinity (*Bulut et al., 2011). Katerji et al. (2011)* report a yield reduction in faba bean at soil salinity levels of ≥6.5 dS m^{-1}.According to (*del Pilar Cordovilla et al. (1999*), root systems are more sensitive than shoots to salinity. In addition, at high salinity levels, nitrogenase activity and nodulation are suppressed (*Abd-Alla et al.,* *2001).* These researchers observe that high salinity treatments of 80 and 120 mM NaCl caused a significant reduction in faba bean shoot biomass of 25 and 49%, respectively. Moreover, nitrogen accumulation in the shoots reduced by 36 and 63% at salinity levels of 80 and 120 mM NaCl, respectively (*Abd-Alla et al., 2001).* Measures undertaken to ameliorate the negative effects of salinity on faba bean plants include foliar application of inoculation with Pseudomonasfluorescens (Hellal, et.al.2012 ,Metwali *et al*., 2015). Salinity-tolerant faba bean genotypes are also available; one example is the line “VF112,” which has been reported as salt-tolerant because salt stress had no effect on its growth or nitrogen fixation (*del Pilar Cordovilla et al., 1995).* Nitrogen fixation and growth in faba bean are adversely affected by low soil pH (*Schubert et al., 1990; Belachew and Stoddard, 2017*). Faba bean grows best in soils with a pH ranging from 6.5 to 9.0 (*Jensen et al., 2010).*

2.4 Faba bean in the farming system

Faba bean benefits crop rotations by providing a disease break and adding Nitrogen (N) to the farming system. Moore et al. 2003) found that a rotation of wheat/faba bean compared to continuous wheat reduced the incidence of crown rot (*Fusarium pseudograminearum)* in the following wheat crop by reducing inoculums carryover. Verrell et al. (2005) found that the inclusion of faba bean reduced crown rot inoculums by approximately 10% compared to continuous wheat under conditions of high crown rot inoculums. *Thomas et al. (2011*) found that faba bean provided an N benefit (*i. e* extra N available at sowing time in a soil that grew a faba bean crop the previous year compared to one that grew a cereal crop) of 40 kg/ha. *Herridge et al. (2010*) quoted quantities of N fixed between 47 and 190 kg/ha and N benefits of between 40 and 50 kg N/ha. Turpin et al. (2002) found that faba bean fixed between 209 – 275 kg N/ha and sourced between 69 – 88% of crop N from the atmosphere. (Schwenke *et al*., 1998) in a survey of chickpea and faba bean crops in northwest NSW found total quantities of N fixed of between 15 and 171 kg N/ha giving an N balance (i. *e* the difference between the amount of N fixed and the amount exported in the plant parts of the harvested pulse crop) ranging from -12 to +94 kg N/ha.Faba bean obtains more crops N from the atmosphere than from the soil and continues to fix N from the atmosphere in the presence of higher soil N compared to chickpea (*Cicer arietinum)*, (Turpin *et al.* 2002). In Australia a shift away from lay farming systems where cereal crops were rotated with legume based pastures resulted in increased interest in growing pulse crops (Siddique and Sykes, 1997).

2.5 Irrigation:

Water is the most limiting natural resources for agricultural production in arid and semi-arid regions. Faba bean usually grows without irrigation, with the exception of crops cultivated in very dry and hot climatic zones. Thus, production is highly dependent on the amount of and variation in rainfall during the growing season *(Oweis et al., 2005*). In semiarid regions, climate change can affect water use efficiency and growth in faba bean (*Guoju et al., 2016)*, given its sensitivity to drought *(Ghassemi-Golezani et al., 2009; Alghamdi et al., 2015*). In the Mediterranean region and similar dry and hot climatic zones, faba bean production without irrigation may be possible if cultivation takes place during the cold season. Moreover, early sowing in autumn is considered an effective strategy for avoiding water stress during the seed filling stage (*Loss and Siddique, 1997)*. Alternatively, faba bean crops can be irrigated at the seed filling stage in order to avoid penalties in yield during drought. Additionally, (*Knott 1999)* reports that faba bean production is usually increased by irrigating spring crops during the flowering stage and early podding. Between 231 and 297 mm of water are required to produce 3–4.4 t ha^{-1} of faba bean dry biomass *(Bryla et al., 2003*). The development of drought-tolerant faba bean varieties is a key challenge in achieving increased and more stable production levels (*Khan et al., 2010;Siddique et al., 2013*). Several genotypes are considered tolerant to drought and can be exploited in breeding programs in order to develop drought-tolerant varieties (*Ali, 2015).* Recently, some varieties (e.g., CS20-DK and NC-58) have been evaluated as tolerant to water stress *(*Girma and Haile, (2014). Ageeb .(1976-77) studied the effect of the irrigation intervals relation to two phases of plant development of two faba bean cultivars in heavy clay soils the results indicated that the reproductive phase was more sensitive water stage than vegetative phase .increase irrigation intervals during second phase from 7 to 14 and 21 days reduced the grain yield. Therefore, decreasing plant water consumption through using more efficient irrigation methods (Tayel *et al*. (2007). Plant Breeding technology, longer irrigation intervals, higher moisture depletion, skipping irrigation during the early vegetative growth or during maturation stage, and timing the length of irrigation interval with the stage of plant growth,(Faki .1991) this will save irrigation through reducing number of irrigation but still attain similar economic yield. Irrigation should take place while the soil water potential is still high enough that the soil can and does supply water fast enough to meet the local atmosphere demands without placing the plants under stress that would reduce yield or quality of the harvested crop .Taylor (1965) added that although a high water status throughout the growing season is necessary to maintain crop growth and high economic yield, the imposition of some stress by longer irrigation interval, higher moisture depletion irrigation during the early vegetative growth stage and the maturation one could still attain similar economic yields as well as saving irrigation water. Timing the length of irrigation interval with the stages of crop growth might bring about a reduction in irrigation number and result in an economic crop yield. Hodges and Heatherly, 1983).Reported that water stress imposed on soybean throughout the growing stages reduced vegetative growth and affects flowering and yield.(Meckel *et al* .1984) claimed that water stress shortens the grain – filling stage and lowers yield. Therefore, soybean needs frequent irrigation to avoid yield loss. (Brown *et al* .1985) showed that water stress at either flowering stage or pod elongation one significantly reduced soybean yield. They that water deficit at flowering stage resulted in greater yield loss than at pod elongation one and that water stress during early reproductive growth many increase flowers and pods abortion. Grimes et at (1988) stated that the efficient production of food and fiber crops in arid and semi – arid regions of the world depends on proper irrigation timing and the application of an optimum water amount at each irrigation. Salih (1992) reported that the irrigation intervals of 7 and 14 days had no effect on broad bean height. Foroud *et al* (1993) indicated that water deficit during flowering stage had little effect on seed yield of soybean whereas, during pod elongation and seed enlargement stages the effects were significant.Farag and El-Shamma(1994) indicated that the highest values of stem length was obtained by irrigation broad bean plant at 7 days intervals.(El Adel .2000) found that the highest yield of pea (5563 and 1020 kg / fed. Green pods and dry grain, respectively) was obtained in the treatment (surge drip, fustigation and irrigation at 100% of Etc .El Adel. (2001) indicated that the highest seed yield of peanut (1190kg / fed.) was achieved by irrigation every day using 100 % of ETc and traditional fertilization. The result of Singer *et al* (2001), on two snap bean cultivars (Giza3 and Bronco) showed that plant highest number of leaves, chlorophyll content, number of flowers and their set percent of both cultivars were significantly affected by water stress. They concluded that irrigation with 75 and 100% of field capacity were most preferable for Bronco, and Giza 3, respectively.Balasio *et al* .2006) studied the response of broad bean to different irrigation intervals (14, 21 and 28 days) on grain yield and the incidence of insect pests on the crop in relation to two stages of growth. They found that the irrigation intervals 28 and 14 days during the vegetative and reproductive stages respectively gave the highest grain yield in the two seasons. Irrigation at 28 days intervals received only 6 irrigations with a total amount of irrigation water of about 4464 m3 ha^{-1} compared to 8 irrigations and total amount of irrigation water of about 7429 m^{3} ha^{-1} under the 14 day irrigation intervals through the grown season.

El- Dakroury (2008) found that increasing irrigation treatment from 60 to100% of the ETo significantly, Increased growth criteria at the 5% level. I. e. plant height, number of branches, leaves and pods / plant, leaves area, and dry weight of both stem and total plant Growth.

2.6 Harvest, Processing, Nutritional Value and Use of Broad bean

Broad bean crops cultivated for fresh seed consumption may be harvested either manually or mechanically once the pods are filled, but before they start to dry. Pods are harvested by hand two to three times during the harvesting period in crops cultivated in small areas for fresh consumption. When broad bean plants are cultivated for their dry seeds, they can be harvested using a conventional cereal combine harvester. Similar to other pulses, proper selection of the harvest stage is critical if seed loss is to be minimized *(Karkanis et al., 2016a*); seeds should be harvested when the moisture content is 14–15% (*Jilani et al., 2012*).

In some countries (such as Canada), disquiet is registered as a preharvest desiccant, and its application is a common practice among pulse growers (*McNaughton et al., 2015*), as this helps farmers to overcome problems caused by slow ripening and weeds during the harvest period. Broad bean seeds also contain ant nutrient compounds. Soaking, dehulling, boiling, pressure-cooking, autoclaving, and extrusion cooking are the main processing methods used to reduce the amounts of these compounds in broad bean seeds, in order to limit their adverse effects on human health (*Luo and Xie, 2013; Patterson et al., 2017; Shi et al., 2017*). Dehulling is efficient in eliminating the tannin and polyphone content *(Alonso et al., 2000*), while soaking and autoclaving inactivate tripping inhibitor activity (*Luo and Xie, 2013; Shi et al., 2017*)the inclusion of plant-based proteins in human diets has a beneficial effect on human health (*Moorthi et al., 2015*).

Broad bean protein content is reported to vary between 17.6 and 34.5% of seed dry matter, while acid detergent fiber (ADF) ranges between 10.1 and 13.7% ;it is also a valuable source of amino acids, being particularly rich in the essential amino acids argentine, lysine, and Lucien, at up to 67 g kg^{-1} dry matter *(Koivunen et al., 2016*). As faba bean also provide macro-, micro-, and non-nutrient phytochemicals, it has been noted to have potential as a functional food. Broad bean also contains ant nutritional compounds such as saponins, lectins, tannins, vicine, convicine, and phytic acid (*Hendawey and Younes, 2013; Multari et al., 2015).* Tannins are known to reduce protein digestibility, while the absence of tannin in zero-tannin faba beans is controlled by either of the two genes zt-1 and zt-2 (*Gutierrez et al., 2008; Woyengo and Nyachoti, 2012*). The consumption of faba bean products containing high levels of vicine and convicine causes favism in humans, which is associated with glucose-6-phosphate dehydrogenase deficiency (*Khamassi et al., 2013b).*Faba bean seed size is an important trait in determining market and consumption form. Large-seeded varieties (broad beans) are widely used for food, either as a fresh green vegetable or (dehulled) dry seeds. Varieties with small- to medium-size seeds are mostly used for animal feed (*Crépon et al., 2010).* Faba bean can also be used in the bakery industry (*Belghith-Fendri et al., 2016);* for example, a combination of faba bean and wheat flour improves the nutritional properties of bread (*Coda et al., 2017).* In Spain, small faba bean seeds (<12 mm) are currently highly accepted in the industry (*Cubero, 2017*). Small-seed genotypes are generally preferred by the frozen faba bean (*Baginsky et al., 2013*) and canning industries; the ability to use a microwave oven encourages the consumption of this legume, because seeds are much more easily cooked, and bags can be stored for up to 10 days at 5°C (*Collado et al., 2017*).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experiment Site:

The experiment was conducted in the farm of College Agricultural Studies Sudan University for Sciences and Technology.Shambat is located at longitude 32°.35/ E and15°.31/N latitude, 288 above sea level within the semi –desert region Adam. (2002). The soil of the site is described by Abdelhafiz.(2001) as loam clay; it is characterized by a deep cracking moderately alkaline clay and low permeability low nitrogen content and pH (7.5-8) and high Exchangeable Sodium percentage (E.S.P).

3.2 Land preparation and Experiment Design

The land was prepared by disc plough, harrowing, leveling and ridging, spacing between ridges 50 cm and holes were 20cm, the size of plot was 4x5m^2 consisting of 4 ridges for each plots. The experiment was arranged in Randomized Complete Block Design **(R.C.B.D),** with Four Replicates and three treatments. The genotype was planted on ridges in plots ,Seeds rate was three seeds per hole, sowing was carried out on November 15th /2017 at shambat .Thinning was carried out after three week from sowing to two plant per hole, weeding was done three times using hand hoeing

3.3 treatments and Source the seeds

The experiment was designed to study the effect of Irrigation Intervals on growth and yield for broad bean was applied at intervals every (7, 14 and 21days). Broad bean cultivar used in this Experiment was improved cultivar of Hudeiba (93).Seeds were obtained from of college agricultural studies Sudan University of Sciences and Technology at Shambat.

3.4 Data Collection

3.4.1. Plant height:

This parameter was recorded from five randomly selected plants from the surface soil to tip tagged plants of each treatments and average was calculated.

3.4.2Number of leaves per plant

Taken from tagged plants each of treatments the randomly selected plant and the average were calculated.

3.4.3 Numbers of Branches per plant

Taken from the five each the randomly selected plants and the average were calculated

3.4.4 Number of plant per m^2:

Taken from of square meter of the randomly selected each of middle plot and the average plant was calculated at time 95% plant maturing stage.

3.4.5 Number of pods of plant per m^2

Number of Pods of plant in meter square was counted to determine the mean number of pods per plant.

3.4.6 Weight of seeds per m^2

Taken from of square meter of the randomly selected each of middle plots and the average weight of seeds was calculated at time 95% plant maturing.

3.4.7 100-seed weight per m^2:

A sample 100-seed was taken from of square meter of the randomly selected each of middle plots and the average 100 weight of seed was calculated at time 95% plant maturing.

3.4.8 Yield kg/ Fed

Taken from of square meter of the random selected each of plots and the average seeds yield was calculated at time 95% plant maturing

3.5 Statistical analysis:

Analysis of the variance was carried out on collected data by using the method of statistical analysis for a randomized complete block design as described by Gomez and Gomez (1984) by using statistic-8, computer program.

CHAPTER FOUR

RESULTS

4.1.1 Plant height(c m):

The means of all characters was presented in Table 1.Analysis of variance showed that no significant differences (P=0.05) in plant height among the three irrigation intervals. The highest plant (49.250 Cm) was recorded in7 interval; the lowest plant (38.57cm) was recorded under 21 day's intervals.

4.1.2 Number of Branches per plant:

Result indicated that was no significant differences (P=0.05) in number of branches per plant between the three of irrigation intervals. The highest number of branches (2.5) was recorded in 7 and14 intervals; the lowest number of branches (1.7) was recorded in interval 21days.

4.1.3 Number of leaves per plant:

Analysis variance showed no significant differences (P=0.05 in number of leaves per plant for three of irrigation intervals. The highest number of leaves (19.05) was recorded in 7and14 day's intervals .The lowest number of leaves (17.25) was recorded in 21 days interval.

4.1.4 Number of plant per m^2:

The effect of irrigation intervals on number of plant /m^2 was not significant (p=0.05) The highest number of plant (17.2) was recorded in 7 days, while the lowest number of plant (10) was recorded in 21 days interval.

4.1.5 Number of pods per plant:

Result showed that there was significant differences (p=0.05)in number of pods per plant .the largest number of pods value (171.7) was recorded 7 days interval, while lowest number of pods value (58.2) was recorded in 21 days interval.

4.2.1 Seeds yield gram/m^2:

Three irrigation intervals affected significantly seed yield (P=0.05) The 7day interval achieved the highest average seeds yield (223.2 g) while the lowest average seed yield (47.3 g) was recorded in 21 day interval.

4.2.2 100-seed weight:

Analysis variance showed no significant differences (P=0.05) in 100 seed weight. The highest average 100-seed weight (48.3 g) was recorded in 7 days interval; the lowest average (37.1 g) was recorded 21day interval.

4.2.3 Yield kg per Fd:

Result Showed significant differences (p=0.05) in yield kilo per Fadden for three regimes irrigation intervals. The highest average yield (937.6 kg) was recorded in 7 days interval; while the lowest average seeds yield (199.1 kg) was recorded in 21 day interval.

Table (1) Means of Growth and yield parameters for broad bean affected by Irrigation intervals season 2017-2018

Parameters / Treatments	P.H cm	N.B/P	N.L/P	N.P/m2	N.P/P	W.S/m^2 (g)	100-S.W/^{m2} (g)	Y.kg/fd
7days	50.4 a	2.3 a	19.1 a	17.2 a	171.7 a	223.2 a	48.3 a	937.6 a
14day	44.4 a	2,5 a	19.1 a	10 b	105.7 b	100.2 b	42.8 ab	420.7 b
21day	39.1 a	1.7 a	17.2 a	11.2 b	58.2 c	47.4 c	37.2 b	199.1 c
C.V	16.9	23.5	4.1	8.5	20.5	20.1	13.6	20.4
L.S.D	13.1	0.9	1.5	1.8	39.8	42.8	10.1	183.1
Mean	44.6	1.7	18.1	12,8	111.9	123.6	42.7	518.5

*P.H=Plant height

*N.L/P=Number of Leaves per Plant

*N.T/P=Number of the Branches per Plant

*N.P/m^2=Number of the Plants per Square Meter

*Y.S/m^2=Yield of the Seeds per Square Meter

*N.P/P = Number of pods per Plant

*100-S.W/M2=100-Seed Weight per Square Meter

*Y.Kg/fd=Yield of Kilo Gram per Fadden

*C.V=Coefficient Variance

*L.S.D=Lest Significant Difference

Table (2) AOV Table for parameters growth and yield of broad bean by effect Irrigation intervals in Season 2017-2018

Source	**D.F**	**F value**							
		p.h	N.L/p	N.B/p	N.p/m^2	N.P/P	100.S.W	S.Y/m^2	Y.kg/fd
Replication	**3**								
Irrigation	2	2.3NS	3.6*	2.6 NS	50.3 **	24.5*	3.6 *	53.4**	53.1**
Error	6								
Total	11								
C.V		16.9	13.13	20.03	8.52	20.5	31.59	20.1	20.1
E.M.S		57.2	34.06	613.4	1.2	529.7	0.31	614.1	10818

NS=no significant

*=significant

**=high significant

Figure (1) indicate the means of growth each 30 days of broad bean

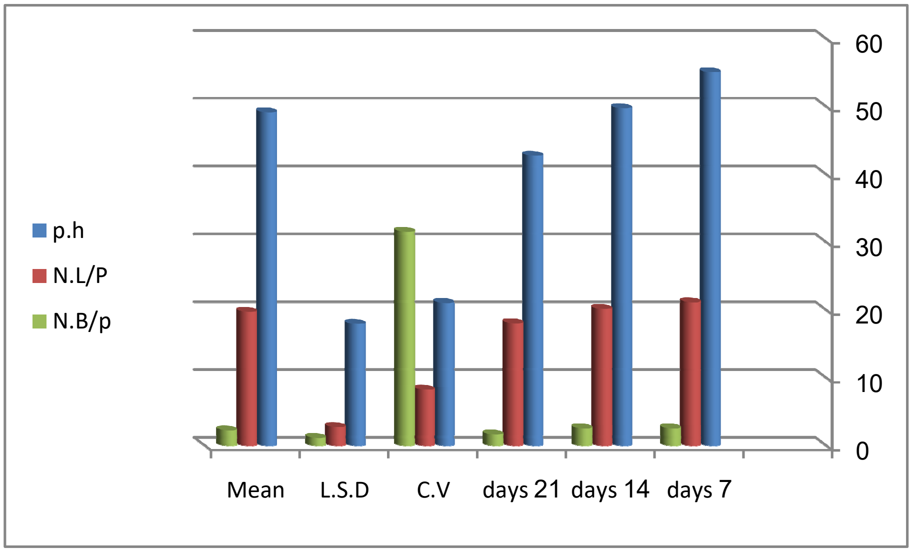


Figure (2) the means growth each 45 days

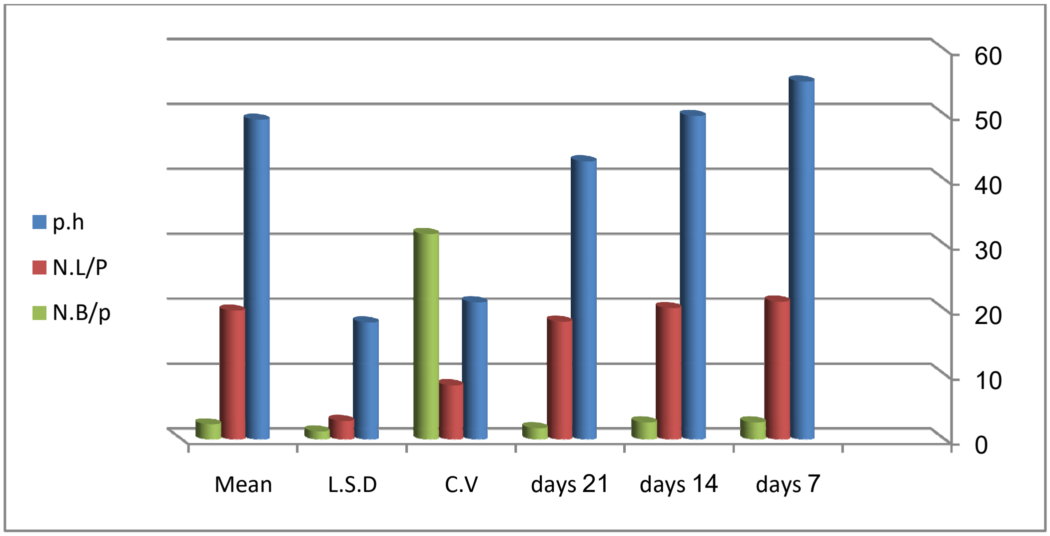
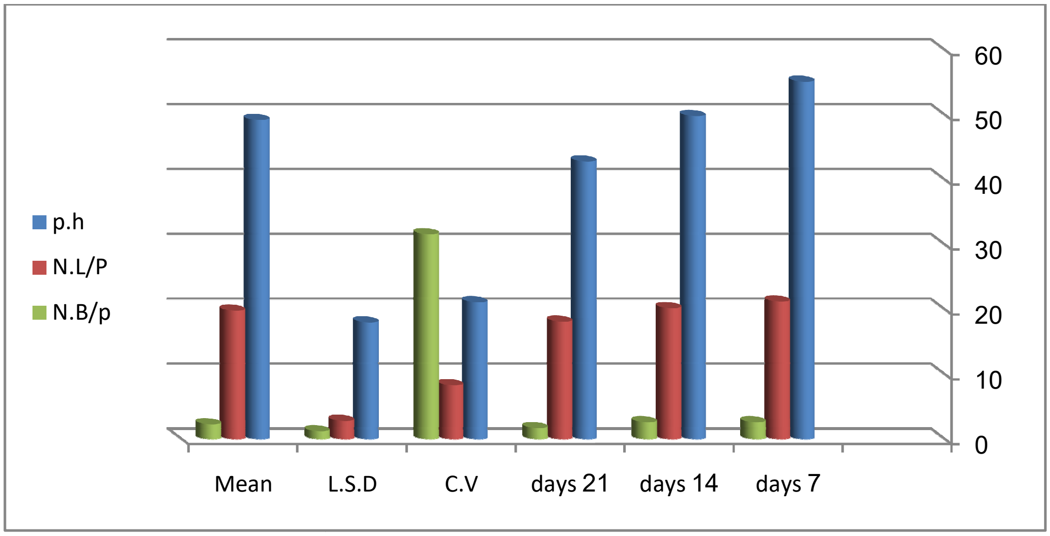


Figure (3) indicate the means parameters growth each 60 days of broad bean



CHAPTER FIVE

DISCUSSION

Water stress effect on growth Plant that suffer from water deficit often show reduction of growth, photosynthesis and respiration. However water deficit can directly affect the increase in the size of plant or components through the action of turgid pressure in cell expansion. Cell division appear to be less severely affected than cell expansion but growth maybe further inhibited by change in carbohydrates metabolism ,nitrogen metabolism and possibly by the production of growth substances and translocation of materials ,Bannist (1976) and katerji *et al* (2011). Plant development is likely dependent on growth stage of the plant ,Agreeb (1976), Helen .*et al* (1989) and Abid *et al* (2017) found that productive growth phase was more sensitive to water stress than the vegetative phase, Heloblethwaiter *et-al* (1982) Reported that Irrigation during the reproductive phase increased intercalary meristem of internodes meditated by the interaction of plant hormones such as ethylene and gibberlin acid thus plant develop more nodes and longer internodes under stress. Hebolethwaite (1983) and Migdadi *et al* (2016) found that the reduction increase in broad bean plant height during late flowering and early grain filling stages coincided with start of pods growth and the reduction in crop vegetative growth**.** This study showed no significant differences of irrigation intervals on plant height, agreed with (Ishag 1973, Ahmed 1989 and El Dakroury 2008) stated that attributed the later reduction in plant height under irrigation intervals to translocation assimilates to the reduction sink; Generally the reduction of plant height due to affected irrigation intervals in broad bean was reported by (conover et al 1989and Balsio 2006). In this result showed significant differences on number of leaves under irrigation intervals with agreed by (Eltony1998) stated because that can be attributed to low leaf number, which maybe lead to low leaf area photosynthetic ability. This study showed high significant differences on number of plant/m2 under irrigation intervals. No found agreed but the reason return to type soil, condition environment and type species.In results showed high significant differences on weight of the seeds /m2 under irrigation intervals; agreed by (Salih 1985) that attributed to the reduction in seeds weight under less frequent watering intervals. On the other (Mohan et al 1982) attributed the reduction in seeds weight to the depressive effect of soil moisture on plant stand and the number of pods per stem which agree with the result Hussein(2014) who Stated that to attributed reduction in seeds weight to decrease in dry matter translocation, as result of reduced source and sink stress.In current study showed significant differences on 100-seed weight under watering intervals agreed with by(Salih et .al 1983) found that 100-seed weight remained unaffected by increasing irrigation ; The difference in seed weight was attributed to supply of assimilate from current photosynthesis or the ability of plant in translocation of the dry matter to growing grains.This results showed that high significant differences under irrigation intervals on seed yield agreed with by (signh 1977, Hussein2014)) who showed that the retaliation of reproductive sink potential in green legumes is limited to 10-30% to cause premature abscission of reproductive structures which is one of several critical physiological traits determining harvestable. broad bean irrigated every 7days significantly increase seeds yield and number of pods /plant (Salih 1985) obtained seed yield of 4.013 and 2.408 Ton /ha when plants were watered 7 or 14 days intervals respectively .However irrigation at growth pods stages gave the highest average seeds yield (Signh et al 1987 and EL-Dakroury 2008).Irrigation intervals used in this study was expected to cause reduction in growth and yield stages. (Bolenos and Edmedes 1993) the results indicated that the reproductive characters were more significantly affected by water intervals in value than the growth characters.

SUMMERY AND CONCLUSION

(1) Irrigation intervals showed significant differences on seeds weight/m^2 and Seed yield.

(2) The yields of 7days were significantly higher compared with those of the other days under irrigation intervals.

(3) Irrigation applied every 7 days was better than others.

(4)This Work should be tested for another season to contend the results

REFERANCES

1-Abd-Alla M. H., El-Enany A. E., Hamada A. M., Abdel Wahab A. M. (2001). Element distribution in faba bean root nodules under salinity and its effects on growth, nodulation and nitrogen fixation. Plant Soil Environ. 47, 399–404.

2-Abdalla, A. A. Et al (2015). Effects of Different Environments on Yield Components of Faba bean (Vicia faba L.). Ijaf, 5(1):pp1-9.

3-Abdalla, A. B. (2005). The determnts of agricultural production and the optimum cropping pattern in the Northern State, Sudan. Phd Thesis, University of Khartoum, Sudan.

4-Abdelhafiz.M.E 2001.Effect of partially acidulated phosphate rock and triple super phosphate and their combination on growth, mineral composition and yield of wheat ph.D .thesis Sudan University of sciences and Technology .

5-Abid G., M'hamdi M., Mingeot D., Aouida M., Aroua I., Muhovsk Y., et al. (2017). Effect of drought stress on chlorophyll fluorescence, antioxidant enzyme activities and gene expression patterns in faba bean (Vicia faba L.). Arch Agron. Soil Sci. 63 536–552.

6-Adam 2002. The agricultural climatic second Edition, (in Arabic), Gezira University p.p 119.

7-Adelaide, AuThomas, G. A., Dalal, R. C., Weston, E. J., King, A. J., Holmes, C. J., Orange, D. N., and Lehane, K. J. (2011). Crop rotations for sustainable grain production on a vertisol in the semi-arid subtropics. Journal of Sustainable Agriculture **35**, 2-26 .

8-Ageeb (1977) Effect of watering intervals and plant sowing date on plant survival and grain yield of faba bean, Annual reports HRS.Sudan.

9-Ageeb O,A.A Hudeiba research station and report 1976-1977 Eldamer,Sudan.

10-Ageeb.O.A (1976)Chick pea Fertilizer watering intervals and plant Spacing Ann,REP of Hudieda ARC State (1975-1976) P3-5 Eldamer.

11-Ahmed .M.E.M(1989) response of faba beans (Vicia faba)to water and heat stress M.sc thesis Faculty of Agriculture ,University of Khartoum.

12-Akibode, S., and Maredia, M. K. (2011). Global and regional trends in production, trade and consumption of food legumes crops (Michigan State University). Report submitted to the Standing Panel on Impact Assessment, pp 23.

13-Alghamdi S. S., Al-Shameri A. M., Migdadi H. M., Ammar M. H., El-Harty E. H., Khan M. A., et al. (2015). Physiological and molecular characterization of Faba bean (Vicia faba L.) genotypes for adaptation to drought stress. J. Agron. Crop Sci. 201, 401–409.

14-Ali M. B. (2015). Physiological response of German winter faba bean (Vicia faba L.) to drought. J. Crop Improv. 29 319–332.

15-Ali, S. M., Sharma, B., and Ambrose, M. J. (1994). Current Herridge, D. F., Manning, B., and mccaffery, D. (2010). Nitrogen benefits of chickpea and faba bean. (N. DPI, ed.).137

16-Alonso R., Aguirre A., Marzo F. (2000). Effects of extrusion and traditional processing methods on antinutrients and in vitro digestibility of protein and starch in faba and kidney beans. Food Chem. 68 159–165.

17-Arbaoui M., Link W. (2008). Effect of hardening on frost tolerance and fatty acid composition of leaves and stems of a set of faba bean (Vicia faba L.) genotypes. Euphytica 162 211–219. 10.1007/s10681-007-9521-4.

18-Baginsky C., Silva P., Auza J., Acevedo E. (2013). Evaluation for fresh consumption of new broad bean genotypes with a determinate growth habit in central Chile. Chil. J. Agr. Res. 73, 225–232.

19-Balasio, E.D., A. Hussein and A. Ahmed, (2006). Effect of watering regimes at two stages of growth on faba Bean grain yield at Selain Basin. American Society of Agricultural Engineers Trans., 8: 433-443.
Bannister .P (1976) Introduction to physiology plant Ecology.Blank well scientific publicans ,London Edinbury Melbournce.

20-Bannister .P (1976) Introduction to physiology plant Ecology.Blank well scientific publicans ,London Edinbury Melbournce

21-Belachew K. Y., Stoddard F. L. (2017). Screening of faba bean (Vicia faba L.) accession to acidity and aluminum stresses.

22-Belghith-Fendri L., Chaari F., Kallel F., Zouari-Ellouzi S., Ghorbel R., Besbes S., et al. (2016). Pea and broad bean pods as a natural source of dietary fiber: the impact on texture and sensory properties of cake. J. Food Sci. 81 C2360–C2366.

23-Bilalis D., Sidiras N., Economou G., Vakali C. (2003). Effect of different levels of wheat straw soil surface coverage on weed flora in Vicia faba crops. J. Agron. Crop Sci. 189 233–241.

24-Bishop J., Jones H. E., Lukac M., Potts S. G. (2016). Insect pollination reduces yield loss following heat stress in faba bean (Vicia faba L.). Agric. Ecosyst. Environ. 220 89–96.

25-Bodner G., Kronberga A., Lepse L., Olle M., Vagen I. M., Rabante L., et al. (2018). Trait identification of faba bean ideotypes for Northern European environments. Eur. J. Agron. 96 1–12.

26-Bolanos,J and G.O Edmeads (1983) Eight cycle of selection for drought tolerance in low land tropical in reproductive behavior Field Crop research P.31-253-268.

27-Bond D. A., Lawes D. A., Hawtin G. C., Saxena M. C., Stephens J. S. (1985). "Faba bean (Vicia faba L.)," in Grain Legume Crops, eds Summerfield R.J., Roberts E.H., editors. (London: William Collins Sons;), 199–265.

28-Bond, D.A.D.A, Lowes. G.C. Hawtin ,M.C.Saxena, and J.S.Stephens, 1985. Faba bean (Vicia faba L) P.199-265. IN.R.J. Summer field and E.H.Roberts (eds).Grain Legumes crop. William Collins, son CO.ltd 8 Grafton Street. London wix 3LA.U K.

29-Bozoğlu H., Pekşen A., Pekşen E., Gülümser A. (2002). Determination of green pod yield and some pod characteristics of faba bean (Vicia faba L.) cultivar/lines grown in different row spacings. Acta Hort. 579 347–350.

30-Brauckmann B. M. and Latt, é K. P. (2010). L-Dopa deriving from the beans of Vicia faba and Mucuna pruriens as a remedy for the treatment of Parkinson's disease. Schweiz Z Ganzheitsmed. 22 292–300.

31-Brown, B.A., C.E., Coviness and D.A., Brown, 1985. Response of selected soybean cultivars to soil moisture Defict Agron. J., 77: 274-278.

32-Bryla D. R., Bañuelos G. S., Mitchell J. P. (2003). Water requirements of subsurface drip-irrigated faba bean in California. Irrig. Sci. 22 31–37.

33-Bulut F., Akinci S., Eroglu A. (2011). Growth and uptake of sodium and potassium in broad bean (Vicia faba L.) under salinity stress. Commun. Soil Sci. Plant Anal. 42 945–961. 10.1080/00103624.2011

34-Cao Y. -Y., Bian X. -C., Chen M. -X., Xia L. R., Zhang J., Zhu F. -Y., et al. (2017). iTRAQ-based quantitative proteomic analysis in vernalization-treated faba bean (Vicia faba L.). PLoS One 12:e0187436. 10.1371/journal.pone.

35-Caracuta V., Barzilai O., Khalaily H., Milevski I., Paz Y., Vardi J., et al. (2015). The onset of faba bean farming in the Southern Levant. Sci. Rep. 5:14-37.

36-Caracuta V., Weinstein-Evron M., Kaufman D., Yeshurun R., Silvent J., Boaretto E. (2016). 14,000-year-old seeds indicate the Levantine origin of the lost progenitor of faba bean. Sci. Rep. 6:37-399.

37-Chen W. (2009). Pollination, fertilization and floral traits co-segregating with autofertility in faba bean. J. New Seeds 10 14–30.

38-Chrisitanson C.B .Bartiono,Ahernao,J and Velek.P.I.G(1995),Fate and efficiency of N Fertilizer applied to millet in Niger plant and Soil P 125-221-231.

39-Coda R., Varis J., Verni M., Rizzello C. G., Katina K. (2017). Improvement of the protein quality of wheat bread through faba bean sourdough addition.LWT - Food Sci. Technol. 82, 296–302.

40-Collado E., Artés-Hernández F., Aguayo E., Artés F., Fernández J., Gómez P. A. (2017). Quality changes of minimally processed fresh and microwave cooking of faba bean seeds. Actas Portug. Hort. 28 306–311.

41-Covover,D.G and Sovrick D.A,A(1989) influence of water deficit on water relaxation and Growth of Echinochia, turning Echinochia curs-gall,and Pennisetum americium,plant physiology P 291-304.

42-Crépon K., Marget P., Peyronnet C., Marget P., Peyronnet C., Carrouée B.,et al. (2010). Nutritional value of faba bean (Vicia faba L.) seeds for feed and food. Field Crop Res. 115, 329–339. Cubero J. I. (1974). On the evolution of Vicia faba L. Theor. Appl Genet. 45 47–51.

43-Cubero J. I. (2017). "Leguminosas hortícolas: guisantes, judías y habas hortícolas" in Cultivos Hortícolas al Aire Libre, eds Maroto J.V., Baxauli C., editors. (Almería: Cajamar Caja Rural;), 703–741.

44-Cubero,J.I. (1994).Evolutionary Trends in Vicia faba Theoretical and applied genetics ,43,59-65.

45-Cunningham S. A., Le Feuvre D. (2013). Significant yield benefits from honeybee pollination of faba bean (Vicia faba) assessed at field scale. Field Crops Res. 149 269–275.

46-Dane S., Laugale V., Lepse L., Silina D. (2017). Influence of legumes on soil fertility in strawberry-legume intercropping. Res. Rural Dev. 2 26–32.

47-del Pilar Cordovilla M., Ligero F., Lluch C. (1995). Influence of host genotypes on growth, symbiotic performance and nitrogen assimilation in faba bean (Vicia faba L.) under salt stress. Plant Soil 172 289–297.]

48-del Pilar Cordovilla M., Ligero F., Lluch C. (1999). Effect of salinity on growth, nodulation and nitrogen assimilation in nodules of faba bean (Vicia faba L.).Appl. Soil Ecol. 11 1–7. 10.

49-Duc G., Agrama H., Bao S., Berger J., Bourion V., De Ron A. M., et al. (2015b). Breeding annual grain legumes for sustainable agriculture: new methods to approach complex traits and target new cultivar ideotypes. Crit. Rev. Plant Sci. 34 381–411.]

50-Duc G., Aleksić J. M., Marget P., Mikić A., Paull J., Redden R. J., et al. (2015a). "Faba bean," in Grain Legumes, ed. De Ron A.M., editor. (New York, NY: Springer;), 141–178.

51-Duc G., Bao S., Baum M., Redden B., Sadiki M., Suso M. J., et al. (2010). Diversity maintenance and use of Vicia faba L. genetic resources. Field Crops Res. 115 270–278.

52-Duce .G.Bole ,Baium.M.Redden, B.Msuse, Vishniakova, M.Zong.x (2010) **Shulze** , R. H. Saskatchewan agriculture Authore(s) E.D Robichaux,

53-El- Adel, M.A., 2000. Effect of irrigation and fertilization method on pea production. Misr. J. Agr. Eng., 17(3)

54-El- Dakroury, M.A.,(2008). Influence of different irrigation systems and irrigation treatments on productivity And fruit quality of some bean varities M. Sc. Thesis, Fac. Of Agri., Ain Shams University.

55-Elfeil, M.A.; Babikir, B. I. And Davis, J. (2001). An economic analysis of wheat, broad beans and sorghum production in the Northern State of the Sudan. University of Khartoum. J. Agric. Sci.:

56-Elnadi (1970) .water relation bean II ,effect of differential irrigation .

57-Eltony,E.M.A.(1988) Growth and yield of Maize as in flounced by water stress at different Growth .M.sc thesis .Faculty of Agriculture University of Khartoum.

58-Faki, H.H., (1991). Water allocation and its effect on faba bean technology adoplion in Shendi area. Pag 72-75

59- FAO (2016). Food and Agriculture Organization of the United Nations (2016).production year book. Rome Italy.

60-Flores F., Hybl M., Knudsen J. C., Marget P., Muel F., Nadal S., et al. (2013). Adaptation of spring faba bean types across European climates. Field Crops Res. 145 1–9

61-Foroud, N., H.H. Mundel, G. Saindon and T- Entz, (1993). Effect of level and timing of moisture stress on

62-Ghassemi-Golezani K., Ghanehpoor S., Mohammadi-Nasab D. (2009). Effects of water limitation on growth and grain filling of faba bean cultivars. J. Food Agric. Environ. 7 442–447.

63-Girma F., Haile D. (2014). Effects of supplemental irrigation on physiological parameters and yield of faba bean (Vicia faba L.) varieties in the highlands of Bale, Ethiopia. J Agron. 13 29–34.

64-Göl ş., Doğanlar S., Frary A. (2017). Relationship between geographical origin, seed size and genetic diversity in faba bean (Vicia faba L.) as revealed by SSR markers. Mol. Genet. Genom. 292 991–999.

65-Gomez, K.A.and A.A.Gomez.(1984).statistical procedures for Agricultural Research and John,wiley and sons, ine .New York. Maize (Zea mays) single-cross hybrids.

66-Grimes, D.W., H. Yamada and S.W. Hughes, (1988). Climate normalized cotton leaf water potentials for irrigation scheduling. Sensores and techniques for irrigation management. Conference proceedings May, 12, 1988. Center for Irrigation Technology Fresno, U.S.A.

67-Guoju X., Fengju Z., Juying H., Chengke L., Jing W., Fei M., et al. (2016). Response of bean cultures' water use efficiency against climate warming in semiarid regions of China. Agric Water Manage. 173 84–90.

68-Gutierrez N., Avila C. M., Moreno M. T., Torres A. M. (2008). Development of SCAR markers linked to zt-2 one of the genes controlling absence of tannins in faba bean. Aust. J. Agric. Res. 59, 62-68.

69-Hebbleth waite.P.D.R.K Scott and J.O.S.K .Ogbe (1983) the effect of Irrigation and bees on the yield and yield component of (Vicia faba) Agronomy, physiology and breeding (ISBN)90-247-296-P17-91).

70-Hellal F. A., Abdelhamid M. T., Abo-Basha D. M., Zewainy R. M. (2012). Alleviation of the adverse effects of soil salinity stress by foliar application of silicon on Faba bean (Vicia faba L.). J. Appl. Sci. Res. 8 4428–4433.

71-Hendawey M. H., Younes A. M. A. (2013). Biochemical evaluation of some faba bean cultivars under rainfed conditions at El-Sheikh Zuwayid. Ann. Agric. Sci. 58 183–193.

72-Hodges, H.F. and L.G. Healherly, (1983). Principles of water management for soybean production in Mississippi.
73-Hussein Abdul-Aziz .F . I(2014). Effect of Water Intervals on Growth and Yield of Broad Bean (Visia faba L.)
in Nile Valley Regional program on Cool- Season Food Leggumes and Wheat. Annual Report 1990/91,

74-Jilani M., Daneshian J., Rabiee M. (2012). Effect of pre-harvest desiccation of paraquat on grain yield and some agronomic characteristics of Faba bean.Adv. Environ. Biol. 6 2502–2504.

75-Karkanis A., Ntatsi G., Kontopoulou C. K., Pristeri A., Bilalis D., Savvas D. (2016a). Field pea in european cropping systems: adaptability, biological nitrogen fixation and cultivation practices. Not. Bot. Horti Agrobot. Cluj Napoca. 44 325–336.

76-Katerji N., Mastrorilli M., Lahmer F. Z., Maalouf F., Oweis T. (2011). Faba bean productivity in saline-drought conditions. Eur. J. Agron. 35 2–12.

77-Kay,D.(1979). Crop and production Digest No-3 Food legumes .London: Tropical products Insitute.UK p 26-47

78-Khamassi K., Ben Jeddi F., Hobbs D., Irigoyen J., Stoddard F., O'sullivan D. M. (2013). A baseline study of vicine-convicine levels in faba bean (Vicia faba L.) germplasm. Plant Genetic Res. 11 250–257.

79-Khamassi K., Harbaoui K., Teixeira Da Silva J. A., Jeddi F. B. (2013). Optimal germination temperature assessed by indices and models in Field bean (Vicia faba L. var. minor). Agric. Conspec. Sci. 78 131–136.

80-Khan H. R., Paull J. G., Siddique K. H. M., Stoddard F. L. (2010). Faba bean breeding for drought-affected environments: a physiological and agronomic perspective. Field Crops Res. 115 279–286.

81-Knott C. M. (1999). Irrigation of spring field beans (Vicia faba): response to timing at different crop growth stages. J. Agric. Sci. 132 407–415.

82-Lepse L., Dane S., Zeipiņa S., Domínguez-Perles R., Rosa E. A. (2017). Evaluation of vegetable-faba bean (Vicia faba L.) intercropping under Latvian agro-ecological conditions. J. Sci. Food Agric. 97 4334–4342.

83-Link W., Balko C., Stoddard F. L. (2010). Winter hardiness in faba bean: physiology and breeding. Field Crops Res. 115 287–296.

84-Loss S. P., Siddique K. H. M. (1997). Adaptation of faba bean (Vicia faba L.) to dryland mediterranean-type environments. I. Seed yield and yield components. Field Crops Res. (52) 17–28.

85-Luo Y-W., Xie W-H. (2013). Effect of different processing methods on certain ant nutritional factors and protein digestibility in green and white faba bean (Vicia faba L.). CYTA- Food. 11 43–49.

86-Maqbool A., Shafiq S., Lake L. (2010). Radiant frost tolerance in pulse crops-a review. Euphytica 172 1–12.

87-Martos-Fuentes M. (2017). Genotyping, phenotyping and transcriptomic analysis of accessions of Vicia faba, Pisum sativum and Vigna unguiculata. Ph.D. Thesis, Technical University of Cartagena, Spain.

88-McDonald M., Copeland L. O. (1997). Seed Production: Principles and Practices. New York, Springer: 1–749. McNaughton K. E., Blackshaw R. E., Waddell K. A., Gulden R. H., Sikkema P. H., Gillard C. L. (2015). Effect of five desiccants applied alone and in combination with glyphosate in dry edible bean (Phaseolus vulgaris L.). Can. J. Plant Sci. 95 1235–1242.

89-Meckel, L.W., D.B., Egli, R.E. Philips and J.E. Leggett,(1984). Effect of moisture stress on seed growth in soybean. Agron. J: 76(4): 647-650.

90-Migdadi H. M., El-Harty E. H., Salamh A., Khan M. A. (2016). Yield and proline content of faba bean genotypes under water stress treatments. J. Anim. Plant Sci. 26 1772–1779.

Mississippi Agricultural Forestry Experiment Station. Bulletin no. 919.
91-Mohan,C.S,Savena,A.D,Richard,T and Steward .R.A (1982),Faba bean in Nile Valley , report on the first phase of the ICARDA/IFAD Nile Valley project (1979-1982).
92-Moore, K., Backhouse, D., Simpfendorfer, S., and Verrell, A. (2003). Crop rotation reduces crown rot in wheat. In "Update of research in progress at the Tamworth Agricultural Institute 2002" (B. Martin, ed.), pp. 43. NSW DPI.

93-Moorthi R. N., Armstrong C. L. H., Janda K., Ponsler-Sipes K., Asplin J. R., Moe S. M. (2015). The effect of a diet containing 70% protein from plants on mineral metabolism and musculoskeletal health in chronic kidney disease. Am. J. Nephrol. 40 582–591. Moreno M., Martinez A. (1980). The divided world of V. faba. FABIS Newslett. 2 18–19.

94-Moreno M., Martinez A. (1980). The divided world of V. faba. FABIS Newslett. 2 18–19.

95-Multari S., Stewart D., Russell W. R. (2015). Potential of fava bean as future protein suppl y to partially replace meat intake in the human diet. Compr. Rev. Food Sci. Food Saf. 14 511–522. 10.1111/1541-4337.12146 .

96-Muñoz-Romero V., López-Bellido L., López-Bellido R. J. (2011). Faba bean root growth in a Vertisol: tillage effects. Field Crops Res. 120 338–344.

97-Mwanamwenge J., Loss S., Siddique K., Cocks P. (1999). Effect of water stress during floral initiation, flowering and podding on the growth and yield of faba bean (Vicia faba L.). Eur. J. Agron. 11 1–11.

98-Nozzolillo C., Ricciardi L., Lattanzio V. (1989). Flavonoid constituents of seed coats of Vicia faba (Fabaceae) in relation to genetic control of their color.Can. J. Bot. 67 1600–1604.

99-NSMA (2016). Northern State Ministry of Agriculture annual report

100-Ofuya , Z.M, Akhide.V (2005). The role of pulse in Human nutrition review ,Journal of Apply Sciences and Environment p.9,99-104.

101-Oliveira H. R., Tomás D., Silva M., Lopes S., Viegas W., Veloso M. M. (2016). Genetic diversity and population structure in Vicia faba L. landraces and wild related species assessed by nuclear SSRs. PLoS One 11:e0154801.

102-Oweis T., Hachum A., Pala M. (2005). Faba bean productivity under rainfed and supplemental irrigation in northern Syria. Agric. Water Manag. 73 57–72.

103-Pampana S., Masoni A., Arduini I. (2016). Response of cool-season grain legumes to waterlogging at flowering. Can. J. Plant Sci. 96 597–603.

104-Patrick J. W., Stoddard F. L. (2010). Physiology of flowering and grain filling in faba bean. Field Crops Res. 115 234–242.

105-Pietrzak W., Kawa-Rygielska J., Król B., Lennartsson P. R., Taherzadeh M. J. (2016). Ethanol, feed components and fungal biomass production from field bean (Vicia faba var. equina) seeds in an integrated process. Bioresour. Technol. 216 69–76.

106-Pociecha E., Kościelniak J., Filek W. (2008). Effects of root flooding and stage of development on the growth and photosynthesis of field bean (Vicia faba L. minor). Acta Physiol. Plant. 30 529–535.

107-Salih ,F.A (1983) Varietal performance of faba bean under two different watering intervals FABIS New letter p 30,16-19 options.

108-Salih,S.H,Ali.A.E and Khalafa allah (1983),Report on back up research faba bean breeding (1982-1983) A.R.C Sudan.

109-Salih,S.H,Ali.A.E and Khalafa allah (1983),Report on back up research faba bean breeding (1982-1983) A.R.C Sudan.

110-Sallam A., Arbaoui M., El-Esawi M., Abshire N., Martsch R. (2016). Identification and verification of QTL associated with frost tolerance using linkage mapping and GWAS in winter faba bean. Front. Plant Sci. 7:1098.

111-Sallam A., Ghanbari M., Martsch R. (2017). Genetic analysis of winter hardiness and effect of sowing date on yield traits in winter faba bean. Sci. Hortic. 224296–301

112-Sallam A., Martsch R., Moursi Y. S. (2015). Genetic variation in morpho-physiological traits associated with frost tolerance in faba bean (Vicia faba L.).Euphytica 205 395–408.

113-Sallam A., Martsch R., Moursi Y. S. (2015). Genetic variation in morpho-physiological traits associated with frost tolerance in faba bean (Vicia faba L.).Euphytica 205 395–408.

114-Schwenke, G. D., Peoples, M. B., Turner, G. L., and Herridge, D. F. (1998). Does nitrogen fixation of commercial, dryland chickpea and faba bean crops in north-west New South Wales maintain or enhance soil nitrogen? Australian Journal of Experimental Agriculture **38**, 61-70.

115-Shi L., Mu K., Arntfield S. D., Nickerson M. T. (2017). Changes in levels of enzyme inhibitors during soaking and cooking for pulses available in Canada. J. Food Sci. Technol. 54 1014–1022.

116-Shiran B., Kiani S., Sehgal D., Hafizi A., Chaudhary M., Raina S. N. (2014). Internal transcribed spacer sequences of nuclear ribosomal DNA resolving complex taxonomic history in the genus Vicia L. Genet. Resour. Crop Evol. 61 909–925.]

117-Siddique K. H. M., Erskine W., Hobson K., Knights E. J., Leonforte A., Khan T. N., et al. (2013). Cool-season grain legume improvement in Australia-use of genetic resources. Crop Pasture Sci. 64 347–360.

118-Siddique K. H. M., Erskine W., Hobson K., Knights E. J., Leonforte A., Khan T. N., et al. (2013). Cool-season grain legume improvement in Australia-use of genetic resources. Crop Pasture Sci. 64 347–360.

119-Singh ,D.P,Singh,P.Sarma,H.C and Turner,N.C(1987) influence of water deficits on the water relations canopy gas exchange and yield of chickpea

120-Singh, S.P, Singh.N.P and pandey R.K(1987) Irrigation Studies in faba bean 1983,FABIS News letter 18 p 24.

121-Singh,C (1977) response of pigeon pea to water stress ,Indian ,J. Agricultural Sciences P 29-35.

122-Solaiman Z., Colmer T. D., Loss S. P., Thomson B. D., Siddique K. H. M. (2007). Growth responses of cool-season grain legumes to transient waterlogging.Aust. J. Agric. Res. 58 406–41.
soybean yield components. Irrigate. Sci., 13: 149-155.

123-Stoddard F. L. (1991). Pollen vectors and pollination of faba beans in southern Australia. Aust. J. Agric. Res. 42 1173–1178

124-Stoddard F. L., Balko C., Erskine W., Khan H. R., Link W., Sarker A. (2006). Screening techniques and sources of resistance to abiotic stresses in cool-season food legumes. Euphytica 147 167–186.

125-Stoddard F. L., Nicholas A. H., Rubiales D., Thomas J., Villegas-Fernández A. M. (2010). Integrated pest management in faba bean. Field Crops Res. 115,308–318.

Sudan. ICARDA/ NVRPOC-017.

126-Suso M., Moreno M., Mondragao-Rodrigues F., Cubero J. (1996). Reproductive biology of Vicia faba: role of pollination conditions. Field Crops Res. 4681–91

127-Tayel, M.Y., A.M. El Gindy, M. Abd- El- Hady and H.A. Ghany, 2007. Effect of irrigation systems on: yield, Water and fertilizer use efficiency of grape. Applied Sciences Research, 3(5): 367-372.

128-Taylor, S.A.,(1965). Managing irrigation water on farm. American Soc. Agricultural Engineers Trans., 8: 433-

The origin and spread of cultivated plant in west Africa , Europe

129-Thomas, G. A., Dalal, R. C., Weston, E. J., King, A. J., Holmes, C. J., Orange, D. N., and Lehane, K. J. (2011). Crop rotations for sustainable grain production on a vertisol in the semi-arid subtropics. Journal of Sustainable Agriculture **35**, 2-26

130-Turpin, J. E., Herridge, D. F., and Robertson, M. J. (2002). Nitrogen fixation and soil nitrate interactions in field-grown chickpea (Cicer arietinum) and faba bean (Vicia faba). Australian Journal of Agricultural Research **53**, 599-608.

131-Verrell, H., Moore, K., Simpfendorfer, S., and Nash, P. (2005). Crop Rotation and its effect on crown root rot, soil water extraction and water use efficiency in wheat. In "Goondiwindi Grains Research Update", pp. 31-34, Goondiwindi.

132-Woyengo T. A., Nyachoti C. M. (2012). IIeal digestibility of amino acids for zero-tannin faba bean (Vicia faba L.) fed to broiler chicks. Poult. Sci. 91 439–443.

Yield and yield component. J .Agricultural sciences Crumb 80-181-189.

133-Zeid M., Schön C. C., Link W. (2003). Genetic diversity in recent elite faba bean lines using AFLP markers. Theor. Appl. Genet. 107 1304–1314.

134-Zhao J., Sykacek P., Bodner G., Rewald B. (2018). Root traits of European Vicia faba cultivars – Using machine learning to explore adaptations to agroclimatic conditions. Plant Cell Environ.

135-Zhou R., Hyldgaard B., Yu X., Rosenqvist E., Ugarte R. M., Yu S., et al. (2018). Phenotyping of faba beans (Vicia faba L.) under cold and heat stresses using chlorophyll fluorescence. Euphytica 214:68 10.

136-Zong X., Liu X., Guan J., Wang S., Liu Q., Paull J. G., et al. (2009). Molecular variation among Chinese and global winter faba bean germplasm. Theor. Appl. Genet. 118 971–978.