Hebron University

College of Graduate Studies & Academic Research

Growth Performance and Yield Components of Five Legume Crops under Rain-fed Conditions

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This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Natural Resources, College of Graduate Studies & Academic Research, Hebron University, Palestine.

2014

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Dedication

I Would Like To Dedicate This Thesis To

My Mother

My Father

My Wife

My son, and

My Brothers

Acknowledgment

I would like to express my thanks to all those who have helped and supporting me in conducting this research.

My deep gratitude and thanks goes also to Dr. Rezq Basheer-Salimia for his supervision, guidance, encouragement, and continuous support.

Special thanks and appreciations to Dr. Abdul-Jalil Hamadan for his scientific help and support.

Many thanks to my colleagues and friends at the Union of Agricultural Work Committees (UAWC).

My deep appreciation, acknowledgment, gratitude, and thanks to my parents, my wife my, son, brothers and sisters for their support, help, encouragement and patience.

For all ……Thank you

Mohammed

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Abstract

The main goals of the present study were to evaluate the growth performance, yield components and chemical composition of five legume crops (chick peas, lentils, broad bean, bitter vetch and common vetch); under three different climatic conditions namely Al-arroub, Dora, and Janata locations. By means of a completely randomized design, five legumes crops, with five replications using a net plot size of 20 m^2 area (4m*5m) / replicate were used.

Morphological parameters including germination date, maturation and harvesting date, stem length, flowering period, fruit set period and 100 seeds weight were recorded. Furthermore, yield parameters including total production (grain and hay), total grain production, and total hay production were also registered.

Grain quality parameters were measured by examining the dry matter, crud protein, and ash content.

Obtained data were statistically analyzed using the one-way analysis of variance (ANOVA) and means were separated using the Tukey's pairwise comparisons at a significance level of $p \leq 0.05$ using the MINITAB package system.

The results showed highly significant environmental (locations) effects for almost all measured traits among the five examined legume crops (chick peas, lentils, and broad bean, bitter vetch, and common vetch). In general, Al-arroub site showed higher morphological and yield values; whereas Janata site presented the lowest values. An exception of this trend is

appeared with common vetch crop which presented significantly the highest yield production at Dora site.

Concerning the quality parameters; no significant variations were observed for all conducted analysis (protein content, dry Matter and ash) for the five examined crops among the three examined sites.

Finally, common vetch "bekia" and bitter vetch "kersana" crops are not recommended for yield production in the regions with less than 300 mm/year since they presented very low production especially at janta site. However, both crops might be suitable as an animal vegetative fodder.

Introduction

Legumes are one of the most important families among the dicotyledonous plants. It is the second only to the grasses (cereals) in providing food crops for world agriculture. Indeed; legumes are rich in high quality protein, providing man with a highly nutritional food resource. In addition, many legumes are able to convert atmospheric nitrogen into nitrogenous compounds, it is useful and available to other plants and this helps to fertilize the soil (Postgate, 1998).

Legumes (grain and forage) are grown on some 180 million ha, or 12-15% of the Earth's arable surface (FAOSTAT, 2009). They account for 27% of the world's primary crop production, with grain legumes alone contributing 33% of the dietary protein nitrogen (N) needs of humans (Vance et al., 2000). In rank order, bean, pea, chickpea, broad bean, pigeon pea, cowpea, and lentil constitute the primary dietary legumes (National Academy of Science, 1994).

Legumes includes around 670 to 750 genera and 18,000 to 19,000 species (Polhill et al., 1981), in which the most common species are used as important grains, pastures, fodders, green manures and agro forestry. Lentil, bean, and soybean are the earliest domesticated legumes respectively (Cohen, 1977; Hymowitz and Singh, 1987; Kaplan and Lynch, 1999).

In West Bank-Palestine, field crops and forages occupy the largest cultivated land after fruit trees with total areas of 44639.3 ha. Legumes constitute a high portion of this area in which bitter vetch (kersana) contribute the majority of the legumes in terms of area covered and total production. More preciously, bitter vetch is covered an area of 2424.1 ha (represent 5.4% of the area of field crops) followed by chick peas (1793.7 ha; 4%), common vetch (1768.4 ha; 3.9%), lentils (1491.6 ha; 3.3%), and broad beans (472.5 ha; 1%) respectively (PCBS, 2007).

Generally, many of the local legume crops are subject to either disappearance or deterioration. In addition, they suffer from many other problems such as drought, unsuitable agricultural practices and the lack of literature and scientific knowledge for the suitability, adaptability and productivity of each legume crop to different Palestinian agri-climatic regions.

Objectives

The main goals of the present research were:

1. To evaluate and compare the growth performance, yield, and chemical components of five local legume crops (broad bean, *Vicia faba*; check pea, *Cicer arietinum;* lentil, *Lens culinaris;* common vetch "bekia"*Vicia sativa* and bitter vetch " kersana" *Vicia ervilia*), under three different agri-climatic conditions.
2. To determine and evaluate the suitability and adaptability of each crop for each location.

Chapter One

Literature Review

1.1 Legumes in general

The leguminosae (fabaceae) is the third largest family of angiosperms after orchidaceae (orchids) and asteraceae (daisies, sunflowers), and second only to poaceae (grasses) in terms of agriculture and economic importance (Lewis et al., 2005).

Based on the plant anatomy, morphology, and biogeography distributions, leguminosae has been traditionally divided into three subfamilies, the Caesalpiniaceae, Mimosaceae, and Papilionaceae (Polhill and Raven, 1981).

Legumes are the demonstrated agricultural importance for thousands of years, beginning with the domestication of lentil (*Lens esculenta*) in Iran dating to 9,500 to 8,000 years ago, their use as a food source during the prehistory of North and South America (beans, more than 3,000 years ago), and their use by the Roman Empire as a food source and for soil improvement (Graham and Vance, 2003).Today, legumes are an increasingly invaluable food source not just for humans, accounting for 27% of the world's primary crop production, but also for farm animals (Graham and Vance, 2003).

Legumes were grown on more than 13% of the total arable land under cultivation in the world in 2004 (Gepts et al., 2005). Grain legumes alone contribute 33% of the dietary protein nitrogen needs of humans, while soybeans (*Glycine max*) and peanut (*Arachi shypogeae*) provide more than 35% of the world's processed vegetable oil and a rich source of dietary protein for the poultry and pork industries (Graham and Vance, 2003).

While they produce nitrogen-containing protein in abundance, legumes are deficient in sulfur containing amino acids and other nutrients needed by people and animals. For this reason, legumes and cereal crops are often raised together to account for the amino acids and other elements they are each deficient in (Gepts et al., 2005).

Many legumes form root nodules to fix atmospheric nitrogen in a symbiotic relationship with the soil bacteria "rhizobia". Leguminosae (Fabaceae), which also includes all other higher plants known to form nitrogen-fixing root nodules (Soltis et al., 2000) as well as many that do not form these symbioses, depending on the species in symbiosis.

Industrially, legumes have many uses in making biodegradable plastics, oils, dyes, and biodiesel fuel. Legumes are used traditionally in folk medicines, but also demonstrate importance in modern medicine. Iso-flavones commonly found in legumes are thought to reduce the risk of cancer and lower cholesterol and soybean phytoestrogens are being studied for use in postmenopausal hormone replacement therapy (Graham and Vance, 2003). Legumes also produce a hypoglycemic effect when eaten, making them a recommended food for diabetics (Gepts et al., 2005).

1.1.1 Broad bean (*Vicia faba*)

1.1.1.1 Origin and distribution of broad bean (*Vicia faba*)

Broad bean (*Vicia faba* L.) is one of the earliest domesticated food legumes in the world (Schultze-Motel, 1972). Its center of origin was localized between the oriental Mediterranean countries and Afghanistan (Cubero, 1974; Ladizinsky, 1975; Zohary, 1977; Abdalla, 1979).

Broad bean production in the world is concentrated mainly in nine major agro-ecological regions, namely; Central Asia, East Asia, the Nile valley, Ethiopia, Oceana, northern Europe, Mediterranean, Latin America, and North America (Bond et al., 1985). In Asia, it covers about 1.098.000 ha, and in North Africa about 347.000 ha. However, in Europe, Broad bean is produced in limited scale (393.000 ha), but a renewal interest for growing this crop was observed during the past ten years due to their values in the symbiotic N2-fixation, especially in organic farming, the need of vegetable proteins in animal feeding, the resistance to Aphanomyces (serious threat to peas; especially in France), and the demand of the Egyptian market of faba bean for human consumption (FAO, 2005).

1.1.1.2 Botanical classification

Vicia faba is a diploid species with (2n = 12) chromosomes. Based on seed size, two subspecies were recognized, paucijuga and faba. The latter was subdivided into var. minor with small rounded seeds (1 cm long), var. equina with medium sized seeds (1.5 cm) and var. major with large broad flat seeds (2.5 cm), (Bond et al., 1985). These three botanical varieties were also differentiated by human use: minor and equina are mainly used for animal feeding whereas major is mostly produced for human nutrition.

Cubero (1974) suggested four subspecies, namely: minor, equina, major, and paucijuga. Taxonomically the crop belongs to section Faba of the genus *Vicia* (Bond et al., 1985; Smart, 1990).*Vicia faba* is an annual herb with coarse and upright stems, un-branched 0.3-2 m tall, with 1 or more hollow stems from the base (Duke, 1981; Bond et al., 1985; Heath, et al., 1994). The leaves are alternate, pinnate and consist of 2-6 leaflets each up to 8 cm long and unlike most other members of the genus; it is without tendrils or with rudimentary tendrils (Bond et al., 1985). Flowers are large, white with dark purple markings, borne on short pedicels in clusters of 1-5 on each auxiliary raceme usually between the 5 and 10th node; 1-4 pods develop from each flower cluster, and growth is indeterminate though determinate mutants are available. About 30% of the plants in a population are cross-fertilized and the main insect pollinators are bumblebees. There is a robust tap root with profusely branched secondary roots (Bond et al., 1985).

1.1.1.3 Economical importance of broad bean

Cultivated Broad bean is used as human food in developing countries and as animal feed, mainly for pigs, horses, poultry and pigeons in industrialized countries. It can be used as a vegetable, green or dried, fresh or canned. It is a common breakfast food in the Middle East, Mediterranean region, China and Ethiopia (Bond et al., 1985). The most popular dishes of broad bean are Medamis (stewed beans), Falafel (deep fried cotyledon paste with some vegetables and spices), Bissara (cotyledon paste poured onto plates) and Nabet soup (boiled germinated beans) (Jambunathan et al., 1994).

Feeding value of broad bean is high, and is considered in some areas to be superior to field peas or other legumes. Broad bean has been considered as a meat extender or substitute and as a skim-milk substitute. Sometimes grown for green manure, but more generally for stock feed. Large-seeded cultivars are used as vegetable. Roasted seeds are eaten like peanuts in India" (Duke, 1981). Straw from broad bean harvest fetches a premium in Egypt and Sudan and is considered as a cash crop (Bond et al., 1985). The straw can also be used for brick making and as a fuel in parts of Sudan and Ethiopia.

As other legumes, *Vicia faba* also characterized by its symbiotic fixation of atmospheric N_2; it is therefore contributing to preserve the soil fertility and to reduce energy inputs during the crop cycle.

1.1.1.4 Environmental requirements

Broad bean requires a cool season for best development. It is grown as a winter annual in warm temperate and subtropical areas; hardier cultivars in the Mediterranean region tolerate winter temperatures of -10°C without serious injury whereas the hardiest European cultivars can tolerate up to -15°C (Robertson et al., 1996). Also, it tolerates nearly any soil type; grows best on rich loams. In addition, it is more tolerant to acid soil conditions than most legumes.

Broad beans are considered to be the least drought resistant of legume crops; however, many cultivars with high water use efficiency have been developed at ICARDA (Robertson et al., 1996). The maturity period ranges from 90-220 days depending upon the cultivars and climatic conditions (Bond et al., 1985).

1.1.2 Chickpea, *Cicer arietinum*,

1.1.2.1 Origin and distribution of chickpea

Chickpea (*Cicer arietinum* L.*)* is an ancient crop usually grown for their seeds which are nutritionally of a very high quality (Saxena, 1990). Mesopotamian records from 3000 B.C. indicate that chickpea was a common food in the Middle East (van der Maesen, 1987). Archaeological evidence, although rare, even dates the cultivation of chickpea back to about 6500 B.C in the regions of current Syria, Palestine and Turkey (Ladizinsky, 1995).

Chickpea is produced worldwide and it is the world's third most important food legume next to haricot bean and soybean (Namvar and Sharifi 2011). Presently, the most important chickpea producing countries are India (63%), Pakistan (9%), Turkey (6%), Iran (4%), Mexico (3%), Myanmar (3%), Ethiopia (2%), Australia (2%), and Canada (1%). Chickpea, India's most important food legume is currently grown in about 6.7 m ha in India and 11.67 m ha worldwide (FAOSTAT, 2008).

In the Middle Eastern countries, chickpea is one of the staple foods and the main chickpea production comes from Syria and Turkey (Singh et al., 1990). Chickpea is grown in tropical, sub-tropical and temperate regions.

1.1.2.2 Botanical classification

The chick-peas (*Cicer arietinum L.*), belongs to the fabaceae family, is an annual self-pollinated crop, diploid (2n=16), autogamous with complete pollination before opening (Maiti and Wesche-Ebeling, 2001; Biçer and Sakar, 2010). However, cross-pollination is rare; only 0-1 % is reported (Smithson et al., 1985).

The genus *Cicer* includes a total of 43 species which involves 9 annual species containing cultured chickpea, 33 perennial species and one unclassified species (Sethy et al. 2006).

Based on seed size and color, cultivated chickpeas which are the most common are of two types:

(1) Macrosperma (Kabuli type): The seeds of this type are large (100-seed mass >25 g), round or ram head, and cream-colored. The plant is medium to tall in height, with large leaflets and white flowers, and contains no anthocyanin.

(2)Microsperma (desi type). The seeds of this type are small and angular in shape. The seed color varies from cream, black, brown, yellow to green. There are 2-3 ovules pod-1 but on an average 1-2 seeds pod-1 are produced. The plants are short with small leaflets and purplish flowers, and contain anthocyanin (Cubero, 1975).

Chickpea is an herbaceous annual and the plant height generally ranges from 30-70 cm. It has tap root system, which is usually deep and strong. The lateral roots develop nodules with the symbiotic Rhizobium bacteria, capable of fixing atmospheric nitrogen in plant-usable form. The nodules (slightly flattened, fan-like lobes) are visible about one month after plant emergence, and generally confined to the top 15 cm of the surface. The leaves are impair-pinnate with serrated leaflets and arise alternatively from the third node. The number of leaflets varies from 5 to 17. Some varieties have simple leaves. The entire surface of the plant shoot, except the corolla, is densely covered with fine hairs known as trachoma's. Many are glandular and secrete a highly acidic substance containing malic, oxalic and citric acids. These acids play an important role in protecting the plant against insect-pests. The plants have primary (generally 1-8), secondary and tertiary branches. Five growth habits, based on angle of branches from the vertical, are classified: erect, semi-erect, semi-spreading, spreading and prostrate. The erect and semi-erect varieties enable mechanical harvesting (Gaur et al., 2010).

1.1.2.3 Economical importance of chickpea

Chickpea is a main nutritive legume crop of rural and urban household of the poor in the developing world (Sharma et al., 2003), particularly in South Asia, who are largely vegetarian either by choice or because of economic reasons. Chickpea rich in proteins, vitamins and minerals (El-Adawy, 2002), being considered the best source of proteins among legume crops around the world (Ferreira et al., 2006).

Chickpea seeds are eaten fresh as green vegetables, parched, fried, roasted, and boiled; as snack food, sweet and condiments; seeds are ground and the flour can be used as soup, dhal, and to make bread; prepared with pepper, salt and lemon it is served as a side dish (Saxena, 1990). A small proportion of canned chickpea is also used, and to produce fermented food. Animal feed is another use of chickpea in many developing countries.

India and Pakistan, chickpeas are consumed locally, and about 56% of the crop is retained by growers (Duke, 1981). In United States and Europe, chickpeas are marketed dried, canned, or in various vegetable mixtures. In Europe, mashed chickpeas from the Mediterranean are sold canned. Mashed chickpea mixed with oils and spices (hummus) is a popular food in the Mediterranean Middle East (Duke, 1981).

1.1.2.4. Environmental requirements

Usually it is grown as a rain-fed cool-weather crop or as a dry climate crop in semi-arid regions. However, optimum conditions include 18-26°C and annual rainfall more than 600 mm (Duke, 1981; Muehlbauer et al., 1982; Smithson et al., 1985).

Generally, it is grown on heavy black or red soils with favorable pH of about 5.5-8.6. Frost, hailstones, and excessive rains damage the crop. Though sensitive to cold, some cultivars can tolerate temperatures as low as -9.5°C in early stages or under snow cover. Daily temperature fluctuations are desired with cold nights with dewfall. In virgin sandy soils or for the first planting in heavier soils, inoculation is said to increase yield by 10-62%" (Duke, 1981). Although spoken of as "day-neutral," chickpea is a quantitative long-day plant, but it gives flowers in every photoperiod (Smithson et al., 1985).

1.1.3 Lentils, *Lens culinaris*

1.1.3.1 Origin and distribution Lentils

Lentil is one of the early domesticated plant species, as old as those of wheat, barley and pea (Harlan, 1992). Lentils probably originated in the Near East and rapidly spread to Egypt, central and southern Europe, the Mediterranean basin, Ethiopia, Afghanistan, India and Pakistan, China and later to the New World including Latin America (Ladizinsky, 1979; Cubero, 1981; Duke, 1981).

The important lentil-growing countries of the world are India, Canada, Turkey, Bangladesh, Iran, China, Nepal and Syria (Ahlawat, 2012). The total cultivated area in the world as around 4.6 million hectares producing 4.2 million tons of seeds with an average production of 1095 kg/ha (FAO, 2010). World production of lentil increased by about 65% over the past 25 years (FAO, 1996). In developing countries alone, lentil production and yield rose by 60% (Hulse, 1990). Major production increases have been recorded in Turkey and Canada.

1.1.3.2 Botanical classification

Lentils is a diployed species (2n = 14). The size of lentil seeds increase from the types grown in eastern regions to western types. Two types, namely; macrosperma, found mainly in the Mediterranean region and the New World (seed size ranging from 6 to 9 mm in diameter and yellow cotyledons with little or no pigmentation), and microsperma (2 to 6 mm with red orange or yellow cotyledons) found on the Indian subcontinent, Near East and East Africa, respectively, are known (Hawtin et al., 1980; Muehlbauer et al., 1985). The first one includes the Chilean or yellow cotyledon types while the latter includes the small seeded Persian or red cotyledon lentils (Kay, 1979).

The botanical features of cultivated lentil can be described as annual bushy herb, slender almost erect or sub-erect, much-branched, softly hairy; stems slender, angular, 15-75 cm height (Duke, 1981; Muehlbauer et al., 1985). Ten to sixteen leaflets are subtended on the rachis (40-50 mm); upper leaves have simple tendrils while lower leaves are mucronate (Muehlbauer et al., 1985). "The leaves are alternate, compound, pinnate, usually ending in a tendril or bristly; leaflets 4-7 pairs, alternate or opposite; oval, sessile, 1-2 cm long; stipules small, entire; stipules absent; pods oblong, flattened or compressed, smooth, to 1.3 cm long, 1-2-seeded; seed biconvex, rounded, small, 4-8 mm × 2.2-3 mm, lens-shaped, green, greenish-brown or light red speckled with black; the weight of 100 seeds range from 2 to 8 g; cotyledons red, orange, yellow, or green, bleaching to yellow, often showing through the testa, influencing its apparent color" (Duke,1981; Kay, 1979; Muehlbauer et al., 1995). Flowers are small, pale blue, purple, white or pink, in axillary 1-4-flowered racemes; 1-4 flowers are borne on a single peduncle and a single plant can produce up to 10-150 peduncles each being 2.5-5 cm long (Muehlbauer et al., 1985).

1.1.3.3 Economical importance of lentils

Lentil is a nutritious food legume. The primary product is the seed which has relatively higher contents of protein, carbohydrate and calories compared to other legumes. Lentils are considered the most desired crops, because of its high average protein content and fast cooking characteristic in many lentil producing regions (Muehlbauer et al., 1985). It can be used as a main dish, side dish, or in salads. Seeds can be fried and seasoned for consumption; flour is used to make soups, stews, purees, and mixed with cereals to make bread and cakes; and as a food for infants (Williams and Singh, 1988). Lentil is an important dietary source of energy, fiber, minerals, vitamins and antioxidant compounds, as well as diverse non-nutritional components like protease inhibitors, tannins, α-galactoside, oligosaccharides and phytic acid (Urbano, G., et al. 2007).

1.1.3.4 Environmental requirements

Lentil is best adapted to the cooler temperate zones of the world and is predominantly grown in areas with an annual average rainfall of 300 to 400 mm (Sarker et al 2003); therefore, it is considered a drought-tolerant crop that tolerates also lower this range. It can grow on a wide range of soil types, however, it is sensitive to water-logging, flooding and soils with a pH below 6.5 (Tang and Thomson 1996).

Lentil is highly sensitive to salinity and suffers from salinity stress. Salt tolerance may be gradually regulated by crops. And the responses to salt stress may be quite diverse at deferent stages of plant development (Munns, 2002; Khan and Ungar, 2001; Johnson et al., 1991).

1.1.4 Common vetch, “Bekia ”*Vicia sativa*.

1.1.4.1 Origin and distribution of common vetch.

Common vetch is originated from southern Europe and is now widespread throughout the Mediterranean basin, western Asia and in countries of the former Soviet Union (Martiniello and Ciola, 1995; Dhima et al., 2007; Yolcu et al., 2010). The major vetch-growing areas are concentrated mainly in Turkey, Syria, Ethiopia, Morocco, Spain and Algeria and to a lesser extent in Iraq, Jordan, Cyprus, Lebanon, and Tunisia (Robertson et al., 1996).

1.1.4.2 Botanical classification of common vetch

Common vetch (*Vicia sativa* L.), diploid crop (2n=12) is an annual scrambling and climbing legume. It has a slender highly branched taproot that can go down to 1-1.5 m deep. Its stems are thin, angled, and procumbent and branched, reaching up to 2 m. The leaves are compound with 3-8 pairs of opposite leaflets and 2-3 terminal tendrils that help climbing. The leaflets are elliptic or oblong, 1.5-3.5 cm long, 5-15 mm wide. Stems and leaves are mainly glabrous. The flowers, borne on leaf axils, are blue to purple, sometimes white, mostly paired, sometimes unique. Pods are cylindrical, 3.5-8 cm long, erect with 4-12 round but flattened black to brownish seeds (Sattell et al., 1998; UC SAREP, 2006; FAO, 2010).

1.1.4.3 Economical importance of common vetch

Generally, mixtures of certain annual legumes (including common vetch), with winter cereals are used extensively for forage production especially in the Mediterranean region (Anil et al., 1998; Qamaret al., 1999; Papastylianou, 2004). However, common vetch is low-yielding crop, particularly in areas with low rainfall (Hadjichristodoulou, 1978) and hinders harvest because it normally lays on the soil surface (Robinson, 1969).

1.1.4.4 Environmental requirements

Common vetch is found in areas with annual rainfall ranging from 310 mm to 1630 mm and on a large variety of soils with a preference for well-drained, moderately fertile soils with soil pH ranging from 6.0 to 7.0. It is not drought-tolerant crop especially during the early stages of establishment (UC SAREP, 2006; FAO, 2010). It can withstand short water-logging periods but no extended flooding periods (Sattell et al., 1998). Regarding cold, common vetch is a moderately tolerant of cold and can grow in areas with mild winters.

1.1.5 Bitter vetch, "Kersana "*Vicia ervilia*

1.1.5.1 Origin and distribution of bitter vetch

Bitter vetch is an ancient grain legume crop of the Mediterranean region cultivated since Neolithic times (Zohary and Hopf, 2000). It is widely distributed throughout the southern half of Europe, Western and Central Asia, and North Africa (Grain, 2008).

Besides the English name, other common names include: Gavdaneh (Persian), yero (Spanish), Rovi (Greek), burcak (Turkish), and kersana (Arabic).

1.1.5.2 Botanical classification

Bitter vetch is an annual herb diploid (2n=2x=14), self-pollinated pulse with beaded pods and angular seeds. The stem erect or ascending, branched, 20-50 cm high. Stipules almost arrow-shaped, dentate. Leaves pinnate (8-12 pairs of leaflets). Leaflets lance-oblong, dense covered by oppressed hairs, notched at the top. Common flower stalks shorter than leaves bearing 2-4 florets and is ended by the spike. Calyx toothed awl-shaped and are longer than the tube. Corolla pinkish or pale blue. Pods hanging down, elongated, 3-4-seeded, constricted between seeds. Mature pods are stramineous. Seed brown or with black picture on the surface, angular or globe-shaped, 5-6mm in diameter, glabrous.

1.1.5.3 Economical importance of Bitter vetch

Bitter vetch is considered as a good source of nutrients and as an alternative feed ingredient for use in poultry diet. Usually, it is grown and harvested for the utilization of its seeds and hay (Abdullah et al., 1999; Sadeghi et al., 2009).Seeds is potentially valuable feed for ruminants as a source of energy and protein (Yalçin et al., 2003; Farran et al., 2005; Sadeghi and Pourreza, 2007). The crop has considerable capacity of nitrogen fixation, and ability to grow in poor soils (LopezeBellido, 1994).

1.1.5.4 Environmental requirements

Bitter vetch is grown in areas with an annual average rainfall higher than 300 mm (Ababneh, 1994) . Some varieties could tolerate lower this range and therefore might consider as drought-resistant varieties. It can grow on a wide range of soil types.

1.2. Growth performances of legume

1.2.1 Morphological and yield characteristics of broad bean *Vicia faba*

1.2.1.1 Stem length

Broad bean is a plant with upright stems, un-branched, with 1 or more hollow stems from the base (Duke, 1981; Bond et al., 1985; Heath, et al., 1994). Stem length ranged between 0.3-2 m tall, however, some true dwarfs and semi-dwarf varieties are also available (Bond, et al., 1985). Plant height depends on plant genotype as well as the environment. In addition, seed sizes could also affect plant height in which plants grown from large seeds are taller than those originated from small seeds (Al-Refaee, et al., 2004).

1.2.1.2 Flowering and fruit set

Broad bean is a self-pollinated crop with significant levels of cross-pollination that vary greatly among cultivars (Suso et al., 1996). The rate of out crossing ranged from 4-89% depending on the used genotype, environmental factors, row space and number of pollinating insects especially honeybees (Rashid and Bernier, 1994). Flowering as well as fruit set of broad bean are determined by many environmental factors such as relative humidity, light and photoperiod, and temperature.

1.2.1.3 Maturation and harvesting period

Depending on the genotype as well as different biotic and a biotic factors, broad beans mature 90-220 days after planting (Bond et al., 1985).

1.2.1.4 Total yield (kg/dunum)

Yield of broad bean is generally determined by many factors. In addition to the genotype effects, water availability is considered as the most significant once and broad bean is reputed to be more sensitive to water deficits than some other grain legumes (McDonald and Paulsen, 1997; Amede and Schubert, 2003). In fact, drought is an important factor especially in countries where crop agriculture is essentially rain-fed (Boyer, 1982; Ludlow and Muchow, 1990). (Kumar and Abbo, 2001) sated that drought-stressed plants exhibit poor growth and low yield.

Several studies were concentrated about the impact of each yield component on the yield such as plant density (Mathews et al., 2008), and sowing date (Kurmawanshi et al., 1994, Sahile et al., 2008). Significant positive correlations between yield and seed number/pod were also reported by(Magyarosi and Sjodin, 1976) who suggested that seed number/pod had a direct effect on yield in broad bean.

1.2.2 Morphological and yield characteristics of chickpea, *Cicer arietinum*

1.2.2.1 Stem length

Chickpea is an herbaceous annual shrub exhibiting morphological variation in most of its traits (Ladizinsky and Alder, 1976). It may be erect or spreading (Purseglove, 1968), un-branched or highly branched (van der Maesen, 1972) and rarely growing taller than 60 cm (Kay, 1979) appearing glandular pubescent, dark or bluish green in color.

1.2.2.2 Flowering and fruit set

Chickpea flowers are solitary, the calyx united and the corolla white, pink or blue (Duke, 1981). The anthers are uniform in size and versatile or alternately versatile (Kupicha, 1981). Flowers are mainly self-pollinated (Nene and Kanwar, 1988) but occasional natural cross-pollination occurs

(Smithson et al., 1985). Pods contain 1 to 2 seeds and the seed coat may be smooth, rogues or granulate (Ladizinsky and Alder, 1976).

Reduced pollen viability is common in legumes during pre-anthesis. 80–90% pollen germination occurs in the range 7–250C. During germination pollen hydration is inhibited by low temperature (Clarke and Siddique , 2004). Additionally, exposing the crops to low temperatures at flowering stage leads to inhibition of pod sets (Lawlor et al., 1998; Srinivasanet al., 1999). High temperatures during seed filling also limit yields (Buddenhagen and Richards, 1988).

1.2.2.3 Maturation and harvesting period

Chickpea can mature in a wide timeframe ranging from 80 to 180 days depending on the genotype, growing conditions and environments .Plants are physiologically mature when the leaves have dropped and the pods turn a tan or cream color. Seed color, which is the most important criteria for proper harvest timing and management, should have turned from green to tan. Due to the indeterminate plant growth of chickpea, differences in pod size and maturity will occur at harvest. Although chickpea pods resist shattering, delaying harvest beyond maturity can result in-broken pod stems and dropped pods. (Margheim et al., 2004).

1.2.2.4 Total yield (kg/dunum)

Several factors effect on the production of chickpeas including soil fertility, shortage of water, diseases, temperature stress during reproductive stage, excessive moisture, ineffectiveness of Rhizobium species and severe drought stress at initial stages of growth (Singh et al., 1998; Yamaguchi and Blumwald, 2005; Toker et al., 2007; Canci and Toker, 2009). Sabaghpour et al. (2006) reported that exposure of chickpea to drought could lead to 35 to 50% of yield losses.

Arshad et al., (2002) found that plant height, number of pods per plant and biological yield were major components contributing to seed yield. In addition, grain yield per plant displayed positive correlations with days to maturity, primary branches, secondary branches, pods per plant and 100 seed weight. Generally, chickpea seed yield varies from one site to another and from one season to the next but in the traditional chickpea growing areas, it averages about 700 kg/ha (Summerfield et al., 1980; Nene, 1987).

1.2.3 Morphological and yield characteristics of lentil, *Lens culinaris*

1.2.3.1 Stem length

Lentil is an indeterminate and branched self-pollinated crop that grows 15 to 75 cm in height (Muehlbauer et al 1985, Erskine and Goodrich, 1991), depending on many biotic and a biotic factors.

1.2.3.2 Flowering and fruit set

Lentil flowers are naturally self-pollinated; however, cross pollination is estimated to occur less than 0.8 % (Wilson and Law, 1972).Flower stalks produce only one to three flowers, which develops pods. Pods are less than 2.5 cm in length and usually contain one or two seeds.

1.2.3.3 Maturation and harvesting period

Lentil maturity is affected mainly by temperature, rainfall and sowing date and ranges from 75 to 180 days (Saxena, 2009).

1.2.3.4 Total yield (kg/dunum)

Several factors affect lentil seed yield including local climate, soil conditions and genetic features. It is reported that lentil seed yield ranged from 1057-2880 kg per ha (Sharaan et al., 2003; Turan, 2003; Colkesen et al., 2005; Bicer and Sakar, 2010). However, the average value of the world lentil seed yield is 1095 kg per ha (FAO, 2010).Although longer days to maturity may increase biomass and yield, it may reduce harvest index, delay maturity and leave the crop susceptible to frost damage (Thomson et al., 1997).

The effect of sowing date on seed yield depends mainly on location. In temperate countries with mild winters autumn sowings can produce high yields. (McKenzie et a1., 1985), however, late sowing found to decrease yield and increase protein content (Sehirali, 1988). The effect of water availability on seed yield of lentils is extremely variable, in which large seed yield increases with water availability (Shatma and Prasad, 1984).

Comparing with other legume crops, lentil is a well-adapted plant that grows in a wide range of soil types. However, the heavy textured soils causes yield reduction, whereas sandy-loam soils are the most suitable for lentil growth (Sehirali 1988; Ozdemir 2002).

Evaluation of quantitative traits in the lentil genotypes showed that there is positive correlation between plant height, number of seeds per pod and primary branches with seed yield (Zaid et al, 2003; Aich et al, 2007).

1.2.4 Morphological and yield characteristics of common vetch "bekia", *Vicia sativa*

1.2.4.1 Stem length

Common Vetch Annual, moderate stem strength and grows as small bushes. 40-80 cm high, with multiple lateral branches from near the base .Large climbing semi-prostrate with 9-16 internodes with multiple green to dark green leaves. Main stem length in common vetch varied from 58.0 to 133.7 cm depending on ecological conditions and applications (Ýlmaz and Can, 1998).

1.2.4.2 Flowering and fruit set

The common vetch flower, like that of most legumes, has the sexual column enclosed in the keel petal. If the column remains closed, only self-pollination can result (if the style and pollen are compatible). If the column is freed, or tripped, and the stigma comes into contact with the pollen from other flowers, cross-pollination can occur. Some species benefit by tripping even if cross-pollination does not occur. Repeated visitation to the flower by pollinating insects also increases productiveness in some species. The flower must be tripped if bees are to collect pollen from it. (http://forages.oregonstate.edu). Flowers: single or pair, medium (10-35mm); cooler-violet/purple or white. Pods: length-medium to long (40-70mm); with 6-8 seeds. The peas like flowers occur in the leaf axils, solitary or in clusters of up to three. The flower corolla is 1 to 3 centimeters in length and whitish to bluish to red or bright pink-purple in color.

1.2.4.3 Maturation and harvesting period

Maturity period in common vetch varied from 209 to 228 days depending on ecological conditions and cultivars used (Albayrak and Tngel, 2003).The fruit is a legume pod up to 6 or 7 centimeters long which is hairy when new and smooth later. It contains up to 12 seeds.

1.2.4.4 Total yield (kg/dunum)

Earlier studies showed that autumn snow vetches had more yield potential than spring vetch (Fırıncıoglu et al, 1997) .However, winter killing is a major problem, and for example, cold tolerance is a central requirement for establishing cool season annual forage legumes in the medium to high elevation areas in West Asia and North Africa (Abd El Moneim and Cocks, 1993).

Common vetch seed has many valuable characteristics, such as high yield, resistance to drought, good adaptation to semiarid regions (Abd El Moneimand Cocks, 1993). However, plant growth is seriously affected by the amount and distribution of rainfall (Acıkgoz, 1988). Common vetch pods account for a high proportion of the total plant biomass (Caballero et al., 1996).

Seed yields found in other studies varied between 0.91 and and 2.79 t ha-1 in common vetch (Tekeli and Ateb, 2002; Karadau, 2004; Orak and Nizam, 2004). Environmental conditions type and level of inoculation and the cultivars used in the trials could be the possible cause of the variation in seed yields reported in the literature and in the present study

1.2.5 Morphological and yield characteristics of bitter vetch "kersana", *Vicia ervilia*

1.2.5.1 Stem length

Stem length of vetch cool season annual legume ranged from 2 to 4 feet long depending on climate and genetic factors. Leaves are composed of 10 to 20 narrow leaflets and are terminated by branched tendrils.

1.2.5.2 Flowering and fruit set

Flowering and fruit set of bitter vetch is so similar to that of common vetch (single or pair flowers, medium size; cooler-violet/purple or white; pods length are medium to long with 6-8 seeds). Self-pollination is dominant also cross-pollination can also occur. In addition, pollinating insects found to increase productiveness in some species.

1.2.5.3 Maturation and harvesting period

Depending on the environmental conditions and the cultivars used, maturity period in bitter vetch varied from 200 to 230 days.

1.2 5.4 Total yield (kg/dunum)

Bitter vetch used for hay production, grazing, or grain and straw production whether grown in monoculture (Droushiotes, 1985) or in mixture with cereals (Osman and Nersoyan, 1986).

Vicia ervilia is a very interesting species with adaptive capacities, especially tolerance to aridity and can be cultivated with poor rainfall (Foury, 1954; Maxted, 1995; Abd El-Moneim and Saxena, 1997).In 350-400 mm average rainfall, yields of only about 2 t/ha are achievable. However with higher average rainfall, more than 3 t/ha grain yield could also be achieved (Enneking and Francis, 2007).

1.8.2 Chemical compositions of legume

Legumes are a major food and feed grain crops in many developing countries owing high nutritional value of its seeds, which are rich in low cost protein and carbohydrate.

Significant genetic variations in chemical composition (e.g. protein) of legume seeds have been reported (Al-Karaki and Ereifej, 1997; Ereifej et. al., 2001). For example, protein contents extended to 27-34% in broad bean(Link et al., 1995; Duc, 1997), 17-24% in check-peas (Ozdemir, 2002), 22-34.6% in lentil (Barulina, 1980), 16.5–26.5% in common vetch (Panayiotou and Economides, 2001), and 21-28.5% in bitter vetch (LópezBellido, 1994; Farran et al., 2001) respectively.

Environmental conditions including soil and climate also determine and utilize significant influences on chemical composition of legumes (Al-Karaki and Ereifej, 1997; Shad et. al., 2009).

Concerning minerals, legumes considered as a good source of dietary minerals, such as phosphorus, potassium, magnesium, calcium, sulphur and iron reported that the environmental conditions

When spring and winter broad beans were compared, winter beans were found to have slightly higher concentration of protein (Duc et al., 1999), indicating that under water deficit condition, protein content of broad beans tends to increase.

Chapter Two

Materials and Methods

2.1 Experimental sites

Three study sites (1.628 dunum / site) were chosen (Table 2.1) for our study as the following:

- Dora site
- Al-Arroub site
- Janata site

Table2.1. Study sites descriptions.

	Study Sites		
	Dora Site	**Al-Arroub Agricultural Experimental Station Site**	**Janata-Bethlehem Site**
Location	14 km south of Hebron city between Dora and Al-dahria cities	9 km north of Hebron city	8 km south-east of Bethlehem city
Elevation	660 m	842 m	629 m
Latitude	31”44	31”63	31“67
Longitude	34”98	35”13	35”24
Topography	Mountainous	Valley	Hilly with moderate to steep slope
Rainfall (2010/2011)	350 mm	461.8 mm	260 mm
Average rainfall	380 mm	632.8mm	310 mm

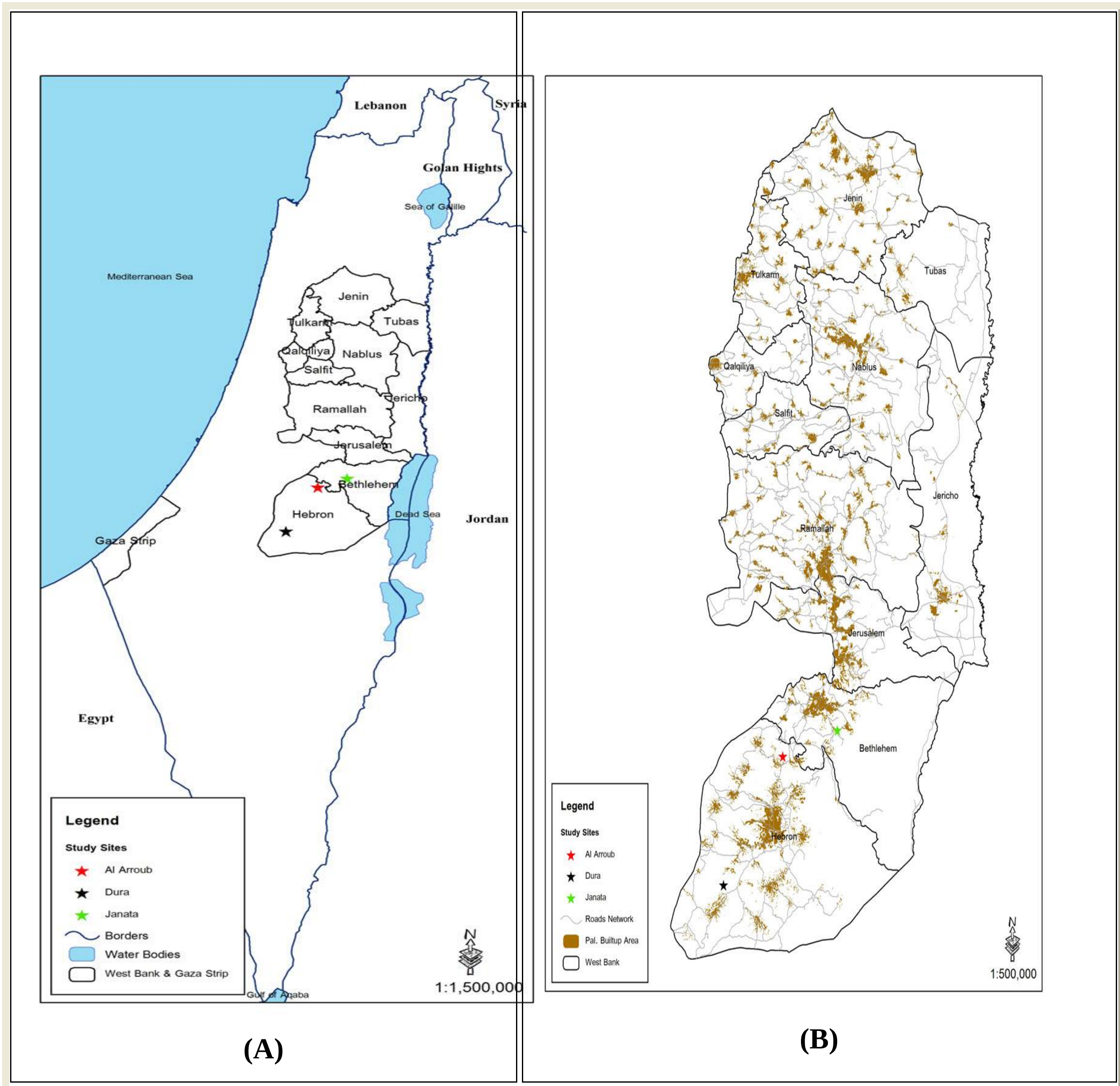

Figure2. 1. Maps of Palestine showing the three experimental sites; A. map of historical Palestine, and B. map of West-Bank.

2.2 Land preparation

For each site, 4 cubic meter of cow-well-fermented manure were added and then, lands were plowed and well prepared for plantation.

2.3 Soil analysis

Soil samples from the three study sites were collected using soil auger and analyzed at the laboratory of soil science, faculty of agriculture, Hebron University. The following nutrients and parameters were conducted: Ca, Mg, Fe, Zn, Cu, Mn, P, B, Na, total nitrogen, crude protein, moisture, dry matter and ash (Table 2.2).

Table 2.2 Soil analysis of the three experimented sites.

#	Conducted parameters	Method
1	Moisture	Oven
2	Dry matter	Oven
3	Ash	Muffle furnace
4	Total Nitrogen	Kjeldahl Nitrogen.
5	Crude Protein	by multiplying the nitrogen concentration by 6.25 (NX 6.25),
6	Calcium(Ca), Magnesium(Mg), Iron(Fe), Zink(Zn), copper (Cu), Manganese (Mn)	Atomic Absorption
7	Potassium (K), Sodium (Na),	Flame photometer
8	Phosphorus (P), Boron(B)	Spectrophotometer

2.4 Experimental design

Completely randomized design was used in our experiment with five local legume crops including: (1) broad bean, *Vicia faba*, (2) check pea, *Cicerarietinum*, (3) lentil, *Lens culinaris*,(4) common vetch, *Vicia sativa*, and (5) bitter vetch, V*icia ervilia*, with five replications using a net plot size of 20 m^2 area (4m*5m) / replicate. To isolate the plots as well as to facilitate the follow-up process (cultural practices, registration, etc), one meter corridors around all the plots were used (Figure 2.2).

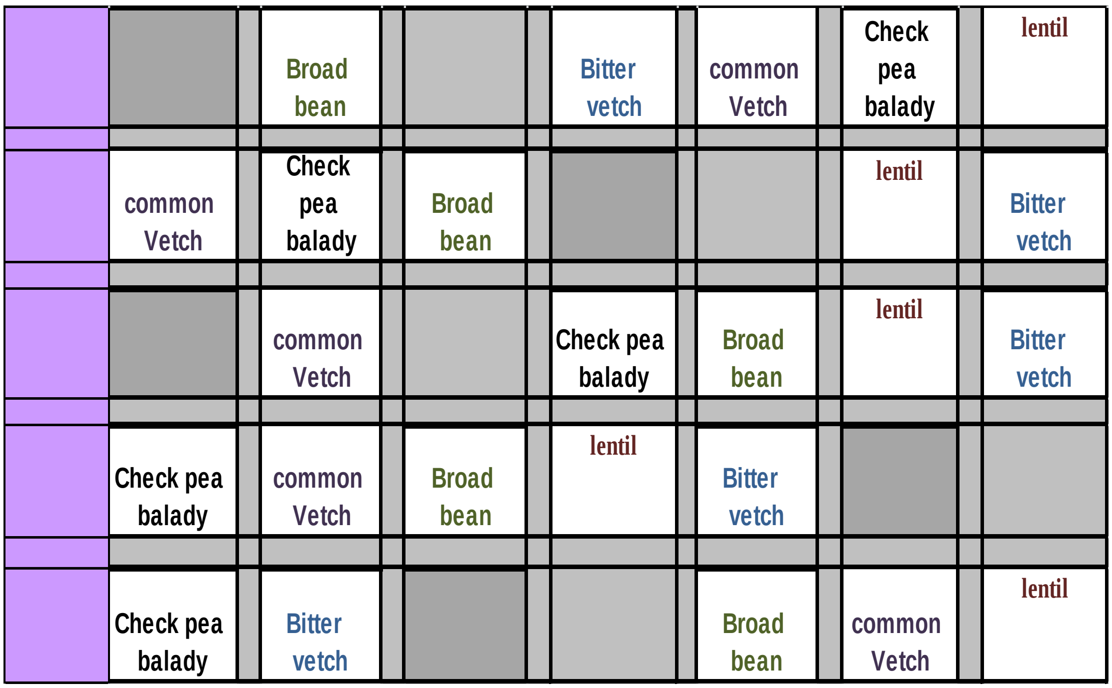

Figure 2.2. Completely randomized design of five legume crops with five replicates.

Figure 2.3. Photo representing the examined five legumes crops planted at Al-Arroub site.

2.5 Sowing

For lentil, Common vetch, and Bitter vetch crops, adoption rate of 300 gram seeds / plot (equivalent to 15 kg/dunum) were used. In addition, 200 gram seeds / plot (equivalent to 10 kg/dunum) were used for Broad bean and Chickpea crops. All crops were sowing manually on November 15th, 2010 in the three examined sites.

2.6 Cultural practices

All of the necessary cultural practices such as weed control, two times spraying for aphids, etc, were conducted throughout the growing season.

2.7 Measured parameters

2.7.1 Morphological and yield parameters

2.7.1.1 Germination date

When 50% of the total germination occurred.

2.7.1.2 Flowering period

The period lasts from the beginning of flowering until all plants were flowered.

2.7.1.3 Fruit set period

The period lasts from the beginning of fruit set until all the fruit set of all plants were done.

2.7.1.3 Maturation and harvesting date

When 50% of the maturation occurred (plants considered mature when the moisture contents of the seeds reaches 15%).

2.7.1.4 Stem length

Twelve legumes plants / crop were randomly selected from each plot throughout the three sites. Each plant was measured with a scale from the stem base up-to the stem apex. Stem length at harvesting was recorded in centimeter.

2.7.1.5 No. of branching

Counted also based on twelve plants / crop.

2.7.1.6 No. of grain / pod

Counted also based on twelve pods / plot. Each pod was threshed separately and grains of each pod was counted and averaged.

2.7.1.7 Weight of 100 grains

For each plot, three samples of 100 grains were randomly chosen and weighed by electronic balance of three digits.

2.7. 2 Yield parameters

2.7.2.1 Fresh weight (kg/dunum)

Plants of each plot were harvested manually, then dried (sub-dried) for a week. Continually, total yield was recorded in kilo-gram (kg) using electronic balance and subsequently converted into dunum (1000 m^2).

2.7.2.2 Grain production (kg/dunum)

Each crop was sun dried and then threshed separately. The grain weight of each plot were recorded in kg and subsequently converted into dunum (1000m^2).

2.7.2.3 Hay production (kg/dunum)

Hay yield of each plot was calculated by subtracting the grain yield from the total yield and then converted into dunum (1000 m^2).

2.7.3 Chemical composition

Seed samples from the five examined crops were collected from the three sites. Seeds were grounded in a Wiley mill and then stored in sealed jars for chemical analysis (AOAC, 1990). Representative samples from the replicates were prepared for the following analysis

2.7.3.1 Dry matter (%)

Dry matter was determined using an oven at 65°C for 24 hours (Ryan et al., 2001).

2.7.3.2. Crude protein

Crude protein (CP) was determined by estimating nitrogen (N) content using Kjeldahl procedure. Percentage of CP obtained by multiplying the nitrogen concentration by 6.25 (NX 6.25), (Peter and Young, 1980; AOAC, 1990)

2.7.3.3. Ash content

According to AOAC (1984), ash content was determined using igniting in muffle furnace at 550C^{o} for 8h.

2.8 Data analysis

The data were statistically analyzed using the one-way analysis of variance (ANOVA) and means were separated using the Tukey's pairwise comparisons at a significance level of $p \leq 0.05$ using the MINITAB package system.

Chapter Three

Results

3.1. Broad bean (*Vicia faba*)

3.1.1. Morphological parameters

Earlier germination was firstly exhibited at Janata site almost after two weeks, followed by Dora (16 days) and Al-arroub (21 days) sites, (Table 3.1).

Flowering takes 5 days at Janta site followed by Dora site 7 days; however, it lasts for 8 days at Al-arroub site. Accordingly, fruit set period lasts 9 days at Janata, 10 days at Dora, and 12 days at Al-aroub site. Similar trends goes also with maturation and consequently harvesting date, in which earlier maturation reveled (27 days from fruit set period) at Janata and 29 days at Dora sites; however, maturation stage lasts for longer period at Al-aroub site with almost 46 days.

Significant variation in stem length variable among the three different sites was observed (Table 3.1), in which Al-arroub site revealed significantly higher stem length followed by Dora and Janata sites respectively.

In reference to crop branching, Al-arroub and Dora sites revealed higher branching than Janata site but not significant .(Table 3.1).

Number of grain per pod presented higher values at Al-arroub site and lower at Janata site (Table 3.1).

Significant variations in the weight of 100 seeds of broad bean at the three different sites were also exhibited (Table 3.1). Al-arroub site revealed significantly higherseed weight (77gram), followed by Dora (49,2gram) and Janata (44, 5 gram) sites respectively.

Table 3.1. Morphological parameters of broad bean (*Vicia faba*) cultivated at three different sites.

Morphological Parameters	Sites		
	Dora	**Al-aroub**	**Janata**
Germination date	16 days	21 days	14 days
Flowering period	7 days	8 days	5 days
Fruit set period	10 days	12 days	9 days
Maturation and harvesting period	29 days	46 days	27 days
Stem length (cm)	47.88b±0.610	64.04a±1.96	033.86c±2.75
No. of branching	03.62±0.665	03.64±00.658	03.30±0.694
No. of grain / pod	2.52ab±0.860	3.52a±0.280	2.04b±0.280
Weight of 100 seed (gram)	49.26 b ±0.662	77.00 a ±.077	44.50c ±0.195

* Means within rows using different letters are differ significantly at the *P value* ≤ 0.05 levels (using one way analysis).

3.1.2. Yield parameters

In general, broad bean at Al-arroub site showed the highest (416,2kg/dunum), fresh weight (grain and hay) among the three different sites. However, the lowest yield (130. 2 Kg/dunum), was presented at Janata site; meanwhile, Dora exhibited intermediate fresh weight (Table 3.2). Regarding the total grain production, Al-arroub site presented the highest grain production (129kg), followed significantly by Dora site (76kg), and Janata site with only 39 kilo-gram per dunum (Table 3.2). Similar trend goes also with the total hay production parameter.

Table 3.2. Yield parameters of broad bean (*Vicia faba*) cultivated at three different sites.

Yield parameters	**Site**		
	Dora	**Al-aroub**	**Janata**
Fresh weight (kg/dunum)	241.0b±37.4	416.2a±13.8	130.2c±23.7
Grain production (kg/dunum)	76.0ab±11.7	129.0a±2.69	39.1c±13.5
Hay production (kg/dunum)	165.0b±25.2	287.2a ±11.4	91.1c±22.1

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.1.3. Chemical composition

Among the three examined site, broad bean presented no significant differences for dry matter, protein content, and ash variables (Table 3.3). In addition, the obtained percentages of these variables were within the international averages (http://www.feedipedia.org).

Table 3.3. Chemical composition of broad bean seeds (*Vicia faba*) cultivated at three different sites.

Parameters	**Site**			**International percentage (feedipedia)**	
	Dora	**Al-aroub**	**Janata**	**MIN**	**MAX**
Dry matter %	90.15±0.328	90.44±0.345	90.36±0.589	83.4	89.6
Protein %	28.69±0.458	28.63±0.829	28.90±0.454	25.4	33.5
Ash %	03.86±0.338	04.07±0.240	03.77±0.391	3.3	4.6

* Means within rows using different letters are differ significantly at the *P value* ≤ *0.05* levels (using one way analysis).

3.2. Chickpea (*Cicer arietinum*)

3.2.1. Morphological parameters

Germination occurred after 16, 19, at Janataand Dora sites respectively, and 23 days Al-arroub, site. (Table 3.4).

Flowering continues almost for 5 days at Janta site, followed by 6 days at Al-arroub site; whereas, it takes 8 days at Dora site. Consequently, fruit set period lasts for 8 days at both Janata and Al-arroub sites; however, it takes longer period (11days), at Dora site. Maturation and consequently harvesting date was earlier at Janata as well as Dora sites by 16 and 17 days respectively. Conversely, late maturation was presented at Al-arroub site by 29 days (Table 3.4).

For the stem length variable, significant variation between the three different sites was observed (Table 3.4), in which Al-arroub site revealed significantly higher stem length followed by Dora and Janata sites, respectively. For crop branching, Al-arroub and Dora sites revealed higher branching than Janata site (Table 3.4).

Number of grain per pod presented higher values at Al-arroub site and lower at Janata site (Table 3.4).

Significant variations in the weight of 100 seeds of chickpea at three different sites were also exhibited (Table 3.4); in which Al-arroub site revealed significantly higher seed weight (39.4gram), followed by Dora (38.56 gram) and Janata (32.2 gram) sites.

Table 3.4. Morphological parameters of chickpea (*Cicer arietinum*) cultivated at three different sites.

Morphological Parameters	Site		
	Dora	**Al-aroub**	**Janata**
Germination date	19 days	23 days	16 days
Flowering period	8 days	6 days	5 days
Fruit set period	11 days	8 days	8 days
Maturation and harvesting period	17 days	29 days	16 days
Stem length (cm)	46.62ab±1.61	51.320a ±1.85	29.56b ±1.610
No. of branching	02.85 ±0.201	02.90 ±0.164	2.78±0.140
No. of grain / pod	01.60b±0.032	02.06a±0.140	1.40bc±0.0812
Weight of 100 seed (gram)	38.56ab±0.51	39.40a±0.510	32.26b±0.3540

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.2.2. Yield parameters

Among the three different examined sites, Al-aroub exhibited the highest yield (grain and hay) by 396.6 Kg/dunum. However, the lowest yield (189 Kg/dunum), was presented at Janata site; meanwhile, Dora exhibited intermediate fresh weight (Table 3.5). In reference to the total grain production parameter, Al-arroub site presented the highest grain production (123.3kg), followed significantly by Dora site (86.6kg), and Janata site with only 41.5 kilo gram per dunum (Table 3.5). Similar trend goes also with the total hay production parameter.

Table 3.5 Yield parameters of chickpea (*Cicer arietinum*) cultivated at three different sites.

Yield parameters	Site		
	Dora	Al-aroub	Janata
Fresh weight (kg/dunum)	312.0b±24.5	396.6a±25.2	189.0c±31.6
Grain production (kg/dunum)	86.6b±15.20	123.3a±17.0	41.5c±30.20
Hay production (kg/dunum)	225.4ab±24.5	237.3a±24.5	147.5bc±24.5

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis)

3.2.3. Chemical composition

Among the three examined site, no significant differences were found for dry matter, protein content, and ash variables of chickpea crop (Table 3.6). Based on the international percentage (http://www.feedipedia.org) protein content of chickpea was exceeding the maximum percentage among the three examined sites; whereas, dray matter and ash parameters were in the averages.

Table 3.6. Chemical composition of chickpea (*Cicer arietinum*) cultivated at three different sites.

Parameters	Site			International percentage (feedipedia)	
	Dora	Al-aroub	Janata	MIN	MAX
Dry matter %	90.25 ±1.00	89.71±0.751	89.69±01.34	87.6	90.8
Protein %	24.78 ±0.469	24.65±0.349	24.98 ±0.419	18.8	25.7
Ash %	3.48±0.140	3.60±0.0577	03.46±0.181	3.0	3.9

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.3. Lentil (*Lens culinaris*)

3.3.1. Morphological parameters

Germination takes 10-11 days at Janata and Dora sites; however, it takes longer time at Al-aroub site by 14 days, (Table 3.7). Flowering period was almost similar at the three evaluated sites which last from 6-7 days.

Fruit set period lasts 7 days at Janata site, 8 days at Dora site, and 11 days atAl-aroub site. Maturation and consequently harvesting date was earlier at Janata site (23 days), followed by Dora site (27 days); whereas, maturity stage at Al-arroub site took longer time comparing with the other two examined sites (Table 3.7).

Significant variation in stem length variable between the three different sites was observed (Table 3.7), in which Al-arroub site revealed significantly higher stem length followed by Dora and Janata sites, respectively.

In reference to crop branching, Al-arroub and Dora sites revealed higher branching than Janata site (Table 3.7).

Number of grain per pod showed similar at the three evaluated sites (Table 3.7).

Significant variations in the weight of 100 seeds of lentil at three different sites were also exhibited (Table 3.7). Al-arroub site revealed significantly higher seed weight (7 gram), followed by Dora (6 gram) and Janata (5.56 gram) sites respectively.

Table 3.7. Morphological parameters of lentil (*Lens culinaris*) cultivated at three differentiates sites

Morphological Parameters	Site		
	Dora	Al-aroub	Janata
Germination date	11 days	14 days	10 days
Flowering period	7 days	7 days	6 days
Fruit set period	8 days	11 days	7 days
Maturation and harvesting period	27 days	30 days	23 days
Stem length (cm)	29.56 b±0.961	38.3 a±0.676	27.98bc±1.69
No. of branching	04.98±0.157	05.01 ±0.166	04.78±0.134
No. of grain / pod	1.00 ±0.00	1.04±0.400	1.00±0.00
Weight of 100 seed (gram)	06.1b±0.105	7.0 a±0.095	5.56c±0.169

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.3.2. Yield parameters

Comparing with the other two sites, lentil crop at Al-arroub site exhibited the highest yield (grain and hay) by 471.2 kg/dunum; however, the lowest yield was presented at Janata site by 288 kg (Table 3.8).

Regarding the total grain production, Al-arroub site presented the highest grain production (43.7 kg), followed significantly by Dora site (18.3 kg), and Janata site with only 4 kilo gram per dunum (Table 3.8). Similar trend goes also with the total hay production parameter.

Table 3.8. Yield parameters of lentil (*Lens culinaris*) cultivated at three differentiates sites

Yield parameters	Site		
	Dora	Al-aroub	Janata
Fresh weight (kg/dunum)	439.5 bc±78.2	471.2a ±23.2	292ab±39.4
Grain production (kg/dunum)	18.3b±2.60	43.70a ±1.99	4.00c±2.45
Hay production (kg/dunum)	421.2ab±36.1	427.5a ±21.3	288b±39.4

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.3.3. Chemical composition

Dry matter, protein content, and ash variables of lentil crop presented similar results with those of broad bean and chickpea crops, in which the sites have no significant differences among these examined parameters (Table 3.9) (http://www.feedipedia.org).

Table 3.9 Chemical composition and quality parameters of lentil crop (*Lens culinaris*) cultivated at three differentiates sites.

Parameters	Site			International percentage (feedipedia)	
	Dora	Al-aroub	Janata	MIN	MAX
Dry matter %	90.47±0.604	89.97±0.873	89.70±0.205	87.1	91.0
Protein %	28.08±0.907	27.22±1.44	28.25±0.469	24.6	30.0
Ash %	5.10±0.359	6.18±0.195	6.42±335	2.7	6.8

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.4. Common vetch “bekia” (*Vvicia sativa*)

3.4.1. Morphological parameters

Common vetch presented almost similar germination period to lentil crop at the three examined sites (10, 11, and 14 days at Janata, Dora, and Al-arroub sites, respectively), (Table 3.10). Regarding flowering period, common vetch takes 6 to 7 days at the three sites. Accordingly, fruit set period lasts 6, 10, and 11 days at Janata, Dora, and Al-arroub sites respectively. Maturation and consequently harvesting date was earlier at Janata site with 16 days, 22 days at Dora, and 27 days at Al-arroub site (Table 3.10).

Significant variation in stem length variable between the three different sites was noticed (Table 3.10), in which Al-arroub site revealed significantly higher stem length followed by Dora and Janata sites, respectively.

In reference to crop branching, Dora site revealed higher branching than the other two sites (Table 3.10).

Number of grain per pod presented higher values at Al-arroub site and lower at Janata site (Table 3.10).

Significant variations in the weight of 100 seeds of broad beans at three different sites were also exhibited (Table 3.5). Al-arroub site revealed significantly higher seed weight (9 gram), than the other two sites.

Table 3.10. Morphological parameters of common vetch "bekia" (*Vicia sativa*) cultivated at three different sites.

Morphological Parameters	Site		
	Dora	**Al-aroub**	**Janata**
Germination date	11 days	14 days	10 day
Flowering period	7 days	7 days	6 days
Fruit set period	10 days	11 days	6 days
Maturation and harvesting period	22 days	27 days	16 days
Stem length (cm)	43.02ab ±1.86	47.62 a±0.146	35.10b±3.36
No. of branching	06.00 ±0.321	05.80±0.226	5.70±0.215
No. of grain / pod	5.50ab ±0.176	05.90a ±0.176	04.20b±0.303
Weight of 100 seed (gram)	07.82b±0.269	9.00 a±0.281	7.13bc ±0.0750

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.4.2. Yield parameters

Conversely to the other crops (faba bean, chickpea, lentil, and better vetch), common vetch presented the highest yield of 625.8 kg/dunum at Dora site. However, the lowest yield was exhibited at Janata site by 266.5kg (Table 3.11).

Regarding the total grain production, Al-arroub site presented the highest grain production (104.5 kg), followed significantly by Dora site (75.7 kg). Conversely, Janata site revealed the lowest grain production with only 37.2 kilo gram per dunum (Table 3.11). For hay production variable, Dora site showed significantly the highest hay production than the other two examined sites; whereas, the lowest hay production presented significantly at Janata site (Table 3.11).

Table 3.11 Yield parameters of common vetch "bekia" (*Vicia sativa*) cultivated at three differentiates sites.

Yield parameters	Site		
	Dora	Al-aroub	Janata
Fresh weight (kg/dunum)	625.8a±34.7	455.4b±26.0	306.5bc±61.9
Grain production (kg/dunum)	075.7b±3.48	104.5a±6.09	040.8c±7.95
Hay production (kg/dunum)	550.1a±31.4	350.9b±20.0	265.2c±54.1

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.4.3. Chemical composition

Among the three examined site, common vetch presented no significant differences for dry matter, protein content, and ash variables (Table 3.12). In addition, the obtained percentages of these variables were within the international averages. (http://www.feedipedia.org).

Table 3.12 Chemical composition and quality parameters CommonVetch" Bekia" *Vicia sativa* Cultivated at three differentiates sites.

Parameters	Site			International percentage (feedipedia)	
	Dora	Al-aroub	Janata	MIN	MAX
Dry matter %	91.03±0.104	88.65.28±1.56	90.66±0.353	75.0	91.0
Protein %	29.30±1.71	28.22±0.467	29.92±1.99	14.7	35.8
Ash %	4.61±0.777	5.05±0.614	4.467±0.785	2.4	7.5

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.5. Bitter vetch "kersana", (*Vicia ervilia*).

3.5.1. Morphological parameters

For the three examined sites, germination as well as flowering periods lasts almost the same by 13-14 and 6-8days, respectively (Table 3.13). However, the sites presented different periods of fruit set variable, in which it takes 7 days at Janata, 9 days at Dora, and 10 days Al-arroub at site. Maturation and consequently harvesting date was earlier at Janata site (17 days), followed by Dora site (22 days), and finally late maturation was exhibited at Al-arroub site (24 days).

Significant variation in stem length variable between the three different sites was observed (Table 3.13), in which Al-arroub site revealed significantly higher stem length followed by Dora and Janata sites, respectively. In reference to crop branching, Al-arroub and Dora sites revealed higher branching but not significant than Janata site (Table 3.13).

Significant variations in the weight of 100 seeds of broad beans at the three different sites were also exhibited (Table 3.13). In fact, Al-arroub site revealed significantly higher seed weight than Dora and Janata sites by 7.9, 7.66, and 6.9 grams respectively.

Table 3.13. Morphological parameters of bitter vetch “kersana” (*Vicia ervilia*) cultivated at three different sites.

Morphological Parameters	Site		
	Dora	**Al-aroub**	**Janata**
Germination date	14 days	14 days	13 days
Flowering period	7 days	8 days	6 days
Fruit set period	9 days	10 days	7 days
Maturation and harvesting period	22 days	24 days	17 days
Stem length (cm)	34.62b±1.53	42.120a ±0.233	27.80c±1.79
No. of branching	5.240±0.416	05.55±0.435	05.01±0.401
No. of grain / pod	2.78bc±0.146	4.32a±0.340	3.4b±0.255
Weight of 100 seed (gram)	7.66ab ±0.252	7.90 a±0.100	6.90b ±0.187

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.5.2. Yield parameters

Significant variations in total yield parameter were presented among the three examined sites. Indeed, Al-arroub showed the highest total yield of 790.7 kg, followed by Dora site (596.4 kg); however, the lowest yield was presented at Janata site by only 280.2 kg (Table 3.14). Regarding the total grain production, Dora site presented the highest grain production (111.3 kg/dunum); whereas, the lowest was revealed at Janata site with only 57.5 kilo gram per dunum (Table 3.14). For hay production at three examined sites, Al-arroub site exhibited significantly the highest hay production; however, the lowest was revealed at Janata site (Table 3.14). Meanwhile, Dora site presented intermediate hay production.

Table 3.14. Yield parameters of bitter vetch “kersana” (*Vicia ervilia*) cultivated at three differentiates sites.

Morphological Parameters	**Site**		
	Dora	**Al-aroub**	**Janata**
Fresh weight (kg/dunum)	596.4b ±37.5	790.7a ±53.0	280.2c±33.7
Grain production (kg/dunum)	111.30 a±8.32	96.6ab ±6.05	57.5c±11.6
Hay production (kg/dunum)	485.1b ±29.2	694.1a ±47.0	222.7c ±42.0

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.5.3. Chemical composition

Among the three examined site, no significant differences were found for dry matter, protein content, and ash variables of bitter vetch (Table 3.15). In addition, these variables were within the international percentage (Feedipedia) of documented for bitter vetch crop.

Table 3.15. Chemical composition and quality parameters bitter vetch "kersana"*Vicia ervilia* cultivated at three differentiates sites.

Parameters	**Site**			**International percentage (feedipedia)**	
	Dora	**Al-aroub**	**Janata**	**MIN**	**MAX**
Dry matter %	91.22±0.329	91.28±0.248	90.43±0.152	90.3	94.85
Protein %	26.32±0.722	25.26 ±1.16	26.95±0.075	21.0	28.52
Ash %	4.33±0.169	4.55±0.612	4.783±0.779	3.0	5.45

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

Chapter Four

Discussion

4.1. Morphological parameters

4.1.1. Germination

Germination is a critical phase in plant growth that determines plant establishment and final crop yield (Zeid, 2011). Germination period of any crop is depending on the prevailing agro-climatic condition (mainly rainfall and temperature), soil type and fertility, the depth of sowing, and the genotypes (cultivars). (Welbaum et al., 1990) stated that germination is directly related to the amount of water absorbed. In fact, germination rate and the final seed germination decrease with the decrease of the water movement into the seeds during imbibition period.

Regarding temperature, (Ellis et al., 1986), indicated that the optimal temperature for seed germination of winter legume crops is about 10–15^{0}C and high germination temperatures are considered to be 22–35^{o}C.

In general, our examined crops showed earlier germination date at Janata, followed by Dora and Al-arroub sites respectively. Since the same genotypes were repeated at the three sites with the same cultural practices (sowing), and the first rainfall date occur at the same time, therefore, the environmental fluctuation among the three sites might explain the differences in the germination period among the three examined sites. In fact, the high temperature characterized Janata might be the reason for the early germination at this site. Similar results confirmed by (Covell et al., 1986), who stated that faster germination temperature occurs at high temperature of 42^{0}C.

Comparably, large seed size crops (broad bean and chickpea) presented late germination comparing with those having small seed sizes (lentil, common vetch and bitter vetch). These results are also in parallel with the works of (Kaya and Day, 2008), (Mut et al., 2010) found that small seeds of sunflower and oat germinated faster compared to large seeds.

Also this research made clear that, the speed of germination in small seed size was faster than other seed size which is in line with the results of (Lafond and Bakers, 1986) and (Roy et al., 1996).

4.1.2. Flowering, fruit set, and maturation periods

Similar trends goes also with flowering, fruit set, and maturation periods for all of the examined crops in which all crops presented earlier periods at Janata, intermediate at Dora and late flowering, fruit set and maturation periods at Al-arroub sites, with the exception for chickpea crop (exhibited late flowering and fruit set at Dora than at Al-arroub site). Indeed, this exception might relate to the genetic makeup factor .Chickpea plant is very sensitive to excess moisture, high humidity and cloudy weather, which adversely affect its yield through limited flower production and seed set (Key, 1979), rather than any factors linked to cultural practices. Chickpea lacks cold tolerance and is sensitive to chilling temperatures (<8°C), especially at its reproductive phase (Srinivasanand et al., 1998), (Bakht et al., 2006).

The long flowering, fruit set and maturation periods exhibited at Al-arroub site might relate to the long rainfall and cold season period (Abu-Alhaija et al., 2011) comparing to the drought once at Janata. (Ahmed et al., 2008) reported that water stress leads to significant decrease in number of days to flowering and maturity stages.

This result also in agreement with (Suso et al., 1993) who found significant differences in days of flowering for some legume cultivars. Furthermore, (Della, 1988) showed that faba bean genotypes had longer time to flowering when grown under irrigation condition than those grown under rain-fed conditions confirming therefore the significant effects of rainfall period.

Concerning fruit set, (Basu et al., 2009) and (Krishnamurthy et al., 2011), reported the reduction impact of heat stress on pod-set, filled pods and pod numbers per plant in chickpea.

4.1.3. Stem length

Concerning stem length, (plant height) is both a genetically and environmentally controlled characteristic. Since were examined the same genotypes we are examined at three different locations, therefore the environmental conditions especially water availability probably explained the higher significant values presented at Al-arroub site for the five examined legume crops comparing with the other two sites. Similar results have been also reported by (Thomas, 1997; Yadavi et al., 2000; Sharpe, 2002) who pointed out that the stem length stage more affected by drought, in the event of increase drought its lead to reduce the stem length of field crop. Furthermore, (Husain et al., 1990) and (Al-Rifaee 2004), have reported that field crops are highly respond to water stress by reducing its rate of height increase.

Indeed, water stress during vegetative and generative stages has the greatest impact on plant height and biomass, (Ghassemi-Golezani et al., 2008), as well as leaf area index, (Casal et al., 1985). Interestingly, plant height is considered an important criterion discriminating among different geographic regions (Suso et al., 1993). These results were in agreement with Della, (1988) who found that plant height of broad bean genotypes varied significantly under rain-fed conditions.

When we made correlation between stem length and total production, positive relationship was obtained. Similar correlation was found by (Kumar et al., 2004) and (Younis et al., 2008).

4.1.4. Number of branches

No Significant variation was observed in number of branches on main stem. These results are in agreement with (Silim and Saxena, 1992), who found that genotypes were different on the number of branches.

(Malhotra et al., 1997) in their studies on irrigation of chickpea in winter sown reported that number of primary branches and secondary branches was not affected by irrigation

It was reported that yield was positively correlated with the number of branch per plant and the number of pod per plant (Ramgiry et al., 1989). (Zaman et al., 1989) and (Kumar et al., 1995) also have reported that there was positive significant correlation between primary branches and yield.

4.1.5 Number of grain per pod

In reference to the number of grain per pod variable, (Ghassemi-Golezani et al., 2012) stated that environmental factors had little effect on grains per pod of chickpea crop and it is mainly influenced by genotypes. Also, other studies indicated that for any given cultivar of faba bean, the average number of seeds per pod is a relatively stable character (Agung and McDonald, 1998). Furthermore, (Abdelmola and Abuanja, 2007) reported that number of seeds per pod was more influenced by genetic than environmental factors. In fact, our results were in contradictory with these above mentioned factors in which reduction in number of grain per pod presented at Janata site was presented for almost the five tested crops. This finding might relate to the drought conditions during the season that characterized this site that probably attributed to the limitation of dry matter partitioning to the reproductive sink or even grain formation factors, (Turkand et al., 1980). Based on this finding, we can easily assume that, number of seeds per pod is influenced by both genetic and environmental factors.

4.2 Yield parameters (weight of 100 seeds, fresh weight, grain, and hay production)

Seeds weight found to be varied considerably among the genotypes (Della 1988). (Kambal, 1968) stated that number of seeds per pod and 100 seed weight is relatively stable trait and did not significantly affected by the environment. However, in other recent studies it is recorded that water deficit during the reproductive growth of legume crops are the most adverse effect on crop productivity (Baigorri et al., 1999; Costa-Franca et al., 2000). Indeed, water stress has significant effects on all plant characteristics and especially on seed yield. Despite being strongly genetically determined, grain weight also depends on climatic conditions, such as water availability or temperature regime (Calderini et al., 1999; Voltaset al., 1999).

In broad bean (as the most important legumes), inadequate moisture is usually the largest constraint for production (Blum and Pnuel, 1990). The sensitivity of broad bean to water stress (Xia, 1994), is probably due to its shallow root system (Day and Legg, 1983), and to the little osmo-regulation (Bond et al., 1994).

(Fang et al., 2009), reported that with terminal drought (drought during pod set and grain filling), seed yields can be reduced by 58-95% compared to irrigated plants.

For these reasons, broad bean is often grown under irrigation in many parts of the world. Until recently, broad bean was only considered suitable for production in Mediterranean-type environments with high rainfall (ICARDA 1994). Similar results with chickpea crop were also reported by Malik and (Anwar, 1994) who reported that 100 seed weight and seed yield have been increased by irrigation in chickpea.

These explanations confirmed the significant weight of 100-seeds revealed at Al-arroub site (high average rainfall and longer season) comparing with Janata site (drought conditions with low average rainfall and short season).

Similar trends go also with the other yield parameters which showed low yield parameters at Janata site and high once at Al-arroub site. Supporting evidences were reported by many researchers (Gwathmey et al., 1992; Behboudian et al., 2001; Ghassemi-Golezani et al., 2008; Bahavar et al., 2009; Niari-Khamssi et al., 2010), who attributed the reduction in grain yields under water deficit to the reduction in number of pods per plant, number of grain per pod and total grain weight. In contrary, seed yield in chickpea was increased by 35% under irrigation compared with zero irrigation (Sharma et al., 2001).

In addition to water effects, temperature also played an important role in limiting the final legume production in which high temperature reduces total grain yield. Indeed, high temperature during the grain filling period can reduce the individual seed size at maturity which may lower grain yield per plant (Ong, 1983). Some studies carried out in Turkey showed that broad bean and chickpea sown in winter had twofold seed yield, compared to those sown in summer (Akdag, 2001; Ece et al., 2004). Other studies recorded that, average daily temperatures of 20-25°C is required for a proper growth of broad bean and higher temperatures leads to fall of flowers and fruits (Sehirali, 1988; Akcin, 1988), resulting thereby in declining the total yield.

(Nakano et al., 1997 and 1998) stated that, heat stress during the reproductive phase in legumes is generally allied with lack of pollination, abscission of flower buds, flowers and pods with substantial yield loss. In chickpea as an example, hot (> 30 ºC) and dry atmospheric conditions lead to profligate loss of flower buds and open flowers in chickpea (Sinha, 1977). High temperature stress also causes yield losses because of damage to reproductive organs (Anyia and Herzy, 2000) and had reduced total and grain yield during drought (Leport et al., 2006). These findings indeed could explain the general trend of low production at Janata site which characterized by a general harsh conditions.

As mentioned above, all tested crops revealed high yield parameters at Al-arrob site and low once at Janata site with the exception of common vetch crop which presented high fresh weight as well as hay production at Dora site comparing with the other two sites, also bitter vetch grain production at Dora presented higher production than other site. Since these crops are behaved differentially, we might assume that this exception is related to the genotype rather than the environmental one. Consequently, this genotype is performed well under the climatic condition of Dora site.

Generally, in many countries of the third world, bitter vetch is growing for hay production rather than for grain (Mihailovic et al., 2005). This indeed explained the higher production presented with this crop comparing with other crops at the same site.

4.3 Chemical composition:

It is well documented that, quantity characteristics are influenced mainly by environmental factors, while the quality once is largely genetically determined (Edwards, 2010). In fact, findings on the nature of genetic control are rather controversial, although all scientists agree that this is undoubtedly a complex subject and one that is difficult to study, due to the strong influence of the environment upon its expression (Nachit et al., 1995). Concerning protein content parameter, it is well documented that protein content is influenced largely by environmental factors (McLean, 1974, Ceyhan, 2008, Wang and Daun, 2008). In our study, its values tended to be rather higher at Janata site but not significant comparing with the other two tested sites. Similar results were also registered by (Durant and Cristina 1997; Ibrahim and Kandil, 2007; Sinaki et al., 2007; Duc et al., 2008; Alghamdi, 2009) who indicated that protein content of legumes such as faba bean tended to increase under water deficit condition. This indeed the case of Janata site (drought conditions) that presented higher protein content. Our finding also confirmed by several researches (Vieiraand et al., 1992; Ghassemi-Golezaniand et al., 1997; Ghassemi-Golezani and Mazloomi-Oskooyi, 2008; Ghassemi-Golezani and Hosseinzadeh-Mahootchy, 2008;

Ghassemi-Golezani, 2010) who reported that water stress can reduce crop yield, but it has no significant effect on seed quality.

Furthermore, the protein contents found to be within the general acceptable legume averages (28% in faba bean; 26-27% in chickpea; 27-28% in lentil; 27-28 in common vetch; and 23-26.5 in better vetch).

A similar trend goes also with ash contents for all examined sites in which no significant differences observed.

Conclusions

- Drought (mainly the limited water availability) is the main factor affecting legumes ontogeny and production, but not the quality (protein content, ash content and dry matter).

- For economical production, broad bean and chickpea crops could be successfully recommended for regions with more than 400 mm/year since both crops are presented un-economical production at Dora and Janata sites.

- Comparing with other legume crops, bekia and kersana are strongly recommended in regions with little average rainfall (around 300 mm /year) as animal vegetative fodder).

- Bekia could be recommended for moderate average rainfall (Dora site) for grain production.

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Abstract in Arabic

الملخص باللغة العربية

نمو وإنتاجية خمسة محاصيل مختلفة من البقوليات تحت ظروف الزراعة المطرية

تهدف هذه الدراسة إلى تقييم نمو وإنتاجية والمحتوى الكيميائي لخمسة محاصيل مختلفة من البقوليات هي الحمص والعدس والفول والبيقيا والكرسنة وذلك تحت ظروف الزراعة المطرية. زرعت هذه المحاصيل في ثلاثة مواقع مختلفة بيئياً تعرف بالعروب, دورا و جناتا وذلك بواسطة التصميم كامل العشوائية حيث تم استخدام خمسة مكررات على شكل شبكة من المربعات مساحة كل مربع 20 متر مربع.

شملت الصفات الشكلية التي تم قياسها كلا من فترة الإنبات فترة النضج والحصاد طول الساق، فترة الإزهار وكذلك وزن الــ 100 بذرة.

اما الصفات الإنتاجية فقد شملت الناتج الإجمالي (القش والحبوب)، الناتج الكلي للحبوب بالإضافة إلى الناتج الكلي للقش. كما وتم قياس جودة الحبوب من خلال فحص المادة الجافة والبروتين ومحتوى الرماد.

هذا وتم تحليل البيانات إحصائيا باستخدام التحليل في اتجاه واحد من التباين (ANOVA) باستخدام برنامج التحليل الإحصائي المعروف باسم (MINITAB).

أظهرت النتائج تأثيراً معنوياً للبيئة (الموقع)على معظم الصفات الشكلية والإنتاجية لمحاصيل البقوليات الخمسة المزروعة. بشكل عام فقدأظهر موقع العروب تأثيراً معنوياً عالياً لمعظم الصفات الشكلية والإنتاجية (الأعلى إنتاجية) في حين بينت النتائج ان الصفات الشكلية والإنتاجية هي الاقل في موقع جناتا بإستثناء محصول البيقيا والذي أظهر أعلى إنتاجية له في موقع دورا.

وفيما يتعلق بمعايير جودة البقوليات، تشير النتائج إلى انه لم يلاحظ ظهور أي اختلافات هامة لجميع التحاليل التي أجريت على الخمسة محاصيل والتي شملت المادة الجافة والبروتين والرماد.

أخيراً توصي النتائج بعدم زراعة محصولي البيقية والكرسنة في المواقع التي تقل فيها نسبة الامطار عن 300 ملم نظراً للإنخفاض الحاد في إنتاجية هذين المحصولين ولكن يمكن زراعتهما كعليقة للحيوانات.