FORAGE YIELD RESPONSE OF SOME GRASS PEA GENOTYPES TO ORGANIC FERTILIZER AND STUBBLE HEIGHT IN DIFFERENT ENVIRONMENTAL CONDITIONS OF SULAIMANI REGION- IRAQ

Hevy Latif Saeed — Researcher
Sanarya Rafiq Muhammed — Professor
Dept. Biot. Crop Sci., Coll. Agri.Engi. Sci., University, Sulaimani., Iraq
e-mails: Hevi.saeed@univsul.edu.iq

ABSTRACT

This study was conducted at two locations, Qlyasan Agricultural Research Station and Kanipanka Nursery Station, during the 2023–2024 winter season to investigate the effects of organic fertilizer and stubble height on forage yield attributes of grass pea genotypes. A split-split plot design was used with three factors: fertilizer application (F0= no fertilizer, F1= organic fertilizer), genotypes (G1: Local, G2: IGC-2011-62, G3: IGC-2011-35, G4: IGC-2011-9), and stubble height (SH1= 5cm, SH2 = 10cm). Fertilizer application significantly increased DFY in Kanipanka. Genotype significantly influenced most forage yield attributes, with G1 showing the highest values. Stubble height significantly affected GFY and DFY, particularly in Qlyasan. Kanipanka outperformed Qlyasan in key yield attributes. Cluster analysis identified two genotype groups, indicating genetic variability. Proper management of fertilizer. Interaction effects were observed for fertilizer × genotype and fertilizer × stubble height. Genotype selection and stubble height can optimize forage yield.

Keywords: ***Lathyrus sativus*** **L., cutting height, dry forage yield, green forage yield, dry matter, fertilizer application, locations.**

مجلة العلوم الزراعية العراقية- 2025 :56 (3):1195-1209 سعيد ومحمد

استجابة حاصل العلف لبعض تراكيب وراثية للهرطمان للأسمدة العضوية وارتفاع الحش في ظروف بيئية مختلفة في منطقة السليمانية– العراق

هيفي لطيف سعيد — باحثة
سناريا رفيق محمد — أستاذ
قسم التكنولوجيا الحيوية وعلوم المحاصيل، كلية علوم الهندسة الزراعية، جامعة السليمانية، السليمانية، العراق

المستخلص

تم إجراء هذه الدراسة في محطتي بحوث قلياسان وكانيبانكا خلال موسم الشتوي 2023–2024، بهدف تقييم تأثير السماد العضوي وارتفاع الحش على صفات إنتاج العلف في تراكيب وراثية للهرطمان(Lathyrus sativus L.). تم استخدام تصميم القطع المنشقة مرتين (split–split plot) بثلاثة عوامل: السماد العضوي (F0 = بدون سماد، F1 = سماد عضوي)، التراكيب الوراثية (G1: محلي، G2: IGC–2011–62، G3: IGC–2011–35، G4: IGC–2011–9)، وارتفاع الحش (SH1= 5 سم، SH2= 10 سم). أظهرت النتائج أن السماد العضوي زاد بشكل معنوي من الغلة العلفية الجافة (DFY) في كانيبانكا، بينما أثر التراكيب الوراثية على معظم الصفات الإنتاجية، حيث سجل G1 أعلى القيم. كما أثر ارتفاع الحش بشكل معنوي على GFY وDFY، خاصة في قلياسان. تفوقت كانيبانكا على قلايسان في الصفات الإنتاجية الرئيسية، وكشف تحليل التجمعات عن مجموعتين من التراكيب الوراثية، مما يعكس التباين الوراثي. كما لوحظت تداخلات معنوية بين السماد و التراكيب الوراثية، وكذلك بين السماد وارتفاع الحش، مما يشير إلى أهمية الإدارة المتكاملة لهذه العوامل في تحسين إنتاجية العلف.

الكلمات المفتاحية: *Lathyrus sativus*, ارتفاع القطع, إنتاج العلف الجاف, إنتاج العلف الأخضر, المادة الجافة, تطبيق السماد, المواقع .

Received:23 /12/2024, Accepted:16/5/2025, Published:30 June.

INTRODUCTION

Grass pea (*Lathyrus sativus* L.) is a legume from the Fabaceae family and the subfamily Papilionoidea, tribe Vicieae, with 2n = 14 diploid chromosomes. It is valued for its dual use as a food grain for humans and as forage and livestock feed because it contains heigh level of proteins, it is widely cultivated in arid and semi-arid regions, grass pea thrives in poor soils and withstands environmental stresses such as drought, floods, low temperatures, as well as resistance to diseases (4). Additionally, it is highly resilient to extreme conditions, including cold and heat waves, submergence, and excessive rainfall (5). Beyond its adaptability, grass pea plays a role in improving soil fertility due to its robust root system and nitrogen-fixing ability (19). Despite these benefits, the cultivation of grass pea is limited due to the presence of the neurotoxin ODAP, which can cause lathyrism when consumed in excess (3,6). Stubble height refers to the height of plant stems or stalks remaining above the ground after crops have been harvested or livestock have grazed. It significantly influences plant health and subsequent growth (25). Shorter stubble height has been shown to reduce overall yield and increase weed issues, while higher stubble heights reduce forage yield, as stubble height directly influences the amount of forage harvested (26). Organic fertilizers consist of natural substances obtained from animal, plant, or mineral sources that are applied to soil or crops to provide vital nutrients, to improve soil fertility, and promote healthy plant growth. Unlike synthetic fertilizers, organic fertilizers are either unprocessed or lightly processed and break down naturally, slowly releasing nutrients while improving soil structure and promoting microbial activity (2, 8, 9, 10, 20). Organic fertilizers play a crucial role in enhancing soil structure and nutrient levels, to achieve sustainable crop growth and high economic benefits (13, 23, 27, 28, 29). Genetic diversity is an essential ingredient in forage production as it influences yield potential, adaptability, tolerance to stress, and nutritional content. Genotypic diversity makes it possible to select high-yielding lines that are more productive, stress-tolerant, and nutritious, allowing for sustainable and effective forage production (14). Comparing different genotypes is crucial for identifying the best forage. Comparing grass pea genotypes is essential for selecting optimal forage and seed production and exploring genetic diversity for future breeding. Studies have shown significant variation in growth, yield potential, and responses to management (21). Despite recognizing grass pea's potential as forage, limited studies have explored the combined effects of stubble height, organic fertilizer, and genotype on forage yield, especially under arid and semi-arid conditions. This research aims to investigate the influence of stubble height and organic manure on the forage yield of different genotypes of grass pea under two climatic conditions in the Sulaimani region. The findings will contribute to organic forage sustainability in supporting animal nutrition and organic animal production for improved human health.

MATERIALS AND METHODS

Experimental site: A field experiment was conducted at two different locations, the first was at Qlyasan Agricultural Research Station, College of Agricultural Sciences and Engineering, University of Sulaimani located (Lat. 35˚ 34′ 307″ N, long. 45˚ 21′ 992″ E, 765 masl), 2 km northwest of Sulaimani City, the second was at Kanipanka Nursery Station (Lat. 35˚ 22′ N, long. 45˚ 43′ E, 550 masl) in Sharazur Valley, 35 km east of Sulaimani City (17), during the growing season of 2023-2024.

Experimental design and treatments Distribution: The experiment was laid out according to Split-Split Plot Design, fertilizer applications (F0: No fertilizer and F1: Organic fertilizer) were implemented in the main plots and arranged according to Randomized Complete Block Design (RCBD) with three replications. sub plots consisted of four genotypes of grass pea (G_1: Local, G_2: IGC-2011-62, G_3: IGC-2011-35, and G_4: IGC-2011-9) obtained from ICARDA, and two stubble heights (different height of forage cutting from ground level) {SH_1= 5cm, and SH_2= 10cm from ground level} were allotted in sub-sub plots for forage traits, each sub-sub plot consisted of four rows, each 2m long with 0.30m spacing between rows.

Sowing and harvesting date: Sowing was done during 7th and 8th December 2023 at

Qlyasan and Kanipanka locations, respectively, according to the recommended seed rates of 60 kg ha^{-1} for four genotypes of grass pea (11), and half of plots were fertilized before sowing with 600 kg ha^{-1} of organic fertilizer (natural organics) made from poultry manure with these contents; Nitrogen (N): 5.44%, Phosphorus (P): 4.8%, Potassium (K): 5.2%, Humic Acid + Fulvic Acid: 15%, Manganese (Mn): 453.15 ppm, Sulfur (S): 0.75%, Calcium (Ca): 1.43%, Sodium (Na): 0.58%, Iron (Fe): 3365.5 ppm, Magnesium (Mg): 0.47%, Zinc (Zn): 291.5 ppm, Boron (B): 57.9 ppm, pH: 6.90, Moisture: <12%, Density: 0.75 g/cm³, Organic Matter (OM): 69.98%. All required agricultural practices were used as needed. Forage cutting was conducted for all sub-sub plots on 26th and 27th March 2024 to determine forage yield attributes at Qlyasan and Kanipanka locations, respectively.

Meteorological data: The metrological data of Qlyasan and Kanipanka locations during the growing season of 2023-2024 are shown in Table (1).=

Table 1. The meteorological data of both locations

Months	Qlyasan Location				Kanipanka Location			
	.Mini .Temp (C°)	.Max .Temp (C°)	.Avg Temp(C°)	Rainfall (mm)	.Mini .Temp (C°)	.Max .Temp (C°)	.Avg Temp(C°)	Rainfall (mm)
October	16.2	27.7	21.9	9.3	15.7	29.9	22.8	6.5
November	10.7	20.1	15.4	78.9	9.7	21.6	15.7	101.0
December	6.9	16.4	11.7	59.1	6.3	17.3	11.8	81.5
January	5.4	13.4	9.4	97.7	6.1	14.8	10.44	134.5
February	5.0	13.1	9.1	196.5	5.0	14.1	9.55	124.0
March	7.7	17.5	12.6	144.6	7.1	18.8	12.95	219.0
April	15.8	27.2	21.5	38.6	12.5	28.1	20.3	52.5
May	16.3	27.8	22.1	99.6	15.1	29.8	22.45	110.5
Total rainfall				724.3				829.5

***(Sulaimani Directorate of Meteorology and Seismology)**

Soil analysis: From both experimental fields Qlyasan and Kanipanka location, the soil samples were taken before tillage at a depth of 0.30 cm, air dried, then sieved through a 2 mm aperture, and finally packed for analysis at the Natural Resources Department, College of Agricultural Engineering Sciences, University of Sulaimani to analyze some physical and chemical properties of soil, as shown in (Table 2).

Table 2. Some physical and chemical properties of soil analysis at experimental sites

Soil properties	Qlyasan Soil Samples	Kanipanka Soil Samples
Sand $g.kg^{-1}$	106.4	33.4
Silt $g.kg^{-1}$	451.5	656.9
Clay $g.kg^{-1}$	442.1	309.7
Texture	Silty Clay	Silty Clay Loam
EC dS m^{-1} at 25°C	0.7	0.11
PH	7.85	7.45
N%	0.14	0.15
Organic matter%	1.13	1.139

*** Natural Resource Department, College of Agricultural Engineering Sciences, University of Sulaimani**

Cluster Analysis: The Hierarchical Cluster Analysis, based on Euclidean Distance and Unweighted Pair-group Method with Arithmetic Linkage (UPGMA), was performed to classify grass

Statistical Analysis: The data collected from the experiment were analyzed by using R language (version 4.4.2) and SPSS (Version 27) statistical software. The experimental design employed was a split-split plot arrangement, and mean comparisons were carried out using the least significant difference test (LSD) at a significance level of 0.05.

RESULTS AND DISCUSSIONS

The statistical analysis in Table (3) shows that the effect of fertilizer on all forage yield attributes did not significant at both locations and their means, except dry forage yield (DFY), which was found to be significant at the Kanipanka location and in the mean of both locations only. The highest dry forage yield was 1.95 and 1.20ton ha^{-1}, exhibited by the application of organic fertilizer F1, while the lowest yield of dry forage recorded by no fertilizer application F0 was 1.78 and 1.09ton ha^{-1} in Kanipanka and the mean of both locations, respectively. The increases in dry forage yield by organic fertilizer application can be attributed to its slow nutrient release, which enhances soil fertility over time, leading to higher biomass accumulation. Also, organic fertilizer improves soil structure, microbial activity, and moisture retention, which may have contributed to increasing dry forage yield. This result agrees with the findings of (7,18). However, others (24) found that the dry mass yield of alfalfa fertilized with manure was up to 15.9% higher compared to mineral fertilizer, highlighting the effectiveness of organic fertilizers in enhancing dry matter yield.

Table 3. Effect of fertilizer on plant height and forage yield attributes of grass pea

Fertilizer	PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	DL/S Ratio
Qlyasan Location							
F0	28.55	3.09	0.41	13.28	11.45	1.83	6.64
F1	28.33	3.40	0.45	13.47	11.60	1.89	6.94
LSD (P≤0.05)	N. S	N. S	N. S	N. S	N. S	N. S	N. S
Kanipanka Location							
Fertilizer	PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	DL/S Ratio
F0	59.30	18.60	1.78	9.93	6.66	3.27	2.07
F1	58.19	19.34	1.95	10.14	6.84	3.30	2.10
LSD (P≤0.05)	N. S	N. S	0.11	N. S	N. S	N. S	N. S
Mean of both Locations							
Fertilizer	PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	DL/S Ratio
F0	43.93	10.84	1.09	11.61	9.06	2.55	4.36
F1	43.26	11.37	1.20	11.81	9.22	2.59	4.52
LSD (P≤0.05)	N. S	N. S	0.10	N. S	N. S	N. S	N. S

N.S: Not Significant

The data in Table (4) shows that the effect of genotypes on all forage yield attributes was significant in Qlyasan, Kani Panka, and the means of both locations, except for dry matter percent at Qlyasan, which was not significant. In Qlyasan location, the maximum values of plant height PH, green forage yield GFY, dry forage yield DFY, and dry stem percent DS% recorded by G1 were 29.55cm, 3.84ton ha^{-1}, 0.51ton ha^{-1}, and 2.07%, respectively. Meanwhile, the minimum values of these traits were 26.30cm, 2.15 ton/ha, 0.29 ton/ha, and 1.59% obtained by G4. However, regarding dry leaf percent DL% and dry leaf/stem ratio DL/S ratio, maximum values were 11.99% and 8.56, respectively, shown by G4, whereas minimum values of both traits were 11.23% and 5.61, respectively, recorded by G1. In Kanipanka location, the highest values of PH, DFY, and DS% recorded by G1 were (63.75cm, 2.20ton ha^{-1}, and 3.46% respectively, but G2 had maximum GFY was 22.29ton ha^{-1}, and G4 showed the highest values of DL% and DL%S ratio were 7.42% and 2.37 respectively, in which minimum values of PH, GFY and DS% were 53.64cm, 15.54ton ha^{-1} and 3.16% respectively exhibited by G4, and lowest DFY was 1.48ton ha^{-1} recorded by G3. Regarding DM% and DL%, G2 gave the minimum percent of both traits were 9.50% and 6.22%, but G1 showed the minimum DL/S ratio, which was 1.88. Also, in the mean of both locations, as in the Qlyasan location, the maximum values of PH, GFY, DFY, and DS% were 46.65cm, 13.03ton ha^{-1}, 1.36ton ha^{-1}, and 2.77%, respectively, recorded by G1. Although maximum DM%, DL%, and DL/S ratio exhibited by G4 were 12.08%, 9.71%, and 5.47 respectively, G4 also had the lowest PH, GFY, and DS%, which were 39.97cm, 38.84ton ha^{-1}, and 2.37%, but minimum DFY was 0.96ton ha^{-1}recorded by G3, and 11.29% and 8.75% for DM% and DL% observed by G2, while smallest DL/S ratio was 3.74 exhibited by G1. The variation in genotypic response to forage yield attributes may be due to genetic variation among genotypes. These findings suggest that genotype selection plays a crucial role in optimizing forage production under varying environmental conditions. Fodder yield is a function of genetic as well as environmental factors that play a vital role in plant growth and development, and ultimately contribute to fodder yield. This result aligns with previous finding (1) Previously confirmed that the maximum green forage yield was contributed by the 'Marble' (Local) genotype of grass pea, while the minimum was contributed by genotype IF1953 However, the maximum dry matter content was contributed by genotype IF1346, while the minimum was contributed by IF1332 (21).

Table 4. Effect of genotypes on plant height and forage yield attributes of grass pea

			Qlyasan Location				
Genotypes	**PH (cm)**	**GFY (Ton/ha)**	**DFY (Ton/ha)**	**D.M%**	**DL%**	**DS%**	**DL/S Ratio**
G1	**29.55**	**3.84**	**0.51**	**13.29**	**11.23**	**2.07**	**5.61**
G2	**28.69**	**3.76**	**0.49**	**13.08**	**11.28**	**1.80**	**6.70**
G3	**29.22**	**3.22**	**0.43**	**13.56**	**11.61**	**1.95**	**6.31**
G4	**26.30**	**2.15**	**0.29**	**13.58**	**11.99**	**1.59**	**8.56**
LSD (P≤0.05)	**1.22**	**0.43**	**0.06**	**N. S**	**0.71**	**0.24**	**1.44**
			Kanipanka Location				
Genotypes	**PH (cm)**	**GFY (Ton/ha)**	**DFY (Ton/ha)**	**D.M%**	**DL%**	**DS%**	**DL/S Ratio**
G1	**63.75**	**22.22**	**2.20**	**9.93**	**6.46**	**3.46**	**1.88**
G2	**60.53**	**22.29**	**2.11**	**9.50**	**6.22**	**3.29**	**1.92**
G3	**57.08**	**15.82**	**1.48**	**10.14**	**6.91**	**3.24**	**2.16**
G4	**53.64**	**15.54**	**1.65**	**10.58**	**7.42**	**3.16**	**2.37**
LSD (P≤0.05)	**0.90**	**0.53**	**0.20**	**0.44**	**0.37**	**0.27**	**0.23**
			Mean of both Locations				
Genotypes	**PH (cm)**	**GFY (Ton/ha)**	**DFY (Ton/ha)**	**D.M%**	**DL%**	**DS%**	**DL/S Ratio**
G1	**46.65**	**13.03**	**1.36**	**11.61**	**8.84**	**2.77**	**3.74**
G2	**44.61**	**13.03**	**1.30**	**11.29**	**8.75**	**2.54**	**4.31**
G3	**43.15**	**9.52**	**0.96**	**11.85**	**9.26**	**2.59**	**4.23**
G4	**39.97**	**8.84**	**0.97**	**12.08**	**9.71**	**2.37**	**5.47**
LSD (P≤0.05)	**0.63**	**0.29**	**0.11**	**0.42**	**0.39**	**0.18**	**0.73**

N.S: Not Significant

Data in Table (5) illustrates that the effect of stubble height on forage yield attributes did significant for most traits but not significant for some traits at Qlyasan, Kanipanka, and the mean of both locations. In the Qlyasan location, the effect was significantly different for these traits, GFY, DFY, DS%, and DL/S ratio, but for the others, it was found to be not significant. The highest values of GFY, DFY, and DS% were 3.76ton ha^{-1}, 0.56ton ha^{-1}, and 2.14%, respectively, observed by 5cm stubble height SH1, but the maximum DL/S ratio was 8.20 recorded by 10cm stubble height SH_2. However, in Kanipanka location, most of the traits were not significant except plant height and green forage yield, which were significant, the highest plant was 60.46cm recorded by SH_2 in compared to SH_1 which recorded minimum plant height 57.04cm, and the highest yield of green forage was 20.09ton ha^{-1} obtained by SH_1, while SH_2 produced lowest yield of green forage 17.85ton ha^{-1}. Regarding the mean of both locations, all traits were significantly different except for dry matter percent, which was found to be non-significant. Maximum PH, DL%, and DL/S ratio were 44.52cm, 9.31%, and 5.16%, respectively, exhibited by SH2 when plants were cut at 10cm stubble height, compared to SH1, which recorded the minimum values of these traits: 42.67cm, 8.96%, and 3.71%. Concerning GFY, DFY, and DS%, the highest values were 11.92ton ha^{-1}, 1.21ton ha^{-1}, and

2.72%, respectively, observed by SH1 when plants were cut at 5cm stubble height, whereas SH2 gave the minimum values of these traits: 10.29ton ha^{-1}, 1.08ton ha^{-1}, and 2.42%, respectively. The results confirm that cutting grass pea at a lower stubble height increases fresh, dry forage yields, and dry stem percent because more plant material is harvested. However, leaving a taller stubble increases dry leaf percent and dry leaf/stem ratio, and can also improve forage quality by reducing the proportion of fibrous stem material, which is higher in fiber and lower in digestibility, and increasing the proportion of nutrient-rich leaf material and digestibility. These findings agree with the previous results of (15,25 ,26).

Table 5. Effect of stubble height on plant height and forage yield attributes of grass pea

Stubble Height	PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	DL/S Ratio
Qlyasan Location							
SH_1 (5cm)	28.30	3.76	0.50	13.39	11.25	2.14	5.38
SH_2 (10cm)	28.58	2.73	0.36	13.36	11.80	1.56	8.20
LSD ($P \leq 0.05$)	N. S	0.21	0.03	N. S	N. S	0.21	1.07
Kanipanka Location							
Stubble Height	PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	DL/S Ratio
SH_1 (5cm)	57.04	20.09	1.93	9.97	6.67	3.29	2.05
SH_2 (10cm)	60.46	17.85	1.80	10.11	6.83	3.28	2.12
LSD ($P \leq 0.05$)	0.90	0.37	N. S	N. S	N. S	N. S	N. S
Means of both Locations							
Stubble Height	PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	DL/S Ratio
SH_1 (5cm)	42.67	11.92	1.21	11.68	8.96	2.72	3.71
SH_2 (10cm)	44.52	10.29	1.08	11.73	9.31	2.42	5.16
LSD ($P \leq 0.05$)	0.53	0.20	0.08	N. S	0.30	0.15	0.53

N.S: Not Significant

The data between in Table (6) shows the interaction effect of fertilizer and genotypes on forage yield attributes in Qlyasan, Kanipanka, and the mean of both locations. There were no significant differences in all traits except for green forage yield and dry forage yield in Qlyasan, green forage yield and dry leaf percent in Kanipanka, and the mean of both locations where significant differences were observed. Maximum GFY values were 4.46, 22.45, and 13.46ton ha^{-1} obtained by the interaction between F1 and G2 at Qlyasan, Kanipanka, and the mean of both locations, respectively, while the minimum values of this trait were recorded when F1 interacted with G4 at Qlyasan, Kanipanka, and the mean of both locations at 1.90, 14.39, and 8.40ton ha^{-1}, respectively. Regarding DFY, the highest value was 0.57ton ha^{-1}, exhibited by the interaction between F1 and G2, whereas the lowest value was 0.26ton ha^{-1}, shown by the association of F1 with G4 in Qlyasan location. Also, F1G2 gave the maximum DL% of 7.45% and 9.80%, in which the minimum value of this trait was 6.01% and 8.49% at Kanipanka and the mean of both locations, respectively.

Table 6. Interaction effect of fertilizer and genotypes on plant height and forage attributes of grass pea

Fertilizer	Genotype	PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	D L/S Ratio
Qlyasan Location								
F_0	G_1	30.05	3.67	0.49	13.23	11.22	2.00	5.67
	G_2	28.33	3.06	0.40	13.34	11.60	1.75	7.22
	G_3	29.16	3.21	0.41	13.07	11.15	1.92	5.97
	G_4	26.66	2.41	0.32	13.50	11.83	1.67	7.71
F_1	G_1	29.05	4.01	0.54	13.36	11.23	2.14	5.54
	G_2	29.05	4.46	0.57	12.83	10.96	1.86	6.17
	G_3	29.28	3.24	0.44	14.05	12.07	1.98	6.64
	G_4	25.94	1.90	0.26	13.65	12.15	1.50	9.41
LSD($P \le 0.05$)		N. S	0.62	0.09	N. S	N. S	N. S	N. S
Kanipanka Location								
F_0	G_1	64.28	22.43	2.21	9.90	6.29	3.61	1.76
	G_2	60.77	22.14	2.11	9.58	6.42	3.15	2.06
	G_3	57.50	15.44	1.28	9.80	6.54	3.26	2.02
	G_4	54.67	14.39	1.51	10.47	7.40	3.07	2.43
F_1	G_1	63.22	22.02	2.19	9.96	6.63	3.33	2.00
	G_2	60.28	22.45	2.12	9.43	6.01	3.42	1.77
	G_3	56.67	16.21	1.69	10.49	7.28	3.21	2.29
	G_4	52.61	16.69	1.78	10.70	7.45	3.25	2.32
LSD ($P \le 0.05$)		N. S	0.75	N. S	N. S	0.53	N. S	N. S
Mean of both Locations								
F_0	G_1	47.16	13.05	1.35	11.56	8.76	2.80	3.72
	G_2	44.55	12.60	1.26	11.46	9.01	2.45	4.64
	G_3	43.33	9.32	0.85	11.43	8.84	2.59	4.00
	G_4	40.66	8.40	0.91	11.98	9.62	2.37	5.07
F_1	G_1	46.13	13.01	1.37	11.66	8.93	2.73	3.77
	G_2	44.66	13.46	1.35	11.13	8.49	2.64	3.97
	G_3	42.97	9.72	1.07	12.27	9.68	2.59	4.47
	G_4	39.27	9.29	1.02	12.17	9.80	2.38	5.86
LSD ($P \le 0.05$)		N. S	0.41	N. S	N. S	0.55	N. S	N. S

N.S: Not Significant

Data in Table (7) indicates the effect of the interaction between fertilizer and stubble height on forage yield attributes of grass pea at Qlyasan, Kanipanka, and the mean of both locations. This effect was not significant on all forage yield attributes except GFY and DFY in Qlyasan and PH in Kanipanka, where the mean of both locations was found to be significant. In the Qlyasan location, the maximum values of GFY and DFY, recorded by the interaction between organic fertilizer application and 5 cm stubble height (F1SH1), were 4.05tons ha^{-1} and 0.55tons ha^{-1}, respectively. Meanwhile, the minimum values of both traits were 2.70tons ha^{-1} and 0.36tons ha^{-1}, obtained by the F0SH2 interaction (without fertilizer and 10cm stubble height). In Kanipanka and the mean of both locations, the maximum value of PH was 60.55cm, observed with F1SH2 (organic fertilizer with 10cm stubble height) at Kanipanka, and 44.53 cm at the mean of both locations, exhibited by F0SH2 (no fertilizer with 10cm stubble height). In contrast, F1SH1 (organic fertilizer with 5cm stubble height) gave the minimum values of PH, 55.83cm and 42.01cm in Kanipanka and the mean of both locations, respectively.

Table 7. Interaction effect of fertilizer and stubble height on plant height and forage yield attributes of grass pea

Fertilizer	Stubble Height	PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	D L/S Ratio
Qlyasan Location								
F_0	SH_1 (5cm)	28.41	3.47	0.46	13.19	11.13	2.07	5.44
	SH_2 (10cm)	28.69	2.70	0.36	13.37	11.77	1.60	7.85
F_1	SH_1 (5cm)	28.19	4.05	0.55	13.60	11.38	2.22	5.33
	SH_2 (10cm)	28.47	2.75	0.36	13.34	11.82	1.52	8.55
LSD ($P \leq 0.05$)		N. S	0.30	0.05	N. S	N. S	N. S	N. S
Kanipanka Location								
F_0	SH_1 (5cm)	58.25	19.76	1.78	9.74	6.55	3.19	2.08
	SH_2 (10cm)	60.36	17.43	1.77	10.13	6.78	3.35	2.06
F_1	SH_1 (5cm)	55.83	20.42	2.07	10.19	6.80	3.40	2.01
	SH_2 (10cm)	60.55	18.26	1.82	10.09	6.89	3.21	218
LSD ($P \leq 0.05$)		1.27	N. S	N. S	N. S	N. S	N. S	N. S
Mean of both Locations								
F_0	SH_1 (5cm)	43.33	11.61	1.12	11.47	8.84	2.63	3.76
	SH_2 (10cm)	44.53	10.07	1.06	11.75	9.28	2.47	4.96
F_1	SH_1 (5cm)	42.01	12.23	1.31	11.90	9.09	2.81	3.67
	SH_2 (10cm)	44.51	10.51	1.09	11.72	9.35	2.36	5.37
LSD ($P \leq 0.05$)		0.75	N. S	N. S	N. S	N. S	N. S	N. S

N.S: Not Significant

Results in Table (8) confirms the data analysis of the interaction effect between genotypes and stubble height on forage yield attributes. Most of the traits show no significant differences in Qlyasan, while some traits showed significant differences, such as plant height, dry leaf percent, and dry leaf/stem ratio. Moreover, in Kanipanka, there is a significant difference in plant height and green forage yield only, while the other traits remain non-significant. Also, in the mean of both locations, significant differences were observed for plant height, green forage yield, and dry leaf/stem ratio, while for the rest of the traits, which were found to be not significant.In Qlyasan location, the maximum value of PH was 30.33cm shown by G1SH2 genotype 1 with 10cm stubble height, and maximum DL% and DL/S ratio were 12.57% and 11.38%, respectively, recorded by G4SH2 genotype 4 with 10cm stubble height, while the minimum value of PH was 26.11cm recorded by the interaction between genotype 4 and 5cm stubble height G4SH1, but for DL% and DL/S ratio, they were 10.83% and 4.79%, respectively, produced by G3SH1 genotype 3 with 5cm stubble height.The highest values of PH were 65.72cm and 48.02cm formed by G1SH2, but the lowest values of both traits were 50.39cm and 38.25cm recorded by G4SH1 at Kanipanka and the mean of both locations, respectively. The maximum GFY was obtained by the interaction between G2 and SH1 which were 24.42ton ha^{-1} and 14.34ton ha^{-1}, whereas the minimum values were 14.91ton ha^{-1} and 18.43ton ha^{-1} produced by G3SH2 and G4SH2, respectively, at Kanipanka and the mean of both locations. Regarding DL/S ratio, at the mean of both locations, the maximum ratio was 6.88, recorded by genotype 4 when cut at 10 cm stubble height G4SH2, while the minimum ratio was 3.45, exhibited by the G3H1 interaction.

Table 8. Interaction effect of genotypes and stubble height on plant height and forage yield attributes

Genotypes	Stubble Height	PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	D L/S Ratio
Qlyasan Location								
G_1	SH_1 (5cm)	28.78	4.34	0.59	13.64	11.39	2.25	5.23
	SH_2 (10cm)	30.33	3.34	0.43	12.95	11.06	1.89	5.98
G_2	SH_1 (5cm)	29.22	4.26	0.57	13.40	11.39	2.01	5.77
	SH_2 (10cm)	28.16	3.26	0.41	12.77	11.17	1.60	7.62
G_3	SH_1 (5cm)	29.11	3.82	0.50	13.11	10.83	2.28	4.79
	SH_2 (10cm)	29.33	2.63	0.36	14.00	12.38	1.62	7.82
G_4	SH_1 (5cm)	26.11	2.61	0.35	13.45	11.41	2.04	5.74
	SH_2 (10cm)	26.50	1.69	0.23	13.71	12.57	1.13	11.38
LSD ($P \leq 0.05$)		0.94	N. S	N. S	N. S	1.10	N. S	2.15
Kanipanka Location								
G_1	SH_1 (5cm)	61.77	23.30	2.26	9.70	6.30	3.40	1.87
	SH_2 (10cm)	65.72	21.14	2.15	10.15	6.62	3.53	1.90
G_2	SH_1 (5cm)	59.78	24.42	2.30	9.40	6.08	3.33	1.84
	SH_2 (10cm)	61.28	20.17	1.93	9.60	6.36	3.25	1.99
G_3	SH_1 (5cm)	56.22	16.73	1.46	10.16	6.88	3.28	2.11
	SH_2 (10cm)	57.94	14.91	1.50	10.13	6.93	3.20	2.21
G_4	SH_1 (5cm)	50.39	15.91	1.69	10.61	7.43	3.17	2.37
	SH_2 (10cm)	56.89	15.17	1.60	10.56	7.42	3.15	2.38
LSD ($P \leq 0.05$)		1.80	0.76	N. S	N. S	N. S	N. S	N. S
Mean of both Locations								
G_1	SH_1 (5cm)	45.27	13.82	1.43	11.67	8.84	2.83	3.55
	SH_2 (10cm)	48.02	12.24	1.29	11.55	8.84	2.71	3.94
G_2	SH_1 (5cm)	44.50	14.34	1.43	11.40	8.73	2.67	3.81
	SH_2 (10cm)	44.72	11.71	1.17	11.18	8.76	2.42	4.81
G_3	SH_1 (5cm)	42.61	10.28	0.98	11.64	8.86	2.78	3.45
	SH_2 (10cm)	43.64	8.77	0.93	12.06	9.66	2.41	5.01
G_4	SH_1 (5cm)	38.25	9.26	1.02	12.03	9.42	2.61	4.05
	SH_2 (10cm)	41.69	8.43	0.92	12.13	9.99	2.14	6.88
LSD ($P \leq 0.05$)		1.07	0.39	N. S	N. S	N. S	N. S	1.06

N.S: Not Significant

Results in Table (9a) shows the effect of interactions among fertilizer, genotypes, and stubble height on forage yield attributes of grass pea at Qlyasan location which was found not significant for all traits with the exception of the trait plant height and green forage yield was observed significant. Maximum PH was 31.0cm recorded by interaction among treatments $F_OG_1SH_2$ no fertilizer application with genotype one and 10cm stubble height, while organic fertilizer with genotype 4 and 5cm stubble height $F_1G_4SH_1$ gave minimum PH was 25.44cm. on the other hand, the highest value of GFY was 4.79ton ha^{-1} produced by interaction among $F_1G_2SH_1$ organic fertilizer with genotype 2 and 5cm stubble height, whereas the lowest value was 1.34ton ha^{-1} exhibited by $F_1G_4SH_2$ interaction.

Table 9a. Interaction effect of fertilizer, genotypes and stubble height on plant height and forage yield attributes at Qlyasan location

Fertilizer: Genotypes: Stubble Height			PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	D L/S Ratio
			Qlyasan Location						
F_0	G_1	SH_1 (5cm)	29.11	4.09	0.54	13.21	11.13	2.08	5.43
		SH_2(10cm)	31.00	3.25	0.43	13.24	11.32	1.93	5.91
	G_2	SH_1 (5cm)	30.11	3.73	0.49	13.26	11.31	1.95	5.86
		SH_2(10cm)	26.55	2.39	0.34	13.42	11.88	1.54	8.58
	G_3	SH_1 (5cm)	27.66	3.28	0.42	13.05	10.86	2.19	4.97
		SH_2(10cm)	30.66	3.14	0.41	13.08	11.43	1.65	6.97
	G_4	SH_1 (5cm)	26.77	2.78	0.37	13.25	11.20	2.05	5.47
		SH_2(10cm)	26.55	2.03	0.28	13.74	12.46	1.28	9.95
F_1	G_1	SH_1 (5cm)	28.44	4.59	0.65	14.07	11.65	2.42	5.03
		SH_2(10cm)	29.66	3.42	0.43	12.66	10.81	1.85	6.05
	G_2	SH_1 (5cm)	28.33	4.79	0.65	13.54	11.47	1.95	5.67
		SH_2(10cm)	29.77	4.13	0.50	12.11	10.46	1.65	6.67
	G_3	SH_1 (5cm)	30.55	4.37	0.57	13.17	10.80	2.37	4.60
		SH_2(10cm)	28.00	2.11	0.31	14.92	13.34	1.58	8.68
	G_4	SH_1 (5cm)	25.44	2.45	0.33	13.64	11.62	2.02	6.01
		SH_2(10cm)	26.44	1.34	0.28	13.67	12.68	0.99	12.82
LSD ($P \leq 0.05$)			1.33	0.60	N. S	N. S	N. S	N. S	N. S

N.S: Not Significant

Data in Table (9b) represents interaction effect among fertilizer, genotypes, and stubble height on forage yield attributes at Kanipanka location was significantly difference for these traits plant height, green forage yield, dry matter percent and dry leaf percent, while for other traits dry forage yield, dry stem percent, and dry leaf/stem ratio was found to be not significant. Maximum PH value was 67.66cm observed by interaction among $F_0G_1SH_2$, while F1G4SH1, produced minimum value of PH which was 49.55cm, but maximum GFY was 24.75ton ha^{-1} produced by $F_0G_2SH_1$ interaction, in which $F_OG_4SH_2$ interaction had minimum value of GFY was 13.71ton ha^{-1}. Concerning dry matter percent DM%, the highest percent 10.93% was obtained by $F_1G_4SH_1$, and the lowest percent was 9.11% showed by interaction $F_0G_2SH_1$, meanwhile, maximum DL% was 7.70% exhibited by interaction among treatments $F_1G_3SH_2$, in which minimum value of this trait was 5.85% observed by $F_1G_2SH_2$ interaction.Regarding the mean of both locations data shows in table (9c), the effect of interaction among fertilizer, genotypes, and stubble height on forage yield attributes was significant for plant height, green forage yield, dry matter percent, and dry leaf percent such as Kanipanka location and not significant for other traits. Maximum PH was 49.33cm recorded by $F_0G_1SH_2$, while the interaction among treatment $F_OG_4SH_1$ had minimum value of PH which was 37.50cm. Although, the highest yield of green forage GFY was 14.44ton ha^{-1} produced by $F_1G_2SH_1$, and the lowest yield 7.87ton ha^{-1} exhibited by $F_OG_4SH_2$ interaction. Concerning dry matter and dry leaf percent, the highest value of both traits was 12.90% and 10.52% showed by the interaction among traits $F_1G_3SH_2$, while the lowest values were 10.64% and 8.16% for DM% and DL% respectively recorded by $F_1G_2SH_2$ interaction.

Table 9b. Interaction effect of fertilizer, genotypes and stubble height on plant height and forage yield attributes at Kanipanka location

Kanipanka Location									
Fertilizer: Genotypes: Stubble Height			PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	D L/S Ratio
F_0	G_1	SH_1 (5cm)	60.89	23.95	2.24	9.35	5.91	3.45	1.74
		SH_2(10cm)	67.66	20.90	2.19	10.44	6.67	3.76	1.78
	G_2	SH_1 (5cm)	62.11	24.75	2.25	9.11	5.99	3.12	1.92
		SH_2(10cm)	59.44	19.52	1.96	10.04	6.86	3.18	2.20
	G_3	SH_1 (5cm)	58.77	15.28	1.09	10.22	6.91	3.31	2.09
		SH_2(10cm)	56.22	15.59	1.46	9.38	6.16	3.21	1.96
	G_4	SH_1 (5cm)	51.22	15.06	1.55	10.28	7.39	2.89	2.56
		SH_2(10cm)	58.11	13.71	1.46	10.66	7.42	3.24	2.30
F_1	G_1	SH_1 (5cm)	62.66	22.64	2.28	10.05	6.69	3.36	2.00
		SH_2(10cm)	63.77	21.39	2.11	9.86	6.57	3.29	2.01
	G_2	SH_1 (5cm)	57.44	24.09	2.34	9.69	6.16	3.53	1.76
		SH_2(10cm)	63.11	20.81	1.90	9.16	5.85	3.31	1.79
	G_3	SH_1 (5cm)	53.67	18.18	1.84	10.10	6.86	3.24	2.13
		SH_2(10cm)	59.66	14.23	1.55	10.88	7.70	3.18	2.46
	G_4	SH_1 (5cm)	49.55	16.75	1.83	10.93	7.47	3.45	2.17
		SH_2(10cm)	55.66	16.63	1.74	10.46	7.42	3.05	2.46
LSD ($P \le 0.05$)			2.55	1.07	N. S	0.83	0.80	N. S	N. S

N.S: Not Significant

Table 9c. Interaction effect of fertilizer, genotypes and stubble height on forage yield attributes at the mean of both locations

Mean of both Locations									
Fertilizer: Genotypes: Stubble Height			PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	D.M%	DL%	DS%	D L/S Ratio
F_0	G_1	SH_1 (5cm)	45.00	14.02	1.39	11.28	8.52	2.76	3.58
		SH_2(10cm)	49.33	12.08	1.31	11.84	9.00	2.84	3.85
	G_2	SH_1 (5cm)	46.11	14.24	1.37	11.18	8.65	2.54	3.89
		SH_2(10cm)	43.00	10.96	1.14	11.73	9.37	2.36	5.39
	G_3	SH_1 (5cm)	43.22	9.28	0.76	11.63	8.89	2.75	3.53
		SH_2(10cm)	43.44	9.36	0.93	11.23	8.80	2.43	4.46
	G_4	SH_1 (5cm)	39.00	8.92	0.96	11.77	9.30	2.47	4.02
		SH_2(10cm)	42.33	7.87	0.87	12.20	9.94	2.26	6.12
F_1	G_1	SH_1 (5cm)	45.55	13.62	1.46	12.06	9.17	2.89	3.51
		SH_2(10cm)	46.72	12.41	1.27	11.26	8.69	2.57	4.03
	G_2	SH_1 (5cm)	42.89	14.44	1.49	11.62	8.82	2.80	3.72
		SH_2(10cm)	46.44	12.47	1.20	10.64	8.16	2.48	4.23
	G_3	SH_1 (5cm)	42.11	11.28	1.20	11.64	8.83	2.80	3.37
		SH_2(10cm)	43.83	8.17	0.93	12.90	10.52	2.38	5.57
	G_4	SH_1 (5cm)	37.50	9.60	1.08	12.28	9.55	2.74	4.09
		SH_2(10cm)	41.05	9.98	0.96	12.07	10.05	2.02	7.64
LSD ($P \le 0.05$)			1.51	0.56	N. S	0.83	0.86	N. S	N. S

N.S: Not Significant

Data in Table (10) shows the presence of significant differences for all forage yield attributes as affected by locations. Kanipanka location predominated Qlyasan location in the plant height (PH), green forage yield (GFY), dry forage yield (DFY), and dry stem percent (DS%) by %51.59, %82.90, %76.92, and

%43.66 respectively, while Qlyasn location exceeded Kanipanka location in other traits as dry matter percent (DM%), dry leaf percent (DL%), and dry leaf/stem (DL/S) ratio by %24.96, %41.42, and %69.34 respectively. The superiority of Kanipanka location in forage yield may be due to the suitability of environmental condition through vegetative growth stage especially the temperature and amount of rainfall in compare to Qlyasan location. Previous results confirmed that the variations in yield can occur because of variations in genetic, soil, weather, and other growing conditions (16,22)

Table 10. Effect of locations on plant height and forage yield attributes of grass pea

Locations	PH (cm)	GFY (Ton/ha)	DFY (Ton/ha)	DM%	DL%	DS%	D L/S Ratio
Qlyasan	28.4415	3.2435	0.4296	13.3769	11.5256	1.8513	6.7924
Kanipanka	58.7469	18.9679	1.8614	10.0381	6.7521	3.2862	2.0826
LSD ($P\leq0.05$)	2.59	1.99	0.198	0.43	0.49	0.22	1.13

Figure (1) shows cluster analysis results of four grass pea genotypes based on forage yield attributes at Qlyasan location. The results reveal that there were two major (K=2) groups for studied grass pea genotypes, the first group consist of three genotypes were (G_1, G_3 and G_2) and the second group was one genotype (G_4). These results indicate that the genotypes in group one was close to each other in agro-morphology and differ with G4 in the second group

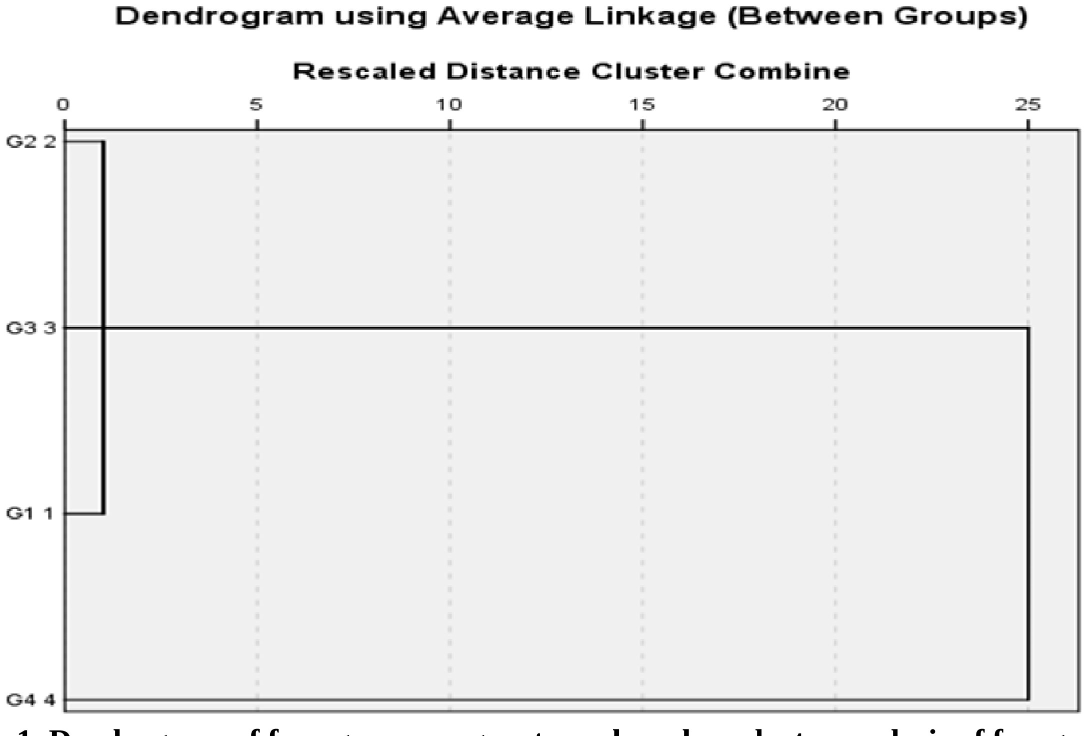

Figure 1. Dendrogram of four grass pea genotypes based on cluster analysis of forage yield attributes at Qlyasan location

Figure (2) shows cluster analysis results of four grass pea genotypes based on forage yield attributes at Kanipanka location. The dendrogram shows that there were two major (K=2) groups for studied grass pea genotypes, the first group consist of two genotypes were (G_1 and G_2) and the second group was two genotypes (G_3 and G_4). These results indicate the presence of variability due to agro-morphology among genotypes used in this study. This result agrees with the previous result found by (21).

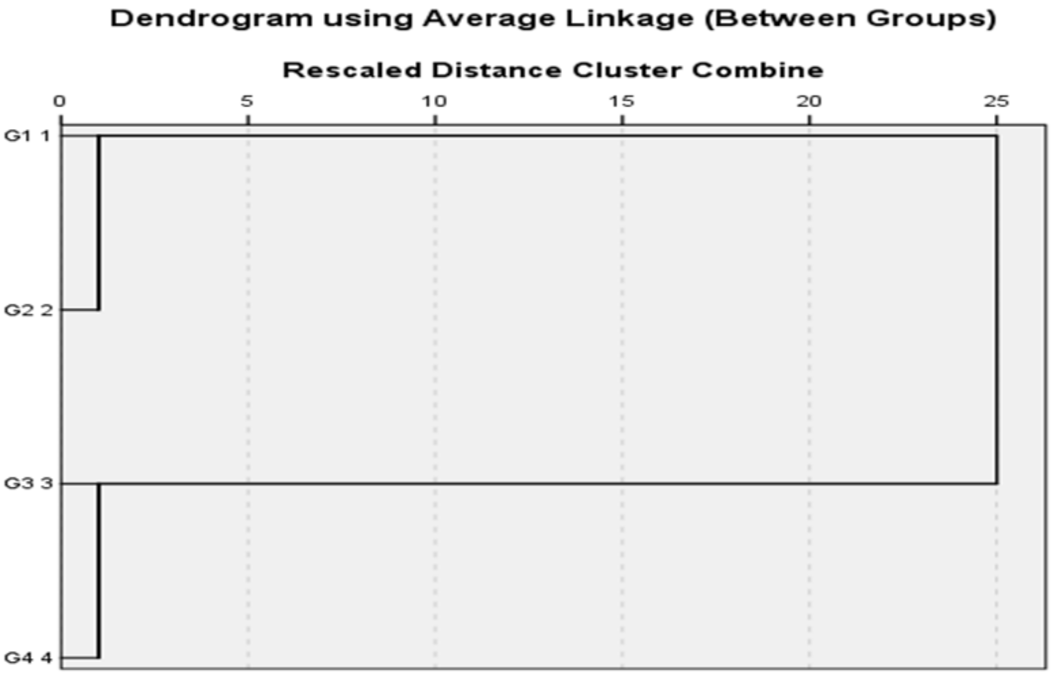

Figure 2. Dendrogram of four grass pea genotypes based on cluster analysis of forage yield attributes at Kanipanka location

CONCLUSIONS

The results from this study underscore the importance of managing fertilizer, genotype, and stubble height for optimizing forage yield in grass pea. Fertilizer application, particularly organic fertilizer, enhanced dry forage yield, while genotype selection proved crucial for achieving superior yield attributes. Stubble height significantly affected the yields, with lower stubble heights 5cm (SH_1) being more effective in increasing green and dry forage yields. Additionally, Kanipanka was found to be more favorable for forage yield production compared to Qlyasan, possibly due to its more conducive climatic conditions. The interaction effects between fertilizer, genotype, and stubble height were found to be significant, highlighting the need for tailored management practices to maximize yield. This study contributes valuable insights into the factors influencing grass pea forage yield and offers practical recommendations for improving forage production in different environmental settings.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

REFERENCES

1. Ahmad, A., A., Wahid, F., Khalid, N., Fiaz, and M.S.I. Zamir, 2011. Impact of organic and inorganic sources of nitrogen and phosphorus fertilizers on growth, yield and quality of forage oat (*Avena sativa* L.). Cercetări Agronomice în Moldova, 44(3), 39–49. https://doi.org/10.2478/v10298-012-0040-7 AGRIS

2. Abebe, T. G., M. R. Tamtam, A. A. Abebe, K. A. Abtemariam, T. G. Shigut, Y. A. Dejen,. and E. G. Haile, 2022. Growing use and impacts of chemical fertilizers and assessing alternative organic fertilizer sources in Ethiopia. Applied and Environmental Soil Science, 2022(1), 4738416. https://doi.org/10.1155/2022/4738416

3. Al-Doss, A., A., Assaeed and A. Soliman, 1998. Growth characters and yield of some selected lines of grass pea (*Lathyrus sativus*). Journal of King Saud University - Agricultural Sciences, 10(1), 67–72.

4. Campbell, C. G. 1997. Grass pea, Lathyrus sativus L. Bioversity International, 18.

5. Das, A., A. K., Parihar, S., Barpete, S., Kumar, and, S. Gupta 2021. Current perspectives on reducing the β-ODAP content and improving potential agronomic traits in grass pea (*Lathyrus sativus* L.). Frontiers in Plant Science, 12, 703275. https://doi.org/10.3389/fpls.2021.703275

6. Dutta, N., S. B., Neog, P. K., Barua, and V. K. Verma, 2024. Evaluation of grass pea (*Lathyrus sativus* L.) landraces for genetic variability and character association for growth, yield and quality attributes. Indian Journal of Plant Genetic Resources, 37(3), 502–512. https://doi.org/10.61949/0976-1926.2024.v37i03.13

7. Genç Lermi, A., H. İ., Erkovan, and A. Koç, 2023. Determination of combined effects of organic and mineral fertilizer on forage yield and quality of annual ryegrass. Agronomy, 13(12), 2935. https://doi.org/10.3390/agronomy13122935

8. Hazra, G. 2016. Different types of eco-friendly fertilizers: An overview. Sustainability in Environment, 1(1), 54–70. https://www.scholink.org/ojs/index.php/se/article/view/327

9. He, Z., B. Ding, S. Pei, H. Cao, J. Liang, and Z. Li, 2023. The impact of organic fertilizer replacement on greenhouse gas emissions and its influencing factors. Science of The Total Environment, 905, 166917. https://doi.org/10.1016/j.scitotenv.2023.166917

10. Jiai, Liu, A. Shu, W. Song, W. Shi, M. Li, W. Zhang, , and Z. Gao, 2021. Long-term organic fertilizer substitution increases rice yield by improving soil properties and regulating soil bacteria. Geoderma, 404, 115287. https://doi.org/10.1016/j.geoderma.2021.115287

11. Kalita, H., and R. Chakrabarty, 2017. Performance of grass pea (Lathyrus sativus L.) varieties under different seed rates in rice (Oryza sativa)–utera situations. Journal of Crop and Weed, 13(1), 113–115.

12. Karim, S. F., S. R., Muhammed, and T. O. Muhammad, 2022. Influence of seeding rates and nitrogen application on growth, forage yield and its components of five vetch (Vicia sativa) varieties under rainfed condition of Sulaimani district-Iraq. Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition), 41(11), 233. https://doi.org/10.17605/OSF.IO/J4AUR].

13. Möller, K., and U. Schultheiß, 2015. Chemical characterization of commercial organic fertilizers. Archives of Agronomy and Soil Science, 61(7), 989-1012. https://doi.org/10.1080/03650340.2014.978763

14. Maleki, H. H., et al. 2024. Deciphering genotype-by-environment interaction of grass pea genotypes under rain-fed conditions and emphasizing the role of monthly rainfall. BMC Plant Biology, 24(1), 559. https://doi.org/10.1186/s12870-024-04431-8

15. Muhammed, S. A., S., Da–Sleman, and R. Hussaen, 2019. Response of some narbon vetch varieties to different defoliation intensities concerning forage, seed yield, and growth traits under rainfed conditions of the Sulaimani Governorate, Iraq. Applied Ecology and Environmental Research, 17(5), 12479–12490. https://doi.org/10.15666/aeer/1705_124791249 0

16. Muhammed, S. R., and S. F Karim, 2021. The effect of harvesting stages and locations on seed yield and its components of some narbon vetch (Vicia narbonensis) lines under rainfed conditions of Sulaimani Governorate-Iraq. Zanco Journal of Pure and Applied Sciences, 33(S1), 1–10. https://doi.org/10.21271/zjpas

17. Muhammed, S. R., and S. F., Karim, 2020. Response of some Narbon vetch (Vicia narbonensis) lines to different harvesting stages for forage yield and its components at two locations of Sulaimani Governorate. Journal of Kirkuk University for Agricultural Sciences, 11(2), 45–56. https://doi.org/10.21271/jkucs.2020.11.2.4 .

18. Maleki, H. H., B., Vaezi, A., Jozeyan, et al. 2024. Deciphering genotype-by-environment interaction of grass pea genotypes under rain-fed conditions and emphasizing the role of monthly rainfall. BMC Plant Biology, 24(1), 559. https://doi.org/10.1186/s12870-024-05256-5 SpringerLink+1BioMed Central+1

19. Shiferaw, E., M. E. Pè, E., Porceddu, and M. Ponnaiah, 2012. Exploring the genetic diversity of Ethiopian grass pea (Lathyrus sativus L.) using EST-SSR markers. Molecular Breeding, 30, 789–797. https://doi.org/10.1007/s11032-011-9662-y SpringerLink

20. Singh, T. B., et al. 2020. Role of Organic Fertilizers in Improving Soil Fertility. In Contaminants in Agriculture: Sources, Impacts, and Management pp. 61–77.

21. Sleman, S., S., Muhammed, D., Ahmad, and D. Abdulkhaleq, 2019. Evaluation of some grass pea genotypes (Lathyrus sativus L.) for forage, seed yield and its components under rainfed conditions in Sulaimani region. Tikrit Journal for Agricultural Sciences, 19(3), 35–46. https://doi.org/10.25130/tjas.19.3.6

22. Tawfiq, S., and S., Muhammed, 2014. Response of three cereal crops to different clipping times for forage yield at two locations of Sulaimani region. Zanko Sulaimani, 16, 23–32.

23. Saleque, M. A., M. J. Abedin, N. I. Bhuiyan, S. K. Zaman, and G. M. Panaullah, 2004. Long-term effects of inorganic and organic fertilizer sources on yield and nutrient accumulation of lowland rice. Field crops research, 86(1), 53-65. https://doi.org/10.1016/S0378-4290(03)00119-9

24. Vasileva, V., and O. Kostov, 2015. Effect of mineral and organic fertilization on alfalfa forage and soil fertility. Emirates Journal of Food and Agriculture, 27(9), 678–686. https://doi.org/10.9755/ejfa.2015.05.288 .

25. Wiersma, D., M., Bertam, R., Wiederholt, and N. Schneider, 2007. The long and short of alfalfa cutting height. Focus on Forage, 1(1), 1–4.

26. Yasuoka, J. I., W., Powell, W. H., Fick, and B. C. Pedreira, 2023. Impact of stubble heights on native hay meadows in southeast kansas. kansas agricultural experiment Station Research Reports, 9(2), 16. https://newprairiepress.org/kaesrr/vol9/iss2/16/ New Prairie Press

27. Zhao, T., He, A., M. N., Khan, Q., Yin, S., Song, and L. Nie, 2024. Coupling of reduced inorganic fertilizer with plant-based organic fertilizer as a promising fertilizer management strategy for colored rice in tropical regions. Journal of Integrative Agriculture, 23(1), 93–107. https://doi.org/10.1016/j.jia.2023.04.035

28. Zhang, J. B., T. B. Zhu, Z. C. Cai, S. W Qin,., and C. Müller, 2012. Effects of long-term repeated mineral and organic fertilizer applications on soil nitrogen transformations. European Journal of Soil Science, 63(1), 75-85. https://doi.org/10.1111/j.1365-2389.2011.01410.x

29. Zhang, M., Y. Yao, Y. Tian, K. Ceng, M. Zhao, M. Zhao, and B. Yin, 2018. Increasing yield and N use efficiency with organic fertilizer in Chinese intensive rice cropping systems. Field Crops Research, 227, 102-109. https://doi.org/10.1016/j.fcr.2018.08.010