Effects of plant density on seed yield and it's components of two pea (*Pisum sativum* L.) cultivars under rainfed condition in Sulaimani province

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Abstract:

This study was carried out to investigate the response of two cultivars of pea (Markerbsen and Zuckerbsen) to three plant densities (20, 40, and 80 plant. m^{-2}) under the rain fed condition in Sulaimani province, during the growing seasons of (2014-2015 and 2015-2016). RCBD in factorial experiments arrangement was used with three replications. The results showed no significant effects of cultivars, plant densities and their interaction on plant height, while, the cultivar of Zuckerbsen was significantly gave higher dry weight compared to Markerbsen and at lowest plant density (20 plant. m^{-2}) followed by (40 plant. m^{-2}). Number of branches.$plant^{-1}$, number of pods.$plant^{-1}$, number of seeds.pod^{-1}, number of seeds.$plant^{-1}$, biological yield had not affected by both cultivars and plant densities. However, the highest and significant weight of seed, 1000 seed weight, harvest index (HI) were obtained in first growing season by Zuckerbsen cultivar at 20 plant. m^{-2} compared with Markerbsen cultivar at (40 and 80 plant. m^{-2}) densities and second growing season . The highest seed yield was obtained by Zuckerbsen cultivar in both growing seasons at plant density of (80 plant. m^{-2}) with value of 3159.95 kg. ha^{-1}) in first growing season and value of (2873.65 kg. ha^{-1}) in second growing season followed by Markerbsen cultivar in first growing season with value of (2599.52 kg.ha^{-1}) at 80 plant. m^{-2}) compared to other plant densities this mean both cultivar performed better in first growing season with higher rainfall and lower temperature during pod development compared to second growing season. This study suggested Zuckerbsen cultivar and plant density of 80 plant. m^{-2} for Sulaimani province.

Key words: Pea, plant densities, dry matter accumulation, yield and yield components.

تاثير الكثافة النباتية على الحاصل ومكوناته لصنفين من البزاليا (*Pisum sativum* L.) تحت ظروف الزراعة الديمية في محافظة السليمانية

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المستخلص:

أجريت هذه التجربة لدراسة استجابة صنفين من البزاليا (Markerbsen و Zuckerbsen) بثلاث كثافات نباتية (20 ، 40 و 80 نبات . م$^{-2}$) تحت الظروف الديمية في محافظة السليمانية ، خلال الموسمين الشتويين (2014 -2015) و (2015-2016). استخدمت التجارب العاملية وفق تصميم القطاعات الكاملة المعشاة وبثلاثة مكررات أظهرت النتائج عدم وجود تأثيرات معنوية للأصناف والكثافة النباتية وتداخلهماعلى ارتفاع النبات ، بينما اظهر الصنف Zuckerbsen تاثير معنوي بالنسبة للوزن الجاف للنبات مقارنة بالصنف Markerbsen وبأقل كثافة نباتية (20 نبات. م$^{-2}$) يليها (40 نبات. م$^{-2}$) عدد الفروع للنبات عدد القرنات للنبات ،عدد البذور للقرنة عدد البذور في النبات والحاصل البيولوجي لم يتأثر بكل من الأصناف والكثافة النباتية. ومع ذلك ، تم الحصول على أعلى حاصل بالنسبة لوزن البذور (غم) وزن 1000 بذرة ، ودليل الحصاد في الموسم الأول للصنف Zuckerbsen عند الكثافة النباتية (20 نبات . م$^{-2}$) مقارنة مع الصنف Markerbsen عند الكثافتين النباتية (40 و 80 نبات .م$^{-2}$) للموسم الثاني. تفوق الصنف Zuckerbsen بحاصل البذور في كلا الموسمين و الكثافة النباتية (80 نبات . م$^{-2}$) إذ أعطى 3159.95 كغم هكتار$^{-1}$ في الموسم الاول و 2873.65 كغم .هكتار$^{-1}$ في الموسم الثاني يليه الصنف Markerbsen الذي اعطى في الموسم الاول (2599.52 كغم.هكتار$^{-1}$) والكثافة النباتية (80 نبات . م$^{-2}$) مقارنة بالكثافات النباتية الاخرى و هذا يدل على ان نمو وتطوركلا الصنفين كان افضل في الموسم الاول إذ كانت كمية الامطار اعلى ودرجات الحرارة منخفضة خلال تكوين القرنات مقارنة بالموسم الثاني . اقترحت هذه الدراسة صنف Zuckerbsen والكثافة النباتية (80 نبات. م$^{-2}$) في محافظة السليمانية .

الكلمات المفتاحية : البزاليا، الكثافات النباتية، تراكم المادة الجافة، الحاصل ومكوناته.

Introduction:

Pea (*Pisum sativum* L.) is a cool season annual grain legume and a member of the family of fabaceae. It is native to Southeast Asia (11), and consider as a high nutrition crop because its grain is rich in protein (27.8%), carbohydrates (42.65%), vitamins, minerals, dietary fibers and antioxidant compounds (17)

Good crop management practices are necessary for the economic pea production, among them varieties and plant density (6) Seeding rate at the rate that result in optimal plant density and may reduce seed costs, lodging and modified the disease costs, above and under a certain seeding rate often adversity affects the crop yield,

because the number of plant/ unit area impact plant size, yield components and ultimately seed yield(4) Furthermore, for optimizing rate of penetration of light into plant canopy and consequently photosynthesis, growth and developments , optimum plant population density is an important factor Ouji,Ei-bok etal (13) Recently, it has been reported that plant population and cultivars are important factors that influencing yield and quality of pea crop (18). For example, studies on the effect of growing seasons and locations on pea yield and yield components indicated that there was a significant differences among genotypes for all traits over the years and locations (5) Moreover , Yucel (18) reported that all examined parameter(plant height, first pod height, full pod height, total pod, seed number seed weight, 1000 seed weight and seed yield) in pea crop were higher in a growing season with higher rainfall and cool temperature during flowering compared to other season and among the three studied cultivars namely (BOLERO, SPRING and UTRILLO) with plant densities (30.40. and 50 plants.m^{-2}) the SPRING with plant density of 40 plant.m^{-2} was suggested for winter pea grown in Mediterranean- type condition. All above can be supported by previously reported by (10) that pea yields vary and greatly depending on planting date, location and year. This variation in yield has been attributed to the highly variable weather condition. This study aims to determine the optimum seed plant density and the most suitable of the pea cultivar for rainfed condition in the Sulaimani province.

Materials and Methods:

Two experiments were conducted at Qulaysan Research center. Sulaimani provinces during two winter seasons from 2015 and 2016 the experiments were designed as factorial arrangement with Random Complete Block Design RCBD In three replications each replication consists of 6 plots, the area of each plot was $1m^2$ with 20cm between rows. Treatments layout were two cultivars of pea (Markerbsen and Zuckererbsen) and three plant densities (20, 40, and 80 plants .m^{-2}). In the first experiment the seeds were sown on 21th November of 2014 and the plants harvested on 6th Jun of 2015. In the second experiment the seeds were sown on 26th December of 2015 and the plants were harvested on 21th May of 2016. All the cultural practice was carried out as usual for rainfed conditions Total precipitation of the growing seasons during 2014-2015 and 2015-2016 are shown in Figure (1) and mean temperature during growing season (2014-2015) and (2015-2016) are shown in figure (2) .

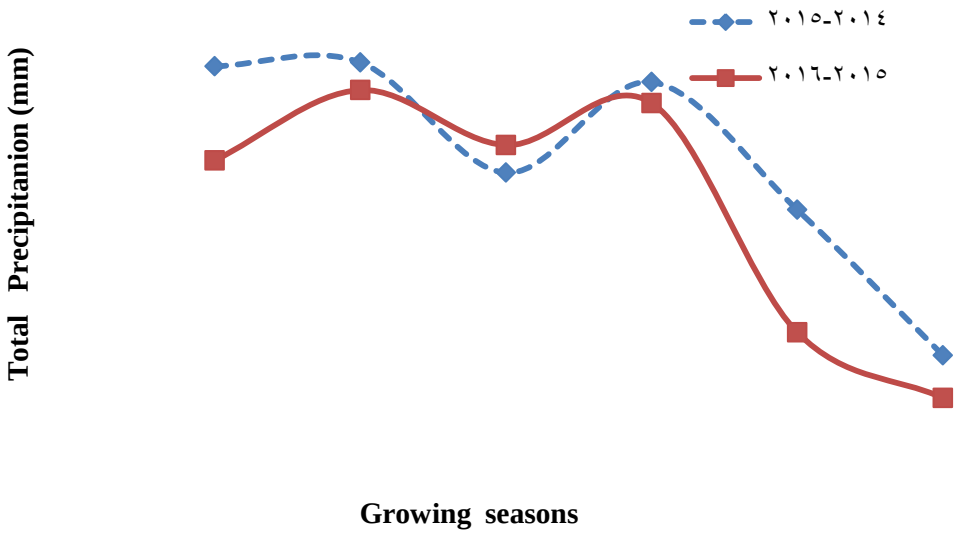

Figure 1: Total precipitation during growing seasons (2014-2015) and (2015-2016)

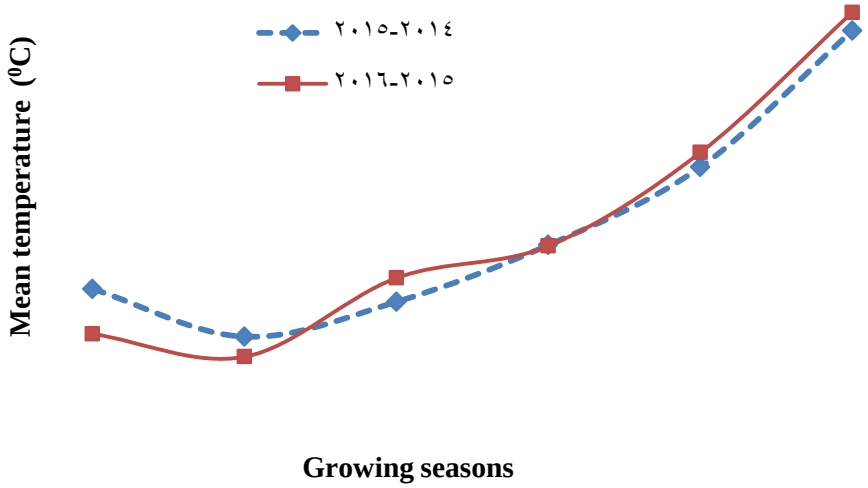

Figure 2 Mean Temperature (^{0}C) during growing seasons (2014-2015) and (2015-2016)

Data collected

At 50% anthesis, plant height and dry matter accumulation of above ground organs were recorded from randomly selected 5 plants from each plots and dried in an oven at 70 ^{0}C to weight stability, then weighed (2).

At harvest, number of branches.plant^{-1}, number of pods.plant^{-1}, number of seeds.pods^{-1} and number of seeds.plant^{-1}, seed weight.plant^{-1}, 100 seed weight (g .plant^{-1}), biological yield (g. plant^{-1}), harvest index (%).

For seed yield (kg. ha^{-1}) all rows were harvested, threshed, cleaned and weighed, then converted to (kg.ha^{-1}).

Statistical analysis

Data were statistically analyzed according to combined analysis using Software (JMP) version7, and comparisons between means were made using least significant differences (LSD) at 0.05 probability level.

Results and Discussion:

Effect of cultivar, plant density, and the interaction between cultivars and plant density on pea plant height and dry weight at % 50 anthesis.

Combined data presented in table1, indicated that there were no significant differences in plant height when recorded at %50 anthesis and for both growing seasons and between two cultivars (Markerbsen and Zuckerbsen) . While, there was a significant differences between two cultivars in dry weight at %50 anthesis which was the cultivar Zuckerbsen accumulated more dry weight , it gave (19.28 g. plant^{-1}) compared to Markerbsen (16.40 g. plant^{-1}).However, there was less and no significant differences in dry weight was recorded for both cultivars in second growing season (13.67 and 13.43g. plant^{-1}) for Markerbsen and Zuckerbsen respectively this means that the both cultivars gave higher dry weight in first growing season compared to second growing season. This might be due to the more precipitation and favorable temperature during year 2014-2015 than 2015-2016 as shown in figure 1,2 at vegetative growth stages. In average the cultivar of Zuckerbsen gave higher dry weight in above organs compared to Markerbsen in both growing seasons this was due the genetic variation between cultivars and environment (1).

In both growing seasons as shown in table1, plant densities had no significant effects on plant height for both cultivars, but there was a slight increment in plant height with increasing plant number of plant.m-^{2} due to competition among plants on light. According to average of two growing seasons, dry weight per plant linearly decreased with increasing seeding rate from 20 to 80 plants.m^{-2}, the increase in space between plants provided a plant with equal opportunity to obtain environmental resources and intercept more light and produce more dry matter. In agreement with this study (12) also reported the significant interaction effect between pea cultivars and plant densities in two years for dry matter accumulation but not for plant height However, in contrast with these results (15, 18) found that the increased plant population significantly increased plant height due to competition among plants on light and the different cultivars produced different plant height.

Effect of cultivars, plant densities and their interaction on yield and yield components :

Data presented in table 2, indicated that each of cultivars, plant densities and the combined growing seasons had no significant effects on number of branches/plant. While, there was a significant effect of cultivars on number of pods.plant^{-1}, number of seeds. pod^{-1}, number of seeds .plant^{-1}, weight of seed.plant^{-1} (g), 1000 seed weight(g), biological yield (g), harvest index (HI) and seed yield (kg.ha^{-1}). According to average growing seasons the highest values recorded (42.77), (6.05) and (257) for number of pod. plant^{-1}, number of seed.pod^{-1} and number of seeds. plant-^{1} respectively, obtained by Markerbsen compared to Zukerbsen with values of (39.50), (5.27) and (222.72) ,respectively. However, the highest values recorded (39.24g), (173.40g), (103.366g) ,

(0.37) and (2172.29 kg.ha-^{1}) for weight of seed.plant^{-1}, 1000 seed weight, biological yield, harvest index (HI) and seed yield respectively, obtained by Zukerbsen compared to Markerbsen with values of (34.83g), (136.22g), (95.148g) , (0.36)) and (1871.9633kg.ha^{-1}) ,respectively, It has frequently significant differences reported between pea cultivars in yield and its components such as by (3, 18, 13,16). In this study results indicates that seed number.plant^{-1} positively correlated to seed number. Pod-^{1} while 1000 seed weight was negatively correlated to number of pod.plant-^{1} in both cultivars indicating the increase in pod number in pea cultivars decrease the 1000 seed weight these results supports those results previously reported by (18) Futher, Falloon and White (7) found negative correlation between 1000 seed weight with pod number. plant^{-1} and seed number.pod^{-1} in pea cultivars. In cotrast to this study (15,14) reported that pea plants at low population significantly produced more number of branches and pods.plant^{-1} as in wider space plants grow vigorously and produce more branches which resulted in more number of pods. Plant^{-1}.

Also according to table 2, plant densities had significant effect on number of seed.pod^{-1}, number of seed. Plant^{-1}, Weight of seed.plant-^{1} (g), 1000 seed weight (g) , and harvest index (HI), all these variable studied significantly decreased with increasing plant population might be due to interplant competition on light and other environmental resources as a result the plant might have lower rate of photosynthesis, growth and dry matter translocation from vegetative organs pre anthesis to seed post anthesis ,these results were in accordance with those reported by (3). Regarding branch number.plant-^{1} and biological yield (g) was less affected by plant densities, while Ayaz, McKenzie et al, (3) found that pod number/ plant less affected by plant population in pea cultivars.

The highest seed weight. plant^{-1} obtained in first growing season at lower population (20 plant.m^{-2}) with value of (48.86 g) followed by (40 plant.m^{-2}) with value of (36.53g) which was led to harvest index (HI) to follow similar pattern.

In term of seed yield (kg.ha^{-1}) significantly increased with increasing plant population. According to average growing seasons plants at highest plant population (80 plant.m^{-2}) produced highest value of (2694.23 kg.ha^{-1}) seed yield followed by (40 plant.m^{-2}) with value of (2208.06 kg.ha^{-1}) and the lowest value of (1164.09 kg.ha^{-1}) obtained by the lowest plant population (20 plant.m^{-2}). The increment of seed yield (kg.ha-^{1}) was due to increased number of plant per unit area, this result was in accordance this reported by Gan,Miller et al, (8) who stated that increased seed yield of high population density directly related to large population/ unit area, and established 75 to 80 plant.m^{-2} as the plant population for dry pea to produce the economic seed yield.

In addition, the data presented in table 3 showed no significant interaction effect of pea cultivars, and the combined years on all variables studied except of seed yield, these results are in contrast to those reported by (3, 18, 13). In first growing, the highest value of seed yield obtained by Zukerbsen cultivars with value of (3159.95 kg. ha^{-1}) followed by Zukerbsen cultivar in second growing season with value of (2873.65 kg.ha^{-1}) and then Zukerbsen cultivar with value of (2599.52 kg.ha^{-1}) com-

pared to Markerbsen cultivar in both growing seasons and other plant densities. However the lowest value of seed yield was obtained by Markerbsen cultivar grown in second growing season and at the lowest plant density which was recorded (1040.01 kg.ha^{-1}) seed yield.

Effect of growing season on a plant height and above ground dry matter accumulation at 50% flowering and on yield and its components at harvest.

Data presented in table 4, showed that at 50% anthesis plant dry matter accumulation and plant height had significantly affected by growing seasons. Pea cultivars significantly accumulated above ground dry matter and produced taller plants in first growing season compared to second growing season. At harvest, the number of branches.plant^{-1}, number of pod.plant^{-1}, number of seed.pod^{-1}, number of seed.plant^{-1}, 1000 seed weight (g) and biological yield (g) had not significantly affected by growing seasons. While seed weight.plant^{-1}, harvest index and seed yield (kg.ha^{-1}) significantly differed between two growing seasons, the seed weight/ plant with value of (39.84g) harvest index (HI) with value of (0.39) and seed yield with value of (2126.35 kg.ha^{-1}) were obtained from first growing season compared to (34.22 g), (0.35) and (1917.91 kg.ha^{-1}), respectively, in second growing season. The increment in plant height and dry matter accumulation at 50% anthesis was due to higher precipitation in first growing season as shown in figure 1, the higher rainfall during and corresponding to the vegetative growth stages and favorable temperature as shown in figure 2, led to the plants accumulated more dry matter and produced taller plants. The increased temperature and lower of rainfall during month corresponding to pod development and seed formation in pea cultivars in second growing season as shown in figure 2, led the reduction in seed weight and seed yield in second growing season. These results indicated that pea crop dry matter accumulation, seed yield and some yield components significantly influenced by environmental factors such as precipitation and temperature. These results are in agreement with that recorded by (10, 3, 18) who reported that dry matter accumulation, yield and yield component are greatly affected by growing seasons. Ayaz,Mckenzie et al, (3) stated that growing seasons affects the growth cycle of crops and the interpreted of radiation into photosynthesis and dry matter accumulation.

It has previously accepted that the two most stages of peas growth cycle sensitive to water deficient are flowering and pod development (7). Moreover, high temperature during grain filling had negative impact on seed weight and consequently seed yield in large and small seeded pea cultivars (9).

Table 1: Effects of pea cultivars, plant densities and the interaction effects of cultivars and plant densities on pea plant height and above ground dry matter accumulation at 50% anthesis for both growing seasons (2014-2015 and 2015-2016) and combined years.

Year	*Cultivars*		*Plant height (cm)*	Total above ground dry matter (g.plant^{-1})
2014-2015	Markerbsen		92.55	16.40
	Zuckerbsen		95.11	19.28
2015-2016	Markerbsen		43.22	13.66
	Zuckerbsen		51.66	13.44
L.S.D (P ≥ 0.05)			N.S	1.268
Combined years	Markerbsen		67.89	15.029
	Zuckerbsen		73.39	16.36
L.S.D (P ≥ 0.05)			N.S	0.896
Year	Plant densities Plant. m^{-2}			
2014-2015	20		85.50	19.91
	40		90.50	17.05
	80		105.50	16.57
2015-2016	20		43.83	14.53
	40		50.17	13.14
	80		48.33	12.97
L.S.D (P ≥ 0.05)			N.S	N.S
Combined years	20		64.67	17.22
	40		70.33	15.09
	80		76.92	14.77
L.S.D (P ≥ 0.05)			N.S	0.847
Year	Plant densities plant.m^{-2} × cultivars			
2014-2015	Markerbsen	20	85.0	18.69
		40	85.00	15.22
		80	107.00	15.30
	Zuckerbsen	20	86.00	21.14
		40	95.33	18.87
		80	104.00	17.84
2015-2016	Markerbsen	20	41.33	15.15
		40	49.67	13.11
		80	38.67	12.71
	Zuckerbsen	20	46.33	13.91
		40	50.67	13.18
		80	58.00	13.23
L.S.D (P ≥ 0.05)			N.S	N.S

Table 2: Effect of cultivars and plant densities on yield and yield components for both year2014-2015 and 2015-2016) and combined years.

Years	Cultivars	No. of branche.plant^{-1}	No. of pods.plan.t^{-1}	No.of seeds.pod^{-1}	No.of seeds.plant-^{1}	Weight of seed.plant^{-1} (g)	Weight of 1000 seed (g)	Biological yield(g)	HI	Seed yield kg.ha^{-1}
2014-2015	**Markerbsen**	3.44	43.77	6.11	268.56	35.55	132.27	92.91	0.38	1996.50
	Zuckerbsen	3.44	40.88	5.11	229.78	44.14	187.01	107.27	0.40	2256.20
2015-2016	**Markerbsen**	1.11	41.77	6.00	245.89	34.11	140.15	97.39	0.35	1747.43
	Zuckerbsen	1.78	38.11	5.44	215.67	34.33	159.79	99.47	0.34	2088.39
	L.S.D (P ≥ 0.05)	**N.S**	**N.S**	**N.S**	**N.S**	**4.90**	**7.86**	**8.36**	**0.011**	**38.54**
Combined years	**Markerbsen**	2.28	42.77	6.05	257.22	34.83	136.22	95.15	0.36	1871.96
	Zuckerbsen	2.61	39.50	5.27	222.72	39.24	173.40	103.37	0.37	2172.29
	L.S.D (P ≥ 0.05)	**N.S**	**1.69**	**0.30**	**15.17**	**3.46**	**5.54**	**5.900**	**0.003**	**27.25**
								2014-2015	**Plant densities Plant.m-^{2}**	
	20	3.83	45.00	6.16	296.33	48.86	167.77	111.81	0.47	1238.76
	40	2.83	39.16	5.66	223.33	36.53	158.04	95.22	0.38	2260.55
	80	3.67	42.83	5.00	227.83	34.15	153.11	93.24	0.36	2879.73
2015-2016	**20**	1.33	37.16	5.50	216.33	37.42	173.28	105.24	0.36	1089.43
	40	1.67	39.66	5.83	231.50	31.47	136.47	95.15	0.33	2155.57
	80	1.33	43.00	5.83	244.50	33.78	140.18	94.81	0.36	2508.73
	L.S.D (P ≥ 0.05)	**N.S**	**45.00**	**0.78**	**44.34**	**4.36**	**14.34**	**N.S**	**0.031**	**62.51**
Combined years	**20**	2.58	41.08	5.83	256.33	43.14	170.52	108.52	0.40	1116.09
	40	2.25	39.41	5.75	227.42	33.10	147.26	95.19	0.36	2208.06
	80	2.50	42.91	5.41	236.17	33.96	146.65	94.07	0.36	2694.23
	L.S.D (P ≥ 0.05)	**N.S**	**N.S**	**N.S**	**N.S**	**3.10**	**10.14**	**5.50**	**0.023**	**44.22**

Table 3 : The interaction effect of cultivars and plant densities on pea yield and yield components for both years (2014-2015 and 2015-2016) and combined years.

Years	Cultivars × Plant densities Plant.m^{-2}		No. of branches. plant^{-1}	No. of pods.plant^{-1}	No.of seeds.pod^{-1}	No.of seeds.plant^{-1}	Weight of seeds.plant^{-1} (g)	Weight of 1000 seed (g)	Biological yield(g)	HI	Seed yield Kg.ha^{-1}
2014-2015	Markerbsen	20	4.00	45.00	7.00	315.00	43.31	137.56	99.60	0.44	1193.25
		40	3.00	40.67	6.00	246.33	32.51	132.06	89.73	0.36	2196.72
		80	3.33	45.67	5.33	244.33	30.83	127.20	89.39	0.35	2599.52
	Zuckerbsen	20	3.67	45.00	5.33	277.66	54.40	197.98	124.01	0.44	1284.27
		40	2.67	37.66	5.33	200.33	40.54	184.03	100.71	0.40	2324.37
		80	4.00	40.00	4.67	211.33	37.47	179.01	97.08	0.37	3159.95
2015-2016	Markerbsen	20	1.00	38.33	5.67	216.66	35.12	162.41	101.75	0.34	1040.01
		40	1.00	40.33	6.00	242.0	31.35	129.48	95.07	0.33	2058.46
		80	1.33	46.67	6.33	279.0	35.86	128.56	95.35	0.38	2143.81
	Zuckerbsen	20	1.67	36.00	5.33	216.0	39.71	184.13	108.72	0.37	1138.84
		40	2.33	39.00	5.67	221.0	31.59	143.45	95.23	0.33	2252.69
		80	1.33	39.33	5.33	210.00	31.68	151.80	94.45	0.34	2873.65
L.S.D (P ≥ 0.05)			**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**88.44**
Combined years	Markerbsen	20	2.50	41.66	6.33	265.83	39.22	149.98	100.68	0.39	1116.63
		40	2.00	40.50	6.00	244.17	31.93	130.77	92.40	0.35	2127.59
		80	2.33	46.17	5.83	261.67	33.35	127.88	92.37	0.36	2371.67
	Zuckerbsen	20	2.67	40.50	5.3	246.83	47.06	191.05	116.37	0.40	1211.55
		40	2.50	38.33	5.50	21+0.67	36.07	163.74	97.97	0.37	2288.53
		80	2.67	39.66	5.00	210.67	34.58	165.41	95.76	0.36	3016.80
L.S.D (P ≥ 0.05)			**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**65.53**

Table 4 : Effect of growing seasons on the pea plant height and above ground dry matter accumulation at 50% anthesis, and on yield and its components at harvest.

Years	At anthesis			At harvest						
	Plant height (cm)	Above ground dry matter (g)	No. of branches.plant^{-1}	No. of pods.plant^{-1}	No.of seed.plant^{-1}	No.ofseeds.plant^{-1}	Weight of seeds(g).plant^{-1}	Weight of 1000 seed (g)	Biological yield(g)	HI	Seed yield kg.ha^{-1}
2014-2015	93.83	17.84	3.44	42.33	5.61	249.17	39.84 a	159.64	100.09	0.39	2126.35
2015-2016	47.44	13.55	1.44	39.95	5.72	230.78	34.22 b	149.97	98.43	0.35	1917.91
L.S.D ($P \geq 0.05$)	**11.13**	**1.16**	**N.S**	**N.S**	**N.S**	**N.S**	**2.92**	**N.S**	**N.S**	**0.02**	**116.39**

Conclusion:

It can be concluded from the results obtained from this study that the cultivar of Zuckerbsen can accumulate more dry matter at anthesis and translocated to grain post anthesis compared to Markerbsen cultivar and gave the economic yield under the increased plant densities till the 80 plants.m-^{2} in Sulaimani province under the favorable weather condition.

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