Effects of different row spacing on growth, forage yield, seed yield and its component of some grass pea *(Lathyrus Sativa*) variety in Sulaimani Governorate, Iraq

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Abstract

This study investigates the effects of varied row spacings of 20, 40, and 60 cm on three distinct grass pea (*Lathyrus sativus*) varieties IF133, IF102, and IF003.The experiment was conducted at the Qlyasan Agricultural Research Station in the Sulaimani Governorate(Lat 35˚ 34' 307"; N, Long 45˚ 21' 992"; E, 755 MASL),during the winter of 2022–2023 to determine the optimal row spacing and variety for grass pea development, forage yield, and yield characteristics under local climatic conditions. The experiment was designed in Factorial and conducted in CRBD (Randomized Complete Block with three-replication .At the Effect of interaction between Grass Pea Varieties and Row Spacing on Growth and Forage Yield Characters. The results showed that the variety IF003 produced the tallest plants with (105.667 cm) when 20 cm of row spacing was used. In contrast, the interaction of 20 cm row spacing with variety IF 102 resulted in the lowest plant height with (72.633 cm). Furthermore, variety IF003 with 20 cm row spacing produced the maximum number of days to 50% flowering reached (121.98 days), while variety IF133 with40 cm row spacing produced the highest number of days to maturity (180.373days). At 40 cm row spacing variety IF133, had the highest stem dry weigh reached (8.172g), while variety IF 102 with 20cm row spacing had the highest dry leaf with (10.325 g).At the Effect of Interactions between Grass Pea Varieties and Row Spacing on Seed Yield and its Components. Showed that variety IF 102 with 40 cm row spacing had the highest harvest Index which is (0.544).While variety IF003 recorded highest biological yield at 60 cm row spacing reached (15.224 tons/ha).

Keywords *Lathyrus sativus*, Planting distances, forage crops, variety, growth, yield.

Introduction

The grass pea (*Lathyrus sativus*) is a significant legume that is valued for its food and feed qualities as well as its adaptability in crop rotations. With its ability to withstand drought, salt, and pests that harm stored grains, this crop shows significant production potential [1]. It may produce fruit even under drought conditions and is ideally suited for growing in areas with low annual rainfall, usually around 250 mm [2]. Ethiopia, Burma, Morocco, India, Ecuador, Peru, Colombia and Pakistan are among the countries that grow grass pea as a winter crop [3]. Notably, it ranks fourth among the crops after soybean, groundnut and bean [4] and contributes to soil fertility through biological nitrogen fixation by symbiotic rhizobia. Roots facilitate nodulation [5]. Due to its low production costs, grass pea is considered an important part of sustainable agriculture [6], and it offers higher protein content than most other vetch species [7].

A study by Kumar *et al*. [8] emphasized the importance of row spacing, showing that 50 cm spacing resulted in better seed yield and quality than narrower arrangements. Effective row spacing management is important during bean feeding as it affects both yield and nutritional effects. The results of Karadeniz and Bengisu [9] show that changing the row spacing can improve yield and quality of rice (Pisum sativum ssp.). This concept affects the use of grass mulching, site-grading measures such as light interception, nutrient absorption, and water efficiency, which affect the area's growth and yield. For crop and animal production, the best area to replace grass is the need to sustain crop and animal systems. Furthermore, the selection of specific grass species plays an important role in performance results, as different species have different tolerances to environmental stress. This variability can be purposefully exploited in order to boost productivity. For example, Kendir *et al.* [10] analyzed the in vitro regeneration of Turkish narbon vetch (*Vicia narbonensis*) and demonstrated that opportunities exist to enhance genetic resources and breeding programs to develop better performing varieties. By choosing dominant and sturdy varieties of grass pea, farmers can supplement their attempts to space out rows in such a way that while putting up the yields, risks caused by the unpredictable climate can also be reduced. This is particularly important in the region where it is a staple crop as the nutritional value of Grass Pea is enormous.

Khandare *et al.* [2] appreciate such consumption, especially in regard to it serving as a potential cure for starving people. Still a dark side or downside connected with grass peas – its chronic disease lathyrism, a harmful neurotoxic condition, only justifies these peculiarities in production and the education of consumers on the correct levels of the product to be consumed. Integrating these health issues among other agronomic concerns will assist in marketing and expanding the use of grass peas as an important crop in the market both domestically and internationally. Also worth emphasizing are modern intercropping techniques, which have great potential in enhancing agricultural productivity and land use efficiency with grass peas. Karadeniz and Bengisu [9] examined the benefits of growing Grass Pea in relay intercropping systems with lowland rice, which demonstrated that these approaches have the potential to optimize resource use and allow multiple crops to be harvested in a year. In Sulaimani Governorate, this innovative technique provides sustainable agriculture models and advocates the use of grass pea in the existing cropping systems aiming to improve ecological and economic benefits. Therefore, in the context of Sulaimani Governorate, this study proposes to assess the effect of inter-row spacing as well as varieties of grass peas on growth and fodder, seed and seed yield as well as yield attributes.

Materials and Methods

Plant Materials and Field Experiment

This research was carried out in the winter period 2022-2023 at Qlyasan Agricultural Research Station, (Lat 35˚ 34' 307"; N, Long 45˚ 21' 992"; E, 755 MASL), College of Agricultural Engineering Sciences, University of Sulaimani. Three varieties of Grass Pea (*Lathyrus sativus*) namely IF133, IF 102 and IF003 varieties were used. The experiment employed three rows spacing of 20, 40 and 60 cm, arranged factorial in a Randomized Complete Block Design and Repeated 3 times. Planting of seeds was done on December 2, 2022, with each plot composed of 4 rows each 2 m long and crossed 30 cm apart with 30 cm between plants in rows.

Plant Measurements

Sampling was carried out on vegetation stage at %50 flowering and maturity for growth and forage yield. From the net plot area, five randomly selected plants from each were labeled for observation of growth and forage attributes and yields which were determined as follows

Growth and Forage Characters Plant height (cm) the number of branches per plant, the number of days to 50 % flowering, the number of days to 50 % maturity, leaf dry weight, stem dry weight and the leaf to stem ratio.

Forage Yield Components Green forage yield, dry matter, and dry yield. Components of seed yield; Information on seed yield, biological yield, and yield index was collected from every plot. The number of pods per plant, the number of seeds per pod, and the seed production (tons/ha) were other characteristics that were measured. The average weight of all the plants in each plot, expressed in tons per hectare, was used to calculate the biological yield. According to Rahman *et al*. [11], the yield index (HI) was computed as the ratio of seed yield to biological yield.

Seed yield (kg/ha) divided by biological yield (kg/ha) is the yield index (HI).

Statistical analysis

An RCBD-based factorial design was used to evaluate the data, in accordance with Steel *et al*. [12] instructions. The least significant difference (LSD) test was used to compare all means at the 5% significance level.

Result and Discussions

Data on how Grass Pea types affect growth and forage yield parameters are shown in Table 1. Notable differences were seen across the varieties for many traits, but dry leaf weight did not show significant differences among them.

Table (1): Effect of Grass Pea (*Lathyrus sativa*) Varieties on Growth and Forage Yield Character

Variety (A)	Plant Height (cm)	No. of Branches/Plant	Days to 50% Flowering	Days to Maturity	Dry Leaves/ Stem Ratio	Dry Stem Weight (g)	Dry Leaf Weight (g)	D.M (%)	Dry Yield (tons/ ha)	Green Yield (tons/ha)
a1	97.522	6.550	133.928	178.307	1.266	6.829	8.399	15.406	4.620	29.988
a2	84.144	5.945	132.537	170.461	1.489	6.516	9.707	14.759	5.739	39.864
a3	101.389	4.410	122.492	162.521	1.792	5.176	9.258	12.953	4.600	35.511
LSD ($p\leq0.05$)	9.773	0.756	1.559	4.194	0.180	1.203	n.s.	2.331	0.902	4.475

Note n.s = Non-significant at p≤0.05. D.M = Dry Matter.

The results show that variety a3 had the tallest plants at 101.389 cm, while a1 was next at 97.522 cm, and a2 was at 84.144 cm. Variety a1 had the most branches per plant with 6.550, but a3 had the least with 4.410. The days to 50% flowering and maturity indicated that a3 matured faster than a1 and a2. In terms of forage yield, a2 had the best dry yield at 5.739 tons/ha and the best green yield at 39.864 tons/ha, showing it is better for forage production. On the other hand, a1 had a moderate green yield of 29.988 tons/ha and a dry yield of 4.620 tons/ha, while a3 had a similar dry yield to a1 but a higher green yield of 35.511 tons/ha. The dry leaf/stem ratio was highest in a3 at 1.792, meaning there were more leaves than stems, which may help forage quality. Variety a2 had the most dry leaf weight at 9.707 g, though this difference was not significant compared to the others. The dry matter percentage was highest in a1 at 15.406%, which might help with storage and handling.Results of this study are in agreement with those of Karadeniz and Bengisu [9] (2022), and Abdullah and Rafaat [13] who demonstrated the effect of management practices and variety selection on forage yield among legumes. In contrast to Karadeniz and Bengisu [9], who reported results of row space on yield of Forage Pea, we found that variety selection had a substantial effect on Grass Pea growth and yield. Similarly, Abdullah and Rafaat [13], identified differential yields of specific Grass Pea lines under different environmental conditions, further emphasizing the significance of selecting ideal varieties for the production of forage. As reported under results and discussion in Table 2, the effect of row spacing differed with respect to plant height, number of branches, days to flowering and maturity, and forage yield. According to the data, row spacing significantly affected days to maturity and percent dry matter. The minimum time to maturity was achieved with the narrowest row spacing (b1) 255.441 days, and the maximum dry yield (18.915 ton/ha) and green yield (62.812 ton/ha) were obtained from the widest row spacing (b2). On the other hand, plant height, number of branches, days to 50% flowering; dry leaves/stem ratio, dry stem weight and dry leaf weight were not affected significantly by row orientation. The optimum row spacing for overall dry or green forage yield was b2 (row b2 gave the maximum yield) which showed that moderate row spacing may be beneficial for enhanced forage production of Grass Pea. Even though the ratio of dry leaves/stem at wide row spacing (b3) was higher, it did not transform into significantly higher yields. These findings indicate the importance of row spacing on the growth and yield potential of Grass Pea. Particularly the greatest forage yield seems to be in row spacing b2. The results of this study were in agreement with Karadeniz and Bengisu [9], who demonstrated that row spacing greatly affects most of the forage yield and quality traits of forage peas. Specifically, they observed that the greatest distance between rows produced the best forage production, which is in line with the findings of our study and reaffirms the importance of this particular factor in yield optimization.

Table (2): Effect of Row Spacing on Growth and Forage Yield Characters of Grass Pea (*Lathyrus sativa*).

Row Spacing (B)	Plant Height (cm)	No. of Branches/Plant	Days to 50% Flowering	Days to Maturity	Dry Leaves/Stem Ratio	Dry Stem Weight (g)	Dry Leaf Weight (g)	D.M (%)	Dry Yield (tons/ha)	Green Yield (tons/ha)
b1	138.200	8.148	194.948	255.441	2.245	8.685	12.834	26.60	12.789	48.072
b2	142.050	8.502	194.100	259.951	2.156	10.161	14.258	30.11	18.915	62.812
b3	144.333	8.709	194.387	251.542	2.421	8.935	13.954	24.291	13.673	56.289
LSD (p≤0.05)	n.s	n.s	n.s	4.194	n.s	n.s	n.s	2.331	n.s	3.763

Note **n.s = Non-significant at p≤0.05. D.M = Dry Matter**

The interaction effects of Grass Pea varieties and Row spacing on some growth and forage yield parameters such as plant height, total number of branches, days to flowering and maturity, leaf/stem dry ratio, and yield components are recorded in Table 3. Results indicated a significant influence of the Grass Pea varieties and row spacing interaction on plant height, days to 50% flowering, days to maturity, dry stem weight and dry leaf weight. Maximum plant height (105.667 cm) was recorded for variety a3b1while a minimum (72.633 cm) was recorded for variety a2b1. Among varieties, a1b2 had the maximum dry stem weight (8.172 g); in case of leaf, it recorded the maximum leaf dry weight in a2b1 (10.325 g).For yield parameters, variety a2b3 produced the highest green yield (46.720 tons/ha), followed by a3b3 and a2b2 (37.871, 36.412) respectively. However, dry yield differences among the variety and row spacing combinations were not statistically significant. These outcomes are consistent with those of Sayar and Basbag [14], they found that wider row spacing could improve several yield metrics, which is similar to what we found. Both studies emphasize the significance of row spacing and variety combinations in maximizing forage yield, indicating that given a range of spacing conditions, the appropriate combination can improve particular growth traits and yield parameters in legume crops.

Table (3): Effect of Interaction between Grass Pea (*Lathyrus sativa*) Varieties and Row Spacing on Growth and Forage Yield Characters

Varieties × Row Spacing (A × B)	Plant Height (cm)	No. of Branches/Plant	Days to 50% Flowering	Days to Maturity	Dry Leaves/Stem Ratio	Dry Stem Weight (g)	Dry Leaf Weight (g)	D.M (%)	Dry Yield (tons/ha)	Green Yield (tons/ha)
a1b1	98.100	6.357	135.560	176.597	1.375	5.020	6.711	15.476	5.311	26.692
a1b2	100.333	6.604	134.173	180.373	1.141	8.172	9.298	15.737	4.217	35.287
a1b3	94.133	6.689	132.050	177.950	1.283	7.294	9.186	15.006	3.716	27.986
a2b1	72.633	6.049	132.353	171.873	1.455	7.120	10.325	14.480	5.268	36.049
a2b2	80.333	5.397	131.013	177.743	1.367	7.203	10.281	14.578	6.359	36.412
a2b3	99.467	6.390	134.243	161.768	1.644	5.225	8.517	15.219	5.591	46.720
a3b1	105.667	3.889	121.983	162.411	1.659	5.230	8.632	13.921	4.985	33.402
a3b2	103.433	5.003	123.013	161.785	1.804	4.947	8.937	11.915	3.679	35.259
a3b3	95.067	4.339	122.480	163.366	1.914	5.350	10.204	13.023	4.195	37.871
LSD (p≤0.05)	16.927	n.s	2.701	7.264	n.s	2.084	2.127	n.s	n.s	n.s

Note n.s = Non-significant at p≤0.05. D.M = Dry Matter.

Table 4. Shows the influence of Grass Pea varieties (a1, a2, a3) on 100-seed weight, pods no per plant, seeds no per pod, harvest index, biological yield and seed yield There were no significant differences between the varieties in 100-seed weight, pods per plant or seeds per pod, the data shows. Otherwise, variety a3 produced the maximum quantity of seed yield (7.158 tons/ha) and biological yield (15.015 tons/ha) but indicated the better harvest index (0.477) seeds. However, the LSD values were significant only on for harvest index, biological yield and seed yield. Finally, variety a3 gave highest results for seed yield and related traits overall indicating that it is better potential to maximize seed yield in the mentioned environmental conditions. Like the

results of the above study, Piergiovanni *et al*. [15], also has reported highly significant differences among the varieties for seed and biological yield suggesting that varietal selection is the most indispensable mean for increasing productivity of Grass Pea within a particular environment and management.

Table (4): Effect of Grass Pea (*Lathyrus sativa*) Varieties on Seed Yield and Its Components.

Variety (A)	100 Seed Weight (g)	No. of Pods/Plant	No. of Seeds/Pod	Harvest Index	Biological Yield (tons/ha)	Seed Yield (tons/ha)
a1	9.939	31.169	3.231	0.375	12.961	4.869
a2	16.820	31.372	2.831	0.382	13.305	5.076
a3	15.262	33.918	3.188	0.477	15.015	7.158
LSD ($p \leq 0.05$)	n.s	n.s	n.s	0.089	0.901	1.511

Note **n.s = Non-significant at $p \leq 0.05$.**

Table 5. Illustrates the effects of different row spacing (b1, b2, b3) on seed yield and its components, including 100-seed weight, number of pods per plant, number of seeds per pod, harvest index, biological yield, and seed yield. The data indicate that row spacing had a significant effect on biological yield and seed yield but not on 100-seed weight, number of pods per plant, number of seeds per pod, or harvest index. Row spacing b2 gave the best results in terms of seed yield (10.611 tons/ha) and harvest index (0.540), and thus this spacing can be recommended for the purpose of seed production. But b3 produced the largest biological yield of (22.239 tons/ha). Row spacing b2 tended to be more effective in giving maximum seed yield while b3 was beneficial for total biomass production, so reflections on how the spacing has to be vary according to the objective (seed yield or total biomass production).According to Abadouz et al. [16], row spacing has a major impact on alfalfa's biological and seed yields. Their findings were similar to ours in that a wider spacing maximized biological yield, while a moderate row spacing produced the maximum seed yield. This implies that, depending on the objectives of cultivation, row spacing can be used to efficiently balance increasing seed output with total biomass.

Table (5): Effect of Row Spacing on Seed Yield and Its Components of Grass Pea (*Lathyrus sativa*)

Row Spacing (B)	100 Seed Weight (g)	No. of Pods/Plant	No. of Seeds/Pod	Harvest Index	Biological Yield (tons/ha)	Seed Yield (tons/ha)
b1	22.125	48.720	4.518	0.443	19.741	7.610
b2	22.513	46.215	4.798	0.540	19.942	10.611
b3	18.393	49.753	4.558	0.444	22.239	7.434
LSD ($p \leq 0.05$)	n.s	n.s	n.s	n.s	0.901	1.511

Note **n.s = Non-significant at $p \leq 0.05$.**

Table 6. Showed the interaction effects of Grass Pea varieties and row spaced on seed yield and its components. The interaction analysis indicates that b2a3 (row spacing b2 with variety a3) resulted in the higher amount of seed production (7.466

tons/ha), but higher HI b2a2 (0.544) indicate the more effective conversion of resources. Although significant differences were found for harvest index and biological yield, other factors such as seed weight, pods, and seeds per pod were not significantly influenced. In brief, variety and row spacing combinations substantially affect some yield components. The best-performing combinations for seed yield were a3b2 and a2b2 for the harvest index, offering insights for optimal variety and spacing selection to maximize yield efficiency in Grass Pea cultivation. Similar to the findings of Karadeniz and Bengisu [9], highlight the importance of appropriate combinations of varieties and row spacing for better yield efficiency. The above correlation highlights that optimal variety × spacing combinations considerably affect seed yield and harvest index, thereby, serving as an important guide to improve crop productivity through proper management in Grass Pea and other legume systems.

Table (6): Effect of Interactions between Grass Pea (*Lathyrus sativa*) Varieties and Row Spacing on Seed Yield and Its Components.

Varieties × Row Spacing (A × B)	100 Seed Weight (g)	No. of Pods/Plant	No. of Seeds/Pod	Harvest Index	Biological Yield (tons/ha)	Seed Yield (tons/ha)
a1b1	10.600	32.263	3.330	0.223	11.459	3.553
a1b2	10.897	28.927	3.327	0.233	12.681	6.625
a1b3	8.320	32.317	3.037	0.255	14.741	4.430
a2b1	12.693	31.847	2.683	0.284	13.409	4.255
a2b2	18.363	27.823	2.987	0.544	11.995	7.130
a2b3	19.403	34.447	2.823	0.377	14.512	3.842
a3b1	20.957	33.330	3.023	0.378	14.613	7.412
a3b2	15.767	35.680	3.283	0.303	15.207	7.466
a3b3	9.063	32.743	3.257	0.257	15.224	6.596
LSD ($p \leq 0.05$)	n.s	n.s	n.s	0.154	1.560	n.s

Note **n.s = Non-significant at p≤0.05.**

The row spacing and grass pea varieties had a significant effect on seed yield, forage and growth, as the study revealed. The optimum variety was determined to be variety a3 for height of plants and yield of seeds and variety a2 for yield of forage dry and forage of green. For forage and seed production, row spacing b2 was the most effective. DFP showed the maximum seed yield by the interaction of variety a3 and row spacing b2, while the best harvest index highlighting the optimum rate of resource utilization was shown by variety a2b2. We concluded that variety a3 and row spacing b2 show the best trade-off between low yield and high yield level, and it provides practical recommendations to improve the Grass Pea in the Sulaimani Governorate. This significant research will help guide farmers to select varieties and row spacings to complement and maximize production goals in forage and seed yields.

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