



Potassium Management for the Improvement of Growth and Yield of Grass Pea (*Lathyrus sativus* L.)

Umed Ali^{1*}, Ghulam Hussain Jatoi¹, Sajjad Ali Khuhro¹, Tahmina Shar², Rafiq Ahmad³ and Mahpara Khatoon⁴

¹Department of Agriculture, Mir Chakar Khan Rind University, Sibi, Balochistan, Pakistan

²Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Sindh, Pakistan.

³Department of Botany, Mir Chakar Khan Rind University, Sibi, Balochistan, Pakistan.

⁴Department of Agronomy, Sindh Agriculture University, Tandojam, Sindh, Pakistan.

(Corresponding author: Umed Ali)

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ABSTRACT: Potassium is the third major nutrient required by most crops for their growth and development. It plays an important role in increasing yield of legume crops but it has been ignored by the grass pea growers of the world. A field experiment was conducted at Pulse Research Sub-Station, Tandojam to test the growth and yield performance of four grass pea genotypes namely Sel-1959, Italian, Sel-299 and Sel-2177 against three potassium levels viz. 00, 10, 20 kg K ha⁻¹. The results indicated that potassium levels and grass pea genotypes exhibited a significant ($P < 0.05$) influence on all growth and yield traits. The combination of 20 kg K ha⁻¹ and grass pea genotype Sel-2177 produced the maximum values for growth and yield traits with 6.00 branches plant⁻¹, 34.67 pods plant⁻¹, 4.66 seeds pod⁻¹, 6.83 fresh pod yield (kg plot⁻¹), 88.00 (g) 1000-seed weight, 23364.10 kg biomass yield ha⁻¹ and 6121.00 kg seed yield ha⁻¹ against crop fertilized with 20 kg K ha⁻¹. The Italian genotype with 00 kg K ha⁻¹ produced minimum results for all growth and yield traits. It was concluded that 20 kg K ha⁻¹ produced maximum seed yield with other growth characteristics, while genotype Sel-2177 produced best results in all parameters than rest of other genotypes. In this regard, the grass pea crop with Sel-2177 genotype and 20 kg K ha⁻¹ is being recommended for Sindh province of Pakistan.

Key words: Potassium levels, grass pea genotypes, seed yield, growth

I. INTRODUCTION

Grass pea (*Lathyrus sativus* L.), a crop growing for centuries as a winter edible pulse crop and is widely used for livestock feed and human consumption in the most parts of the world especially India, Spain, France, Pakistan, Bangladesh, China, Nepal and most countries of Africa continent [1]. This crop is being honoured as the "poor men's diet" [2]. This crop is either grown under 'utera' conditions and utilize remnant water or is sown on rain-fed areas of the world where it must exist on minimum moisture until harvest. The crop normally is considered to require low or zero inputs and therefore not only utilize remnant water but also must utilize remnant soil nutrients.

There is a high concentration of protein (19-32.5% of DM), macro and micro nutrients and a high level of amino acids, particularly lysine present in the seeds of this crop. Basically it has low (1.6%) fat level but the starch content supplies enough energy [3]. Not only nutritional, but this magical crop has many benefits, it plays an important role in the nitrogen fixation, adding about 67 kg ha⁻¹ in a single season. So, this crop can also be more beneficial as a legume crop in crop rotation system. On the other hand, it supplies high yield and protein benefits on the subsequent non legume crop [4]. Because of its high protein content, this crop species have been considered as a forage legume crop. The main qualities of this crop are its sturdiness, tolerance against abiotic stresses, its adaptability to different soil types including marginal soils [5]. Grass pea can withstand in most adverse conditions so that this crop has got more popularity in the countries which face very adverse weather conditions throughout the year [6].

Fertilizer plays an important role in affecting crop production. Fertilizer recommendation for different soils and crops is a technical job [7] and fertilizer management is the key aspect that affects growth, development and yield of the crop [8]. Potassium ranks third in its importance after nitrogen and phosphorus [9] and considered as a main macro element which plays a vital role in crop growth and development [10]. Potassium can improve water relations of the plants and increase photosynthetic capacity [11], which in turn may increase yield of most pulse crops. It also maintains turgor pressure of cell which is basic requirement for cell expansion. Potassium helps in osmotic-regulation of plants and also supports plants in closing and opening of stomata [12], triggers about 60 different types of enzymes [13], as well as plays a functional role in synthesising protein, making plants to withstand against insect pest and diseases and boosts crop yield up to maximum level [14]. Potassium application to leguminous crops with phosphorus is essential at flowering and pod setting stage of the crop [15]. Along with that, it has been shown that potassium has increased the growth and yield of a variety of crops including pulse crops [16-18].

A very limited research regarding the use of potassium on grass pea has been carried out worldwide especially in Sindh, Pakistan has been fully ignored. Therefore, the present study was taken to investigate the effect of different levels of potassium on growth and yield performance of grass pea and to identify the optimum level of potassium for obtaining maximum yield of grass pea. Such study is said to be useful in order to create awareness among the research and farming communities of Sindh, Pakistan about the judicious use of potassium on grass pea to get maximum production.

II. MATERIALS AND METHODS

A. Plant Material

The experiment was carried out at Pulse Research Sub-Station, Tandojam, Sindh, Pakistan. In this regard, four grass pea genotypes viz. Sel-1959, Italian, Sel-299 and Sel-2177 were tested against different K levels. The experiment was laid out in a randomized complete block design (RCBD) with Split plot arrangement. The net plot size was kept as 5 m x 4 m. The seeds were taken from Pulse Research Sub-Station (R.R.I Dokri), Tandojam. The seeds were sown at the rate of 25 kg ha⁻¹ using single coulter hand drill. The depth was 2-3 cm, whereas 10 cm plant to plant distance and 30 cm row to row space was kept. The sowing was completed in November, 2019 and the crop was harvested in April, 2020.

B. K treatment and Nutrition Management

The crop was treated with three Potassium levels i.e. 00 kg, 10 kg and 20 kg K ha⁻¹. While recommended dose of nitrogen and phosphorus were applied at the rate of 10-20 kg ha⁻¹ through Urea (N-46%), Diammonium phosphate (DAP) (N-18%, P-46%) and Muriate of potash (MOP) (50% K₂O). The full dose of phosphorus and potassium and half dose of nitrogen was applied as a basal dose and remaining nitrogen was applied in two equal splits at first and second irrigation.

C. Agronomic Management

The crop was kept weed free throughout the growing season. Two irrigations were applied at flowering and grain development stage. The crop was harvested at its full maturity. Harvesting and threshing practices were performed manually. Branches per plant, pods plant⁻¹, seed pod⁻¹, fresh pod yield (kg plot⁻¹), 1000-seed weight(g), Biomass yield (kg ha⁻¹) and seed yield (kg ha⁻¹) were recorded.

D. Trait Measurement

Following traits were measured with their procedures.

(i) **Branches per plant:** Branches per plant were recorded from five selected plants taken randomly at the time of maturity and the mean was worked out.

(ii) **Pods plant⁻¹:** Pods plant⁻¹ were counted from five selected plants taken randomly from each treatment and average was calculated.

(iii) **Seeds pod⁻¹:** The seeds pod⁻¹ were counted at maturity of the crop from five selected plants of each treatment taken at random and mean was worked out.

(iv) **Fresh pod yield (kg plot⁻¹):** Fresh pods of whole plot were harvested and weighed separately and mean was worked out for all the treatments.

(v) **1000-seed weight (g):** One thousand seeds from each plot in each replication were collected at random and weighed to record the 1000-seed weight (g).

(vi) **Biomass yield (kg ha⁻¹):** All the straw with grains obtained from each plot after harvest were weighed. Biomass yield ha⁻¹ was calculated in kilograms on the basis of biomass yield plot⁻¹ using the following formula:

$$\frac{\text{Biomass yield per plot (kg)}}{\text{Plot Size (m}^2\text{)}} \times 10000$$

(vii) **Seed yield (kg ha⁻¹):** The seed yield (kg ha⁻¹) was calculated by using the same above formula as like Biomass yield (kg ha⁻¹).

E. Statistical Analysis

The data thus collected was subjected to statistical analysis using STATISTIX-8.1. Least significant differences (LSD) were used to test for significant differences among the treatments (P=0.05) and figures were made from Graph Pad Prism software version 6.01.

III. RESULTS

A. Branches plant⁻¹

Increasing the level of K from 0 to 20 kg K ha⁻¹ significantly increased ($P < 0.05$, Table 1) the number of branches plant⁻¹. The grass pea crop given 20 kg K ha⁻¹ produced maximum branches plant⁻¹ while the control (0 kg K ha⁻¹) plots produced lowest branches plant⁻¹ in each genotype (Fig. 1). Among all four genotypes, Sel-2177 produced highest branches under each K level. The genotype Sel-1959 produced 2nd most maximum branches plant⁻¹ under 0 and 20 kg K ha⁻¹. However the genotype namely Italian produced lowest number of branches plant⁻¹ under each K level.

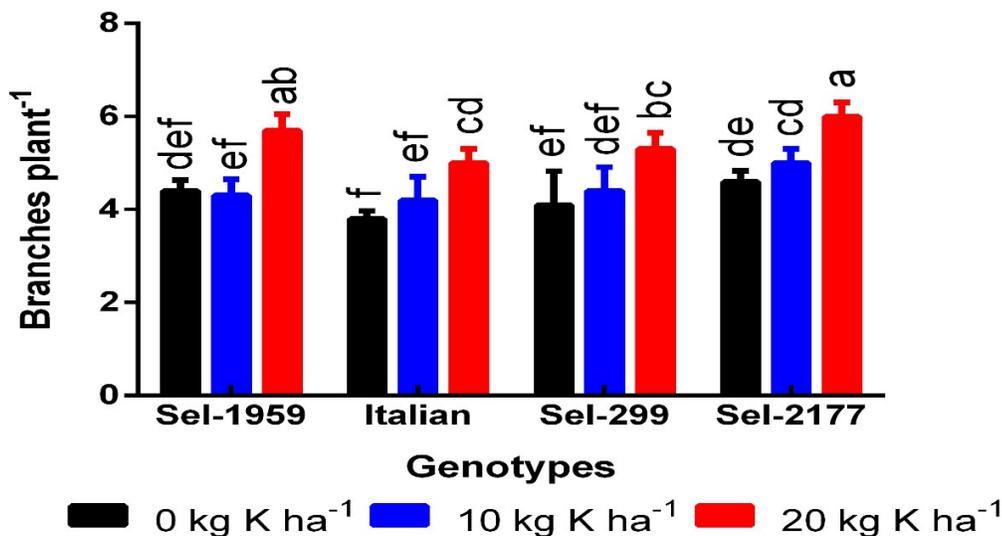


Fig. 1. Effects of three potassium levels (0, 10, 20 kg K ha⁻¹) on branches plant⁻¹ of four genotypes (Sel-1959, Italian, Sel-299 and Sel-2177) of grass pea crop. The different letters indicate significant difference among treatments ($P < 0.05$), and all of the results are presented as mean \pm SD. Mean values were derived from the performance of three replicates.

B. Pods plant⁻¹

The results showed that the pods plant⁻¹ in grass pea crop were significantly increased ($P < 0.05$, Table 1) with increasing potassium level. The maximum pods plant⁻¹ were produced by the high level of K (20 kg ha⁻¹) while the lowest pods plant⁻¹ were produced where no (control) K was applied (Fig. 2). In case of genotypes, Sel-2177 produced maximum pods plant⁻¹ under each K level followed by the genotype Sel-1959 which produce 2nd highest number of pods plant⁻¹ after Sel-2177. The genotypes Sel-299 and Italian were ranked as third and fourth in producing maximum pods plant⁻¹ under 0, 10 and 20 kg ha⁻¹.

C. Seeds pod⁻¹

The results regarding seeds pod⁻¹ showed a significant increase ($P < 0.05$, Table 1) effect of increasing K level on grass pea genotypes. It was observed that 20 kg K ha⁻¹ produced highest number of seeds pod⁻¹ (Fig. 3). While the control (0 kg K ha⁻¹) produced lower most number of seeds pod⁻¹ in each genotype with one exception in the genotype Sel-299 which showed no significant difference between 0 and 10 kg K ha⁻¹. For the case of genotypes, it was observed that the

genotypes Sel-1959 and Sel-2177 produced similar number of seeds pod⁻¹ under 20 kg K ha⁻¹ whereas under 0 and 10 kg K ha⁻¹, Sel-2177 produced maximum number of seeds pod⁻¹ with the genotype Italian producing minimum number of seeds pod⁻¹ for each K level.

D. Fresh pod yield (kg plot⁻¹)

Increasing level of K significantly increased ($P < 0.05$, Fig. 4, Table 1) the fresh pod yield (kg plot⁻¹). The crop provided with K at 20 kg ha⁻¹ produced supreme fresh pod yield, the ordinary fresh pod yield was noted in crop given potassium at 10 kg ha⁻¹. Whereas the lowest fresh pod yield was obtained in control plots. The fresh pod yield in grass pea crop was improved with increasing potassium level; which indicated the positive response of higher K levels for this trait. In case of genotypes, the fresh pod yield was significantly ($P < 0.05$, Table 1) greater in genotype Sel-2177, followed by the genotype Sel-1959 under each potassium level. However, the genotype Sel-1959 and the genotype Sel-2177 showed similar results for producing fresh pod yield (kg plot⁻¹) under 20 kg K ha⁻¹. The lowest fresh pod yield was noticed by the genotype Italian.

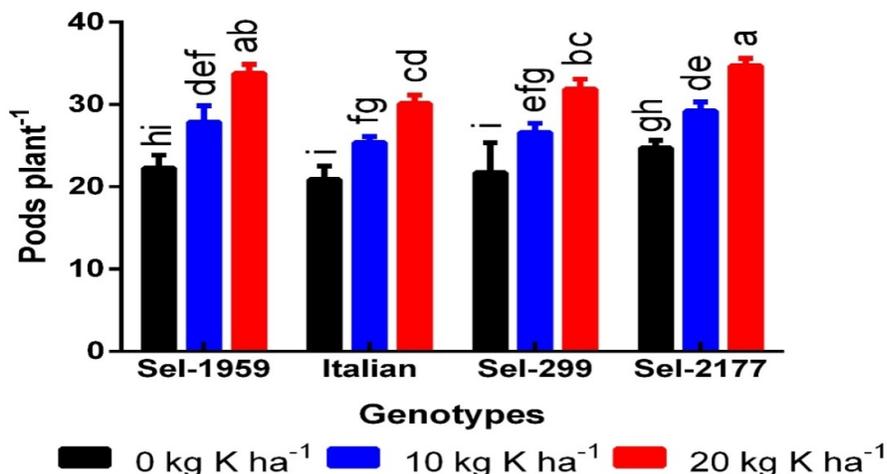


Fig. 2. Effects of three potassium levels (0, 10, 20 kg K ha⁻¹) on pods plant⁻¹ of four genotypes (Sel-1959, Italian, Sel-299 and Sel-2177) of grass pea crop. The different letters indicate significant difference among treatments ($P < 0.05$), and all of the results are presented as mean \pm SD. Mean values were derived from the performance of three replicates.

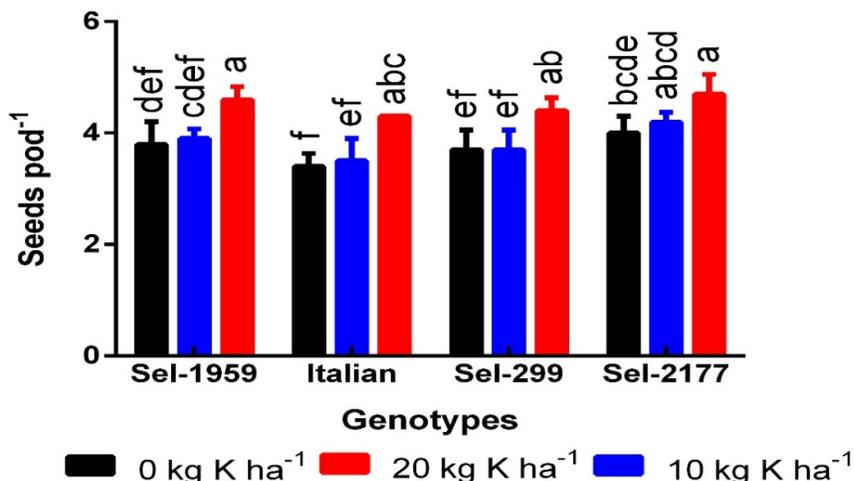


Fig. 3. Effects of three potassium levels (0, 10, 20 kg K ha⁻¹) on seeds pod⁻¹ of four genotypes (Sel-1959, Italian, Sel-299 and Sel-2177) of grass pea crop. The different letters indicate significant difference among treatments ($P < 0.05$), and all of the results are presented as mean \pm SD. Mean values were derived from the performance of three replicates.

Table 1: Two-way ANOVA comparing the effect of varying potassium levels on different grass pea genotypes for branches plant⁻¹, pods plant⁻¹, seeds pod⁻¹, fresh pod yield, 1000 seed weight, biomass yield and seed yield.

Indicators	F-value (Sources of variation for 2-way ANOVA)		
	Genotype	K levels	Genotype x K levels
Branches plant ⁻¹	22.82**	26.05**	0.32ns
Pods plant ⁻¹	11.01**	115.32**	0.27ns
Seeds pod ⁻¹	5.57*	22.38**	0.18ns
Fresh pod yield (kg plot ⁻¹)	11.65**	159.05**	0.21ns
1000-seed weight (g)	6.42*	12.68**	0.38ns
Biomass yield (kg ha ⁻¹)	40.02**	256.62**	0.73ns
Seed yield (kg ha ⁻¹)	11.35**	91.59**	0.32ns

F-values are shown; **significant difference at $p = 0.01$, *significant difference at $p = 0.05$, and ns = Non-significant

E. 1000-seed weight(g)

The grass pea crop showed a consecutive improvement in its seed index with each increment in K level. The crop fertilized with K at 20 kg ha⁻¹ significantly ($P < 0.05$, Fig. 5, Table 1) resulted in the highest 1000-seed weight (g), while the lowest 1000-seed weight (g) was seeded in the plants grown in control (0 kg K ha⁻¹). In case of grass pea genotypes, the highest 1000-seed weight (g) was obtained in the genotype Sel-2177, followed by the normal 1000-seed weight (g) produced by the genotype Sel-1959. Statistically, there was no significant

difference in 1000-seed weight (g) of the genotypes Italian under 10 kg K ha⁻¹ and Sel-299 under 0 and 10 kg K ha⁻¹. However, the lowest 1000-seed weight (g) under 0 K kg ha⁻¹ was produced by the genotype Italian.

F. Biomass yield (kg ha⁻¹)

The biomass yield (kg ha⁻¹) of four genotypes was analysed to check the effect of K levels on grass pea. The results showed that biomass yield (kg ha⁻¹) of the grass pea crop was significantly ($P < 0.05$, Table 1) enhanced by increasing the level of potassium.

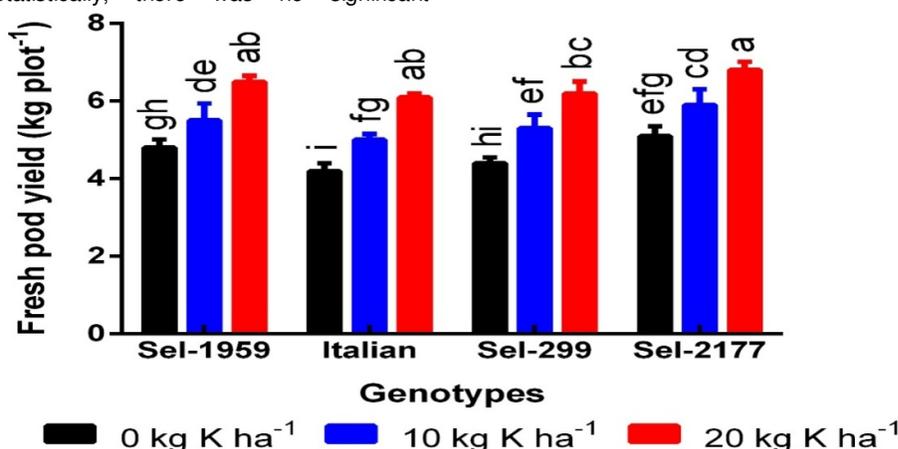


Fig. 4. Effects of three potassium levels (0, 10, 20 kg K ha⁻¹) on fresh pod yield (kg plot⁻¹) of four genotypes (Sel-1959, Italian, Sel-299 and Sel-2177) of grass pea crop. The different letters indicate significant difference among treatments ($P < 0.05$), and all of the results are presented as mean \pm SD. Mean values were derived from the performance of three replicates.

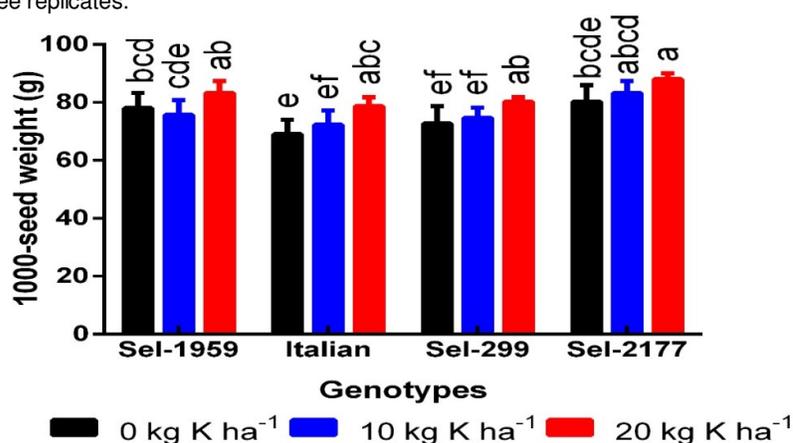


Fig. 5. Effects of three potassium levels (0, 10, 20 kg K ha⁻¹) on 1000-seed weight (g) of four genotypes (Sel-1959, Italian, Sel-299 and Sel-2177) of grass pea crop. The different letters indicate significant difference among treatments ($P < 0.05$), and all of the results are presented as mean \pm SD. Mean values were derived from the performance of three replicates.

The highest biomass yield (kg ha^{-1}) was obtained in the plots where 20 kg K ha^{-1} was applied whereas control plots showed lowest biomass yield (kg ha^{-1}) in every genotype (Fig. 6). In situation of the genotypes, it was observed that Sel-2177 produced highest biomass yield (kg ha^{-1}) under each K level and the genotype Sel-1959 ranked 2nd. However, it was observed that the genotype Italian produced lowest biomass yield (kg ha^{-1}) under each K level.

G. Seed yield (kg ha^{-1})

The results showed an increasing trend of seed yield (kg ha^{-1}) with the increment of K treatment. The crop provided with potassium at the rate of 20 kg ha^{-1} significantly ($P < 0.05$, Table 1) produced maximum seed yield (kg ha^{-1}) while the minimum seed yield was found in control (0 kg K ha^{-1}) plots (Fig. 7). In case of genotypes, the seed yield was significantly ($P < 0.05$, Table 1) higher in the genotype Sel-2177, followed by Sel-1959 under each potassium level. The lowest seed yield (kg ha^{-1}) was obtained from the genotype Italian at every K level.

IV. DISCUSSION

The growers in the drylands do not apply potassium (K) fertilizers and therefore the crops not only suffer from K deficiency but also promotes other abiotic stresses. In Pakistan, K status of soils is rapidly decreasing at the painful rate. The net K exhausting rate is even steeper $0.3 \text{ kg ha}^{-1} \text{ year}^{-1}$. This may be due to the trifling ($0.8 \text{ kg ha}^{-1} \text{ year}^{-1}$) use of K in Pakistan as compared to world's average K use ($15.1 \text{ kg ha}^{-1} \text{ year}^{-1}$) [19]. In fact, today the use of K rate is almost half of what it was in mid 90s. Under K deficient conditions photosynthesis in crops is depressed as a consequence of sucrose accumulation in the leaves which affects every aspect of crop [20]. Balanced crop nutrients management is a key factor for improving crop productivity and growers income [21]. The published research work of many workers indicates that K application under moisture stress condition not only fulfils crop's K requirement but also improves crop growth, dry matter partitioning and increase yields significantly [22].

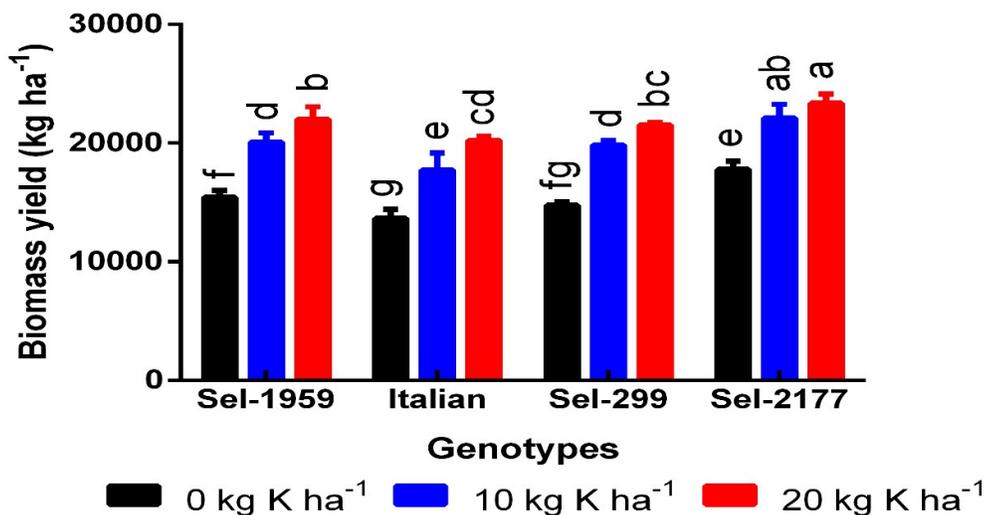


Fig. 6. Effects of three potassium levels (0, 10, 20 kg K ha^{-1}) on biomass yield (kg ha^{-1}) of four genotypes (Sel-1959, Italian, Sel-299 and Sel-2177) of grass pea crop. The different letters indicate significant difference among treatments ($P < 0.05$), and all of the results are presented as mean \pm SD. Mean values were derived from the performance of three replicates.

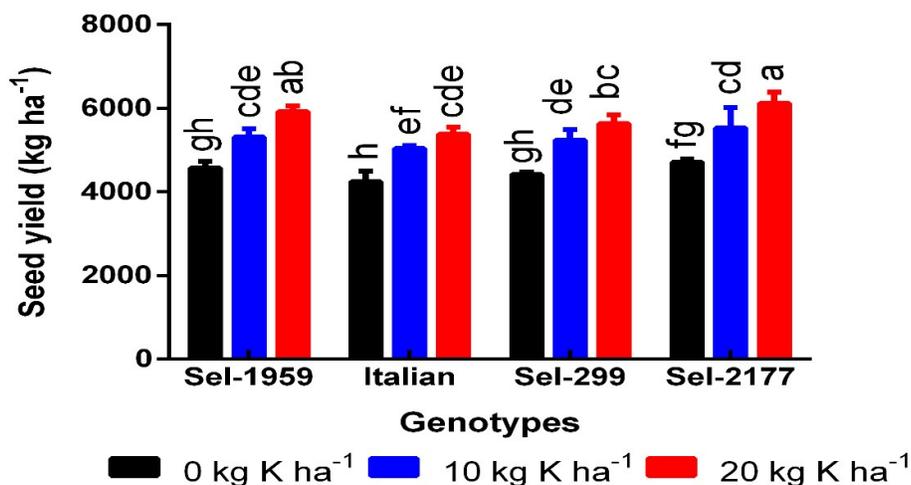


Fig. 7. Effects of three potassium levels (0, 10, 20 kg K ha^{-1}) on seed yield (kg ha^{-1}) of four genotypes (Sel-1959, Italian, Sel-299 and Sel-2177) of grass pea crop. The different letters indicate significant difference among treatments ($P < 0.05$), and all of the results are presented as mean \pm SD. Mean values were derived from the performance of three replicates.

Potassium has important functions in plant water relations where it regulates ionic balances within cells and also play a significant role in the activation of more than 60 enzymes which catalyse various metabolic process [23].

In current research, it was observed that branches plant⁻¹, pods plant⁻¹, seeds pod⁻¹, fresh pod yield, 1000-seed weight, biomass yield and seed yield were significantly ($P < 0.05$, Table 1) increased as the potassium level was increased from 0 to 20 kg K ha⁻¹ (Fig.1-7). Our results were in agreement with the previous researchers, who observed highest branches plant⁻¹ in field pea and lentil crops when they applied 15 and 20 kg K ha⁻¹, respectively [17 and 24]. Potassium as 150 kg K₂O has a significant effect on pods plant⁻¹ of field pea and produced maximum pods plant⁻¹ [25]. Pods plant⁻¹ were significantly higher in mung bean when 20 kg of potassium was applied [16]. A significant increase in number of seeds pod⁻¹ was noted due to the application of potash [26]. In another study, it was claimed that number of seeds pod⁻¹ were increased when K₂O level was increased [27]. Potassium either alone or with other nutrient (P and Zn) can increase the fresh pod yield to its maximum level [25, 28]. Not only this, but potassium has also proved to be beneficial in enhancing the fresh and dry weight of the plants at seedling stage when it was applied at 0.75% KNO₃ as seed priming [29]. Our findings are in accordance with previous researchers, who reported that weight of 1000-seed was increased with increasing potassium levels [17, 18, 30]. Grain yield of chickpea was significantly affected by different levels of potassium by producing maximum grain yield at 60 kg K₂O ha⁻¹ [31], our results agrees with this previous study.

Four different genotypes were tested against different K levels to check the maximum growth and yield of grass pea genotypes. It was observed that Sel-2177 performed very well while the genotype Italian showed poor performance in each situation against K levels for each character viz. branches plant⁻¹, pods plant⁻¹, seeds pod⁻¹, fresh pod yield (kg plot⁻¹), 1000-seed weight (g), biomass yield (kg ha⁻¹) and seed yield (kg ha⁻¹) (Fig. 1-7).

V. CONCLUSION

It was concluded from present research that potassium levels had significant ($P < 0.05$) positive effect on the growth and yield of grass pea genotypes. Potassium supplied at the rate of 20 kg ha⁻¹ produced maximum seed yield, while genotype Sel-2177 showed its superiority in all growth and yield parameters than other genotypes. So, the grass pea crop with Sel-2177 genotype and 20 kg potassium ha⁻¹ is being recommended for Sindh province of Pakistan.

Conflicts of Interest: The authors declare no conflict of interest.

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