Study the phnotypic and productive characters of seven selected genotypes of chickpea (*Cicer arietinum* L.) cv. (Kabuli and Desi) under rainfall conditions in Sulaimani Province, Iraq

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Abstract

Seven selected chickpea genotypes, (Kabuli and Desi) varieties, were cultivated in the winter season and spring seasons in experimental fields of Bakrajo Technical Institute-Sulaymani Polytechnic University for growing season 2019/2020. Vegetative, productive, and infection by chickpea pod borer characters for genotypes were studied and compared characters of Kabuli's five genotypes with the two Desi genotypes. There were significant differences between vegetative and productive characters, the Brazilian winter genotype had the highest plant height (45.9 cm), and the number of primary and secondary branches had the highest for the Red Desi genotype (20.0) branches. This genotype was the highest in number of pods per plant (53.7) pods.plant^{-1}. The maturity period was the longest for winter genotypes by (190-195) days while was the shortest for spring genotypes by (120-126) days in this area. Brazilian winter and Red Desi genotypes showed a high productivity recorded (1803, 1697) kg.ha^{-1}, respectively. The Brazillian and Bazyan genotypes had the highest weight of hundred seeds (45.34, 42.36 gm), respectively. The local high product genotype had a high amount of hay (3762) kg. ha^{-1} regarding straw production, the straw and seed production had a positive relationship with dry and wet weight for all genotypes. The chickpea borer infection was about 1.9% in the Bazyan genotype and at 0.1% for the Philip3 genotype that made seed injury and decreased the products.

Keywords: Kabuli, Desi chickpea, vegetative and productive characters, selected genotypes

Introduction

Chickpea plant (*Cicer arietinum* L.) belonging to the family (Fabaceae) is an annual plant, self-pollinated, and cool-season crop. It is the most crucial legume globally after peas, broad beans, and kidney beans. Chickpea is grown in more than 50 countries in the world with area coverage of 89.7%,4.3%,2.6%, and 0.4% in Asia, Africa, Australia, America, and Europe, respectively. The major countries producing chickpea are India, Pakistan, Turkey, Iran, and Australia (13). The chickpea is a famous legume field crop, and it is grown in the north of Iraq, especially in Sulaimani, Erbil, Dhouk, and Naynawa provinces, and produces a suitable quality of spring genotypes (5). The world average chickpea yield is less than 1 ton.ha^{-1}, which is far less than the potential yield of 6 t.ha^{-1} under irrigated conditions(28). The expected yield of chickpea is reduced due to biotic stresses caused by insects, bacteria, fungi, nematodes and viruses, and abiotic stresses, such as drought, nutrient deficiencies, salinity, chilling, and yearly rainfall (23).

Chickpea legume seeds play an important role in reducing hunger and malnutrition, especially in developing countries, by the high content of protein with major cereals such as rice, wheat, and corn. For seed market type, chickpea is classified into two groups, namely Desi and Kabuli types. The grains of Desi chickpea are smaller in size, light to dark black, and thick seed coats. Grains of Kabuli chickpea are larger in size, a whitish-creamy color, and thin seed coats. Chickpea seeds are important sources of energy and plant protein becouse the seed protein contains essential amino acids for human diet. In addition, chickpea plants, similar to other legume plants, replenish soil fertility through biological nitrogen fixation by bacterial nodules located on secondary roots and taproots (27).

The efficiency of breeding programs of legume crops such as chickpea, pigeon pea, and groundnut has been considerably improved by modern genomic tools and technologies (28). Chickpea's annual production was 10.461.215 tons^{-1}, harvest area was 11.551.857 ha, and the yield 905.5 kg.ha^{-1} in the world. Chickpea plants can be grown in rotation with the other cereal plants as a great source of atmospheric nitrogen fixation (12). The effect of different fertilizer treatments on chickpea varieties for all treatments was significant, except for 100 seed weight, and harvest index with grain yield ranged from 1274 kg.ha^{-1} to 1479 kg.ha^{-1} among treatments. The control group produced (1479 kg.ha^{-1}), while urea (1478 kg.ha^{-1}), di-ammonium phosphate (1449 kg.ha^{-1}), and super phosphorus (1332 kg.ha^{-1}) as fertilizer treatments produced more grain yield than bacterial inoculation (1274 kg.ha^{-1}) according to (10).

There was a progressive increase in number of pods per plant affected by inter- and intra-row spacing increasing while the highest dry biomass (10650.27 kg.ha^{-1}) was recorded at 20×5 cm spacing (19).The use of improved cultivars and agronomic techniques by farmers and government supports had an increasing effect on total chickpea production (11). In many years, early discontinuing rainfall will reduce chickpea productivity to about 1 ton.ha^{-1} seeds despite having the potential to produce 3.5 - 4 ton.ha^{-1} seeds under optimum growing conditions (22). Drought and heat stresses can reduce chickpea seed yield up to 70% (29). Chickpea plants are also sensitive to some diseases such as dry root rot, collar rot, fusarium wilt, ascochyta blight, botrytis of grey mold, chickpea pod larvae borer, and types of weeds which further reduce seed and straw yields (17). Currently, chickpea farming had a mechanization harvesting problem because of short stem height from the ground surface. Expensive labor further burdens the manual harvesting process and adds to the cost of production (7).

Water deficits at the flowering stage and the post-flowering stages have been found to cause greater injuries than those at the vegetative stages (21). Seed yield is a complex character and largely depends upon its components, and the interaction with the environment. To breed a stable variety, it is necessary to get information on the extent of genotype x environment interaction for yield and its component characters (24). Chickpea seeds of the Desi type are generally consumed as dry seeds or ground as starch or flour and in sauces such as fried and boiled seeds or soups. Kabuli genotype seeds are used for salads, vegetable mixes, and canned foods. The seeds in green pods can be consumed fresh, or may also be roasted, salted, or consumed as snacks. Chickpea is an important source of protein in the diets of poor countries and is important in vegetarian diets (25). Several by-products of chickpea cultivation and processing are used for animal feeding, including low-grade and culled chickpeas, bran, crop residues (husks, straw), and chickpea hay. Chickpea seeds similar to those of other important legume seeds such as field pea while chickpea seeds were the lowest used for feeding animals (6).Dry leaves could be used for traditional medicine (1). Chickpea residues after harvesting can produce a substantial amount of biomass, often considered an agricultural waste adding as organic fertilizer. Straw is one of the main by-products of cereal and grain legume crops (18). After chickpea seeds threshing, a large amount of straw about (400 $kg.ha^{-1}$) usually equal to or more than the seed yield remain. Chickpea straw generally contains a high amount of plant protein, greater energy, and lower cell wall contents than cereal straws.

Seed production infected by gram pod borer during seedling to maturity stage could cause injuries to the plant leaves, flowers, and pods. The larvae are the feeding stage for this insect on the leaves and bore into green pods then feed on seeds to cause more than 8% injuries to seed yield. The borer damage begins from the third week of gram pod borer life (*Helicoverpa armigera* Hubner) in November to the first week of December. There is more than one generation causing an average of 30-40 % damage to pods on chickpea fields in Iraq (3).Production short duration and high productive genotypes with high seed quilty ,straw and and using machinazation harvesting are the best aims of researche under rainfall water only(5).

Materials and Methods

The present study was carried out during the agricultural field experiments of Bakrajo Technical Institute, Sulaimani Polytechnic University in Sulaimani province/Iraq, in the growing season 2019-2020. The field is located near Sulaimani city, about 7 Km west. The experimental site has an altitude of 838 meters above sea level, total rainfall of 850 mm in this season (5 and 2). The experimental soil as physical and chemical properties was analyzed in the institute soil laboratory, and the type of soil was clay loam as shown in table 1.

Table 1. Physical and chemical properties of field experiment soil .

Soil structure properties	E.C.	PH	% N	AvailableP+++ (ppm)	Soluble K+ Meq/L	Soluble Ca++ Meq/L	% Sand	% Silt	% clay
Soil sample Ingredients	0.32	7.09	0.23	27.9	0.359	11.61	12.09	46.12	41.78

The land cropped with wheat during rainy season 2018/2019. It was plowed two times a week before and at sowing time with adding 50kg tri-super phosphate fertilizer. The treatments were laid out in a randomized complete block design (RCBD) with three replications. The three blocks were divided into seven plots with 3 m (2 m long x 1.5 m wide)with spacing between blocks and plots were 1 m. Chickpea genotype seeds prepared from Bakrajo crop production experimental station included winter genotypes (Brazilian, Bazyan, Philip2, and Philip3), and spring genotypes (local high product, Black Desi, and Red Desi), which are collected from certified.

Seeds were drilled in row planting method on each plot had five rows at 30 cm inter-row and 10 cm intra-row spacing. There were two planting periods, winter planting for the four winter genotypes on 1st November 2019 with the first rain falling, while spring planting began on 1st March 2020 for the spring genotypes, depended only on rain falling for irrigation during growing season.

Weeding was done twice in the growing season handly. Weeding for the first time was done one month after planting at rainfall and the second three weeks later without any chemical weed control did not used. At maturity, five plants were randomly selected from every three inner rows of the plot area to record data. Growth parameters were measured for plant height, biomass, root length, number of primary a secondary branches per plant, 50%flowering days, and ripping days. Yield component parameters were recorded as number of full seeds and pods per plant, number of seeds per pod,100-seed weight, seeds weight per hectare, straw weight per hectare, number of hallow pods per plant, and number of infected pods by pod borers (*Helicoverpa armigera* H.) (26). The total values of each measured parameter were divided by five to calculate the average values per plant of each treatment (plot). Seeds, straws,biomass and seed yields were recorded by harvesting the square meter of the plots .

The pod borer was measured by selecting 100 pods from the plots, the tested pods for holes, larvae, and larvae waste to obtain the infection percentage (32).

Statistical Analysis

All the relevant data from the experimental plots were subjected to analysis of variance

(ANOVA) using the XLSTAT from Microsoft Excel 2016, computer software program v. 2016.02.28451. When the treatment effects were significant, the means were separated following the least significant difference (LSD) test.

Results and Discussion

Table 2. Growth, vegetative and maturity parameters for chickpea genotypes

Genotype name	Plant height .cm^{-1}	Biomass. gm. $plant^{-1}$	No. of branches .$plant^{-1}$	Root length. cm^{-1}	Maturity days	No of pods.$plant^{-1}$
Black Desi	41.2	26.3	12.2	19.7	122	44.3
Red Desi	32.3	31.9	20.0	17.1	120	53.3
Local high product	40.5	33.8	12.5	21.4	126	19.8
Philip2	40.5	41.6	13.3	19.5	195	21.4
Philip3	39.9	30.0	12.5	17.6	193	22.7
Bazyan	36.9	42.4	13.2	15.7	190	29.7
Brazilian	45.9	40.5	6.8	20.5	190	14.3
Mean	39.6	35.21	12.93	18.79	162.29	29.36
LSD.0.05	4.899	21.204	3.05	2.447	7.644	14.429

A) Plant botanical characteristics:-

1) Plant height (cm):- The results in table 2 revealed significant differences for genotypes where Brazilian genotype gave the maximum height by 45.9 cm whereas Red Desi genotype gave the minimum height by 32.3 cm. Plant height was significantly different for genotypes (8). Findings of table 2 presented wide range values for plant height that varied from (45.9 - 32.3) cm. Similar results were found for various characters studied for chickpea by (7). The plant height had a very important role in mechanical harvesting (2).

2) Biomass (gm.$plant^{-1}$):- In table 2, Bazyan genotype had high biomass 42.4 g.$plant^{-1}$ while Philip2 and Brazilian winter genotypes provided (41.6 and 40.5) g.$plant^{-1}$ respectively. The lowest biomass represented by Black Desi genotype 26.3 g.$plant^{-1}$. The present result in agreement with other studies (7 and 26). The vegetative growth, flowering, and pod-filling stages are essential for obtaining a higher seed yield of chickpea genotypes (9).

3) Number of branches.$plant^{-1}$:- As shown in table 2, the number of primary and secondary branches had a significant effect on biomass weight, number of pods.$plant^{-1}$, seed.$plant^{-1}$. The maximum number of branches was realized by Red Desi genotype (20.0) branches.$plant^{-1}$, whereas the minimum number of branches was for Brazilian genotype (6.8) branches.$plant^{-1}$. This result agrees with such other results (26), as an increasing number of branches leads to an increase in the number of pods and seeds in several genotypes.

4) Root length (cm):- There was a significant difference between root length of all genotypes. The longer root length was by the local high product, Brazilian winter, Black Desi, and Philip2 (21.4, 20.5, 19.7, and 19.5 cm) respectively table 2.

The genotypes under study were significant in all growth traits such as plant height, biomass,100 seed weight per plant because the length of roots increased anchor the plants into the ground, absorbing amount of rainfall water, bacterial nodules on roots, effect of water stress treatments, and plant height, turning in producing more pods and seeds (21 and 4). Besides, increasing the root length of chickpea plants can absorb available soil moisture from deeper soil layers for chickpea plants (32).

5) Maturity periods days:- There were two sowing seasons, the winter genotypes were planted on the first day of November-2019, and the spring genotypes were planted on the first day of March-2020. The early date of sowing took more time to maturity of chickpea. The winter sowing needed from 190-195 days for maturity and harvesting, while the spring genotypes needed 120-126 days for maturity and harvesting table 2. In this case, we chose the available genotypes that had a high yield along with resistance to the environment and pest effects. The effect of one irrigation was not significant in the two years results. This could be due to the increase in grain yield accompanied by an increase in biomass yield, which maintains the harvest index values that were non-significant as a result of irrigation treatment (15).

6) Number of pods per plant:- The maximum number of fertile pods was by Red Desi genotype (53.3 pods.plant^{-1}), followed by Black Desi genotype having small seeds (44.3 pods.plant^{-1}) table 3. The minimum number of pods was by Brazilian genotype having large seeds. In general, the number of fertile pods led to increasing yield (21).

Table 3. Yield and its components parameters for chickpea genotypes

Genotypes	No. of seeds .pods $^{-1}$	No. of infected pods by borer	Empty pods .plant $^{-1}$	100 seeds weight
Black Desi	1.33	0.7	6.9	9.71
Red Desi	1.54	0.8	3.5	10.78
Local high product	1.15	1.1	3.7	33.77
Philip2	1.14	1.0	3.4	34.1
Philip3	1.09	0.1	0.1	35.98
Bazyan	1.11	1.9	3.6	42.36
Brazilian winter	0.96	0.7	3.2	45.34
Mean	1.19	9.0	3.49	30.29
LSD 0.05	60.62	1.044	2.602	2.458

B) Yield and its components parameters for chickpea genotypes:-

1) Number of seeds per pod:- The number of grains.pod^{-1} was found significantly high in Red Desi and Black Desi chickpea genotypes (1.54, 1.33) grains.pod^{-1}, respectively. The lowest number of grains.pod^{-1} was in Brazilian genotype (0.96) grains.pod^{-1} table 2. Consequently, an increasing number of grains.pod^{-1} made seeds size smaller and had a high yield (25). This result was close to the mean seed number per filled pod was higher at 1.45 seed.pod^{-1}, 45% of pods had two seeds for genotypes (20).

2) One hundred seed weight (g.100 seed^{-1}):- The data in table 3 showed that 100 seed weight of Brazilian and Bazyan chickpea genotypes (45.34 and 42.36) g.100 seed^{-1} was significantly higher because of the large size of seeds. In contrast, the lower mean of 100 seed weight in small seed genotypes (9.71 and 10.78) g.100 seed^{-1} for Black Desi and Red Desi, respectively, that decreased the yield but the marketing price of seeds was high. This character differs genetically according to (16) indicated that the seed yield per plant was between 0.1 g.plant^{-1} and 79 g.plant^{-1}, but it was 15.2 g.plant^{-1} for Sierra genotype and 13.9 g.plant^{-1} for CA2969 genotype. As the seed size in the F3 population, the 100 seed weight ranged from 7 g.plant^{-1} to 64 g.plant^{-1}, while it was 27.4 g.plant^{-1} to 46.9 g.plant^{-1} (20).

3) Grain yield per square meter and hectare (g.m^{-2}):- The analysis of variance for grain yield per m^2 or hectare indicated highly significant differences between genotypes (table. 3). The grain yield per m^2 varied from (136.5) g.m^{-2} by Bazyan to (180.3) g.m^{-2} by Brazilian table 4. The highest yield was recorded by Brazilian (1803) kg.ha^{-1}and Red Desi (1697) kg.ha^{-1} while the lowest yield was for Bazyan (1365) kg.ha^{-1}. For all other genotypes, the yield was close to the mean of production. The increase in seed yield is attributed to sufficient storage of soil moisture, temperature and nutrient uptake, better plant growth in case of the optimum time of chickpea sowing which resulted in a higher number of fruit branches, number of pods.plant^{-1}, and 1000-seed weight (25). The market value of chickpea is mainly decided by the color, shape, and size of the genotype seeds (23).

Table 4. Seed and straw production (kg.ha^{-1}) for chickpea genotypes

Genotypes	**Straw production kg.ha^{-1}**	**seed production kg.ha^{-1}**
Black Desi	**2871**	**1528**
Red Desi	2931	1697
Local high product	3762	1543
Philip2	3297	1430
Philip3	3442	1463
Bazyan	3428	1365
Brazilian winter	2320	1803
Mean	3150.14	1547
LSD.0.05	255.754	43.49

4) Straw yield per square meter and hectare (g.m-^{2}):- The diversity in the chemical composition of chickpea straw can be due to different chickpea varieties, leaf stem ratio, growing condition extent of foreign materials (6). Chickpea straw can be used as a ruminant feed compared to other plant straws. Chickpea straw has a relatively high nutritive value. Chickpea straw was a secondary product after seeds. It also was used for feeding animals for the high content of carbohydrates, fibers, and protein. The maximum straw product was (3762, 3442, and 3297) kg.ha^{-1} for the cultivated genotypes (local high product, Philip3, and Philip2), respectively,

whereas the minimum product (2320)kg.ha^{-1} for Brazilian genotype table 4. As an increase in straw product for genotypes decreases the yield of chickpea. Straw quality was determined by measuring chemical composition, carbohydrate, and protein fractions in vitro gas production (14).

5) Number of empty pods.100 pod^{-1}:- Reproductive development of chickpea genotypes was in contrast with yields in the field. The drought, soil type, and genetic factors imposed from early podding reduced biomass, reproductive growth, harvest index, and seed yield of the genotypes. Discontinuing rainfall at the end of the drought season led to at least doubled the percentage of flower abortion, pod abscission, and the number of empty pods.plant^{-1} (28). The maximum empty pods were (6.9) empty pods.100 pod^{-1} by Black Desi genotype and the minimum empty pods were (0.1) pods.100 pod^{-1} by Philip3 table 3. There was no effect of water treatment on the number of empty pods found in genotypes and the percentage of empty pods to total 100 pods (20).

6) Number of infected pods by (*Hilicoverpa armigera*):- The pod borer larvae population was recorded by calculating the number of punched or bored pods or live larvae inside of 100 pods collected from experimental plots. The percentage of pod borer infection ranged from 0.1% for Philip3 genotype to 1.9% for the Bazyan genotype, table3. This pest in many years can cause high infection to cultivated chickpea genotypes and decrease yield. These injuries vary due to area, weather factors in terms of drought and sowing date (3). The yield losses from damages were higher about 16-33 borers in one plot given the supplement irrigation during flowering and podding, but the yield losses in the Desi genotypes were lower than that in Kabuli genotypes. Yield losses were also greater in large seed than in small seed genotypes (31).

Conclusion

The analysis of this research indicates the highly significant difference between all genotypes of the experiment such as seed, straw production. There was a difference between winter and spring genotypes. The results of the experiment were varied especially 100 seed.plant^{-1}, plant height, and straw production. Maximum seed weight was in Brazilian winter genotype 180.3 g.m^{-2} because of the largest size of its seeds. In Contrast, Brazilian winter genotype has a minimum number of pods and number of seeds.pod^{-1} (14.3 and 0.96) consecutively. Desi genotype had minimum seed production of 9.71, 10.78 g.m^{-2} for black and Red Desi genotypes due to the small size of seeds. On the other hand, they had a high number of branches.plant^{-1} 53.3 and 44, number of seeds.pod^{-1} 1.54 and 1.33 for Red and Black Desi respectively. Local chickpea production in Iraq needs more experiments in terms of producing a sufficient chickpea seed yield to avoid importing chickpea seeds yearly. Introduce low cost, high value and environmentally friendly plants like chickpea have the potential to enhance agricultural productivity. Iraq has sandy desert lands in middle and south governments that could be used for planting chickpea genotypes to replenish nitrogen and organic matter substantial to the soil for one season (winter or spring season with rainfall and low water supply).

The Iraqi people consume Desi chickpea so-called (Humus ajam) with many types of foods. Chickpea like other legume food has a narrow genetic base, hence the breeding programs should focus on wide hybridization. We need breeding and selecting new genotypes for Iraqi soils and the environment. Further, the animal industry and extension farmers need for using chickpea straw as a by-product benefit in Iraq. Also, evaluation of the vegetative and seed production of the genotypes is recommended in future studies.

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