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Interactive impact of potassium and sulphur to enhance the growth and yield characteristics of lentil (*Lens culinaris*) genotypes

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Abstract

Potassium and sulphur are macronutrient and important for improving the growth, yield as well as quality of legume species but unfortunately are being fully ignored in the farmer's field for lentil cultivation. Due to their deficiency, yield of lentil crop has decreased up to the marked levels. The performance of five lentil genotypes namely GS-6, GS-10, P-14216, P-14223 and NVUT-E3 was evaluated against different potassium and sulphur levels i.e. K-S = 00-00, K-S = 30-15, K-S = 60-30 kg ha^{-1} at the experimental fields of Pulse Research Sub-Station, Tandojam. The results indicated a significant ($P \leq 0.05$) impact of potassium and sulphur on lentil genotypes for all measured traits. The growth and yield traits of all genotypes were enhanced as the potassium and sulphur levels were increased. The highest growth and yield traits were recorded when the plants were treated with K-S = 60-30 kg ha^{-1}. The control plots showed lower performance. Among the genotypes, GS-10 responded well as compared to other genotypes. While the performance of genotype NVUT-E3 was observed lower. It was concluded that potassium and sulphur at the rate of 60-30 kg ha^{-1} proved best for producing higher yields, while genotype GS-10 exhibited maximum results in all growth and yield traits.

Keywords: Interactive impact, Potassium, Sulphur, Lentil Genotypes, Growth, Yield

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1. INTRODUCTION

Lentil (*Lens culinaris* L.) is known as Masur or Dal Masur in local Indo-Pak region and utilized as a grain vegetable worldwide. It is a leguminous crop which belongs to Fabaceae family. It is evident that lentil is one of the earliest cultivated crops of the world which was domesticated in Southeast Asia around 7000

B.C[1]. Lentil is a high valued crop because it contains 60% Carbohydrates, 25% Protein and 11% water and is highly digestible than other grain legumes[2]. A decrease in the yield of lentil has been observed because of the instability in the use of macronutrient but it can be overcome through fulfilling crop's nutrient requirements. Among nutrients, potassium (K) has been fully ignored in the production technology of pulse crops which has resulted in imbalanced nutrition and reduced production. Soils have become deficient of K due to intensive cropping. K is required in macro quantities and is primarily important for the growth of crop plants[3]. Potassium is mainly required for protein and carbohydrates synthesis, enzyme activation, photosynthesis and for producing a resistance mechanism against various pests and diseases[4]. Jahan[5] stated that potassium is the basic requirement of leguminous crops during flowering and pod setting stages. It has been documented that potassium can improve growth, yield, biological nitrogen fixation and protein content of pulse crops[3,6,7].

Sulphur (S) has become 4th most limiting crop nutrient after nitrogen (N), phosphorus (P), potassium (K)[8]. The main reasons behind its deficiency are intensive farming, use of high yielding cultivars, soil erosion, emissions of sulphur dioxide through industries and limited use of sulphur fertilizers[9]. Sulphur is one of the elements required to enhance yield, quality and nodulation capacity of legume crops[10,11]. S has important role in plant metabolism as it is required to produce highly valuable amino acids such as cysteine and methionine. Another main function of sulphur is to synthesize ferro-sulphur proteins which are responsible in driving biochemical and physiological process of plants such as electron movement in photosynthesis and fixation of nitrogen[12]. Sohu[13] reported that the highest (6.98 q/ha) seed yield of lentil crop was observed when S was applied at 8.5 kg ha^{-1} along with other nutrients. Lentil yield and yield attributes were significantly enhanced by applying 40 kg gypsum form of sulphur per hectare[14].

Only little information is available on internet for the research on the combined effect of K and S and even though that information has not been transferred to farmers correctly. Due to the unawareness, farmers seldom use these important macronutrients in their lentil fields, and this is the reason that farmers are unable to get maximum growth and yield of their crops. For solving this research gap, the current study was designed to discover the optimum dose and to investigate the combine influence of potassium and sulphur for obtaining maximum growth and yield of lentil crop. Another goal of the study was to find suitable genotype(s) responsive to K and S nutrients in accordance with the growth, yield and yield components. The study will create awareness among research and farming communities for the judicious use of potassium and sulphur fertilizers in their lentil fields to get maximum yield benefits.

2. MATERIALS AND METHODS

2.1 Site Selection and Plant Material

The experiment was carried out at Pulse Research Sub-Station, Tandojam, Sindh, Pakistan (Late. 68.33°, long. 25.25°). A Randomized Complete Block Design (RCBD) was used with split plot arrangement where five genotypes were placed in main plots while combined potassium (K) and Sulphur (S) levels were placed in subplots. A total of three replications were designed to check the standard error. Five lentil genotypes namely GS-6, GS-10, P-14216, P-14223 and NVUT-E3 were analysed against three combined levels of potassium (K) and Sulphur (S). The net plot size was kept as 5 m x 5 m. The seeds were taken from Pulse Research Sub-Station, Tandojam of Rice Research Institute (R.R.I) Dokri, Sindh, Pakistan. The seeds were sown by single coulter hand drill and the 30 kg per hectare seed rate was kept on the recommendation of Agriculture Research Institute (A.R.I), Sindh. The depth of seed was 3 cm, whereas 10 cm plant to plant distance and 30 cm row to row space was kept. The sowing was completed by 30 November, 2019 and the crop was harvested in April, 2020. Experimental site contained following properties of soil:

Table 1. Physical and Chemical Properties of soil

Properties	Value
Soil Type	Clay loam
Sand	25%
Silt	35%
Clay	45%
pH	7.9 (alkaline)

EC	0.36 dSm^{-1}
Organic matter	0.67%
N	0.03%
P	7.38 mg kg^{-1}
K	75.0 mg kg^{-1}

2.2 Potassium and Sulphur treatment and Nutrition Management

The crop was treated with three potassium and sulphur levels viz. K-S = 00-00, K-S = 30-15, K-S = 60-30 kg ha^{-1}. The control plots received no K and S fertilizers; only nitrogen and phosphorus were applied through Urea and Diammonium Phosphate at 25-50 kg ha^{-1}, respectively. The potassium and sulphur were applied through Muriate of potash and elemental sulphur, respectively. The total phosphorus, potassium, sulphur and 50% nitrogen were applied as basal dose and remaining 50% nitrogen was given in two equal splits i.e. 25% at first irrigation and 25% at second irrigation.

2.3 Agronomic Management

The crop was kept free from weeds, stubbles and crop residues. Interculturing practices were performed when felt necessary. Total three irrigations were applied and the crop was harvested at its full maturity. Harvesting and threshing practices were performed manually. The data of different lentil genotypes was collected for various parameters such as plant height (cm), branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, seed weight $plant^{-1}$ (g), 1000-seed weight (g) and seed yield (kg ha^{-1}). The obtained seed yield (kg $plot^{-1}$) was calculated by the following formula to get the seed yield in kg ha^{-1}.

$$Seed\ yield\ (kg\ per\ ha) = \frac{Seed\ yield\ per\ plot\ (kg)}{Plot\ Size\ (m^2)} \times 10000$$

2.4 Data analysis

The collected replication wise data was analysed through STATISTIX-8.1 software. The Analysis of Variance (ANOVA) and Least Significant Difference (LSD) were obtained to testify the significant difference among treatments at probability level ($P \leq 0.05$). The graphs were made through GraphPad Prism software version 6.01.

3. RESULTS AND DISCUSSIONS

3.1 Plant height (cm)

Interaction of potassium and sulphur showed significant ($P \leq 0.05$, Fig. 1. Table 2.) positive effects on the plant height of all lentil genotypes. In the treatment K-S = 60-30 kg ha^{-1}, the genotype GS-10 was observed highest in plant height followed by P-14216 and P-14223 which were statistically similar. While the lower plant height was observed in the genotype NVUT-E3. In case of K-S = 30-15, the higher plant height was seemed in the genotype GS-10 followed by P-14223 genotype. Remaining genotypes (GS-6, P-14216 and NVUT-E3) were statistically similar to each other. In control plots, the tallest plants belonged to the genotype GS-10. The genotypes GS-6 and P-14223 were statistically similar and ranked 2nd. However, P-14216 and NVUT-E3 were ranked 3rd and appeared statistically alike of each other. It is stated that Plant height was enhanced when potassium was applied at 90 kg ha^{-1} along with cobalt at 8 kg ha^{-1} in lentil fields[15]. Mohseni[16] described an effective rise in the height of lentil plants when potassium was applied with different nitrogen fertilizer levels. However, not only potassium but sulphur has also proved to increase plant height when it was applied at 90 kg per ha in a two years experimental research on lentil cultivar Sazak-91[17].

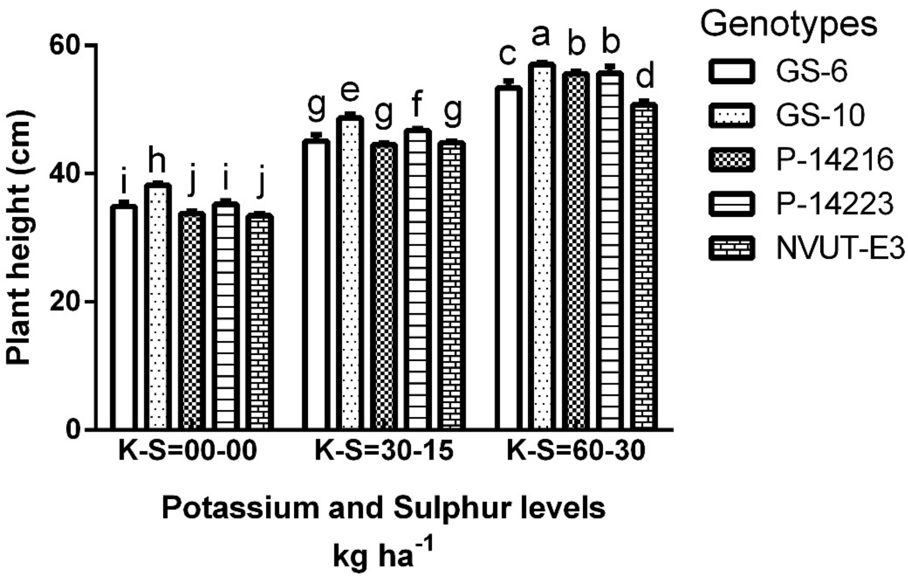

Fig. 1. Interactive impact of potassium and sulphur on plant height (cm) of five genotypes (GS-6, GS-10, P-14216, P-14223, and NVUT-E3) of lentil crop. The various alphabetical signs show significant difference among different treatments (P≤0.05), and all of the results are presented as mean ± SD. Mean values were derived from the performance of three replicates.

Table 2. Two-way ANOVA comparing the F-values for the interactive impact of K-S levels on various lentil genotypes for different studied parameters

Indicators	F-value (Sources of variation for 2-way ANOVA)		
	Genotypes	**K-S levels**	**Genotype x K-S levels**
Plant height (cm)	55.08**	5078.97**	12.11**
Branches plant^{-1}	34.01**	1940.26**	5.09**
Pods plant^{-1}	144.70**	5319.49**	11.11**
Seeds pod^{-1}	81.61**	926.82**	6.50**
Seed weight plant^{-1} (g)	184.97**	7047.33**	5.04**
1000-seed weight (g)	210.06**	1729.10**	0.70^{ns}
Seed yield (kg ha^{-1})	102.78**	2595.68**	3.64**

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

3.2 Branches plant^{-1}

Increasing the level of K and S from 00-00 to 30-15 and then 60-30 kg ha^{-1} significantly increased (P≤0.05, Table 2.) branches plant^{-1} of lentil crop. The treatments that given 60-30 kg K-S ha^{-1} exhibited more number of branches while the control (00-00 kg K-S ha^{-1}) plots produced less number of branches plant^{-1} in each genotype (Fig. 2.). Among all five genotypes, GS-10 produced highest branches under each K-S level. The genotype P-14223 produced 2nd most maximum branches plant^{-1} under 00-00 and 30-15 kg K-S ha^{-1}. The same genotype (P-14223) produced significantly similar branches plant^{-1} as GS-10 in 60-30 kg K-S ha^{-1}. The lowermost branches plant^{-1} were observed in the genotype NVUT-E3 under each K-S level. An increase in branches plant^{-1} was observed in comparison of control plots when foliar potassium was applied under different irrigation regimes[18]. Jahan[5] confirmed that 45 kg K ha^{-1} has significantly increased the branches plant^{-1} in various lentil cultivars. This shows that the application of K can significantly enhance the branches plant^{-1} of lentil crop and our results agrees with these above researches. Cimrin[19] reported that sulphur in pyrite form at 120 kg ha^{-1} proved beneficial for producing more branches plant^{-1} in the year 2003 and 2004.

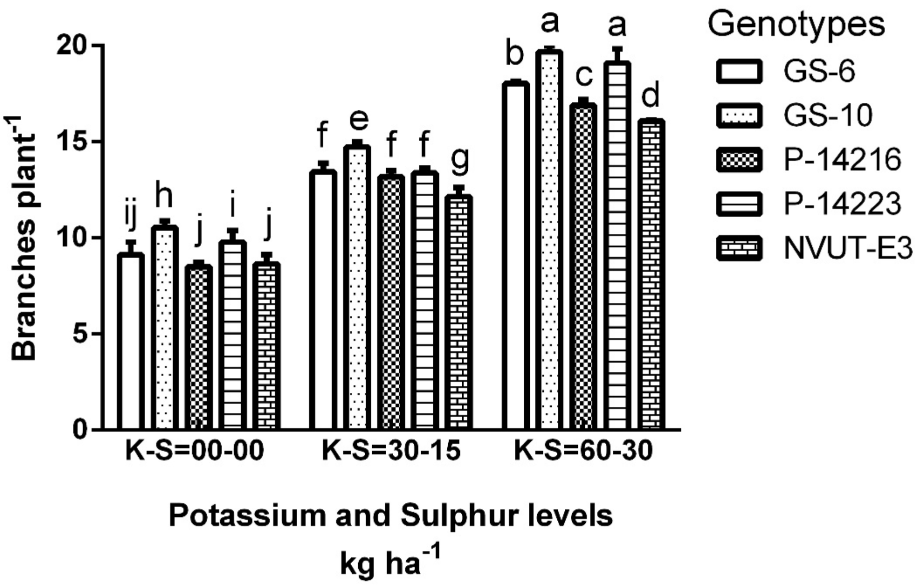

Fig. 2. Interactive impact of potassium and sulphur on branches plant^{-1} of five genotypes (GS-6, GS-10, P-14216, P-14223, and NVUT-E3) of lentil crop. The various alphabetical signs show significant difference among different treatments (P≤0.05), and all of the results are presented as mean ± SD. Mean values were derived from the performance of three replicates.

3.3 Pods plant^{-1}

The results exhibited that the pods plant^{-1} in lentil genotypes were significantly increased (P≤0.05, Table 2.) with increasing potassium and sulphur levels. The genotype GS-10 produced supreme number of pods plant^{-1} in each K-S level followed by P-14223, GS-6 and P-14216 (Fig. 3.). The lower number of pods plant^{-1} were observed from the genotype NVUT-E3. In case of potassium and sulphur, the 60-30 kg K-S ha^{-1} produced more pods plant^{-1} than 30-15 and 00-00 kg K-S ha^{-1}. Sahay[15] reported that pods plant^{-1} increased by increasing the levels of potassium from 0-90 kg ha^{-1} along with cobalt. In another study, Togay[17] reported that the yield of pods plant^{-1} of lentil crop was increased by 27.5 and 30.9 in 2004 and 2005, respectively, when they applied 90 kg S ha^{-1}. The foliar application of K after 60 and 90 DAS significantly enhanced the yield of pods plant^{-1} by 44.57 in 2012 and 43.26 in 2013 in a two years experiment[18]. These results are in agreement with our findings.

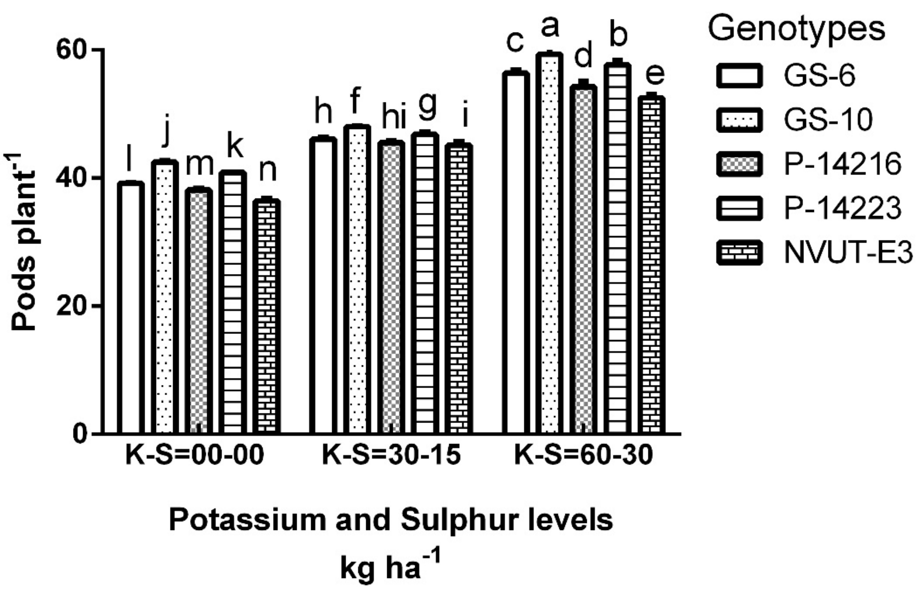

Fig. 3. Interactive impact of potassium and sulphur on pods plant^{-1} of five genotypes (GS-6, GS-10, P-14216, P-14223, and NVUT-E3) of lentil crop. The various alphabetical signs show significant difference among different treatments (P≤0.05), and all of the results are presented as mean ± SD. Mean values were derived from the performance of three replicates.

3.4 Seeds pods^{-1}

The results regarding seeds pod^{-1} showed a significant (P≤0.05, Table 2.) effect regarding increasing rate of K-S on lentil genotypes. The higher (60-30 kg ha^{-1}) rate of K-S significantly produced more number of seeds pod^{-1} than K-S = 30-15 and K-S = 00-00 kg ha^{-1} (Fig. 4.). Among different genotypes, it was observed that the genotype GS-10 produced maximum number of seeds pod^{-1} under each K-S level followed by P-14223 which was ranked 2nd for producing more seeds in pods. The minimum seeds pod^{-1} were computed in the genotype NVUT-E3. The remaining genotypes i.e. GS-6 and P-14216 were ranked on 3rd and 4th position, respectively. Shukla and Singh[20] reported that seeds pod^{-1} of three lentil varieties i.e. DPL-62, L-4076, IPL-81 were markedly enhanced when S was applied by gypsum at 40 kg ha^{-1}. Along with that, it has also been reported that K played its role in increasing seeds pod^{-1} of lentil crop in pot as well as field experiment[21].

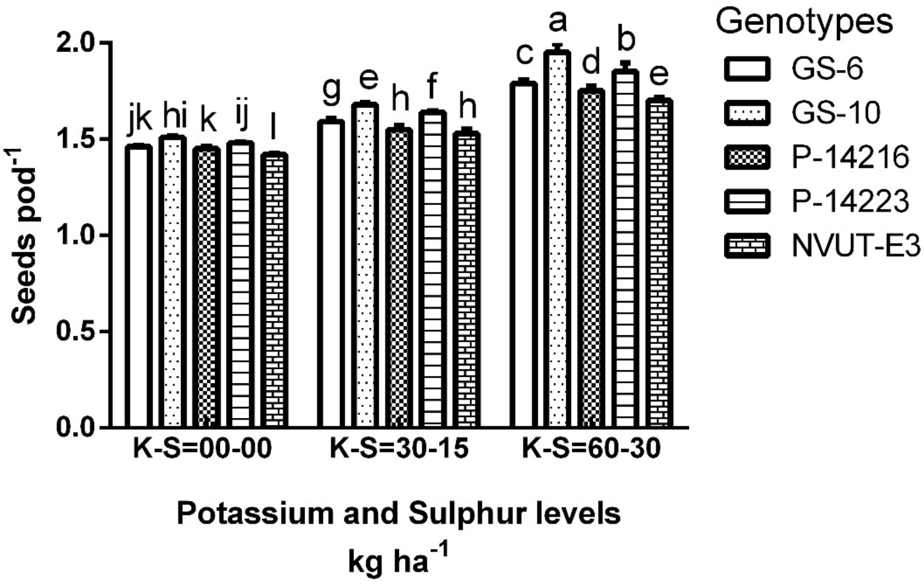

Fig. 4. Interactive impact of potassium and sulphur on seeds pod^{-1} of five genotypes (GS-6, GS-10, P-14216, P-14223, and NVUT-E3) of lentil crop. The various alphabetical signs show significant difference among different treatments (P≤0.05), and all of the results are presented as mean ± SD. Mean values were derived from the performance of three replicates.

3.5 Seed weight plant^{-1} (g)

Increasing level of K-S significantly (P≤0.05, Table 2.) increased the seed weight plant^{-1} (g). The crop provided with K-S at 60-30 kg ha^{-1} produced greatest seed weight plant^{-1}, the ordinary seed weight plant^{-1} was noted in the crop given K-S at 30-15 kg ha^{-1}. Whereas the lowest weight of seeds plant^{-1} was obtained in control treatments (Fig. 5.). In case of genotypes, the seed weight plant^{-1} was seemed well in genotype GS-10, followed by the genotype P-14223 under each potassium-sulphur level. While the genotypes GS-6 and P-14216 ranked 3rd and 4th in seed weight plant^{-1}, respectively. The lowest seed weight plant^{-1} was noticed in the genotype NVUT-E3 under each K-S level. The maximum (6.48 g) of seed weight plant^{-1} as compared to other treatments was acquired by Jahan[5] when they applied 25 kg potassium ha^{-1}. Similarly, Tariq[22] also observed same kinds of results in Mung bean plants. Our findings are in agreement with both of these studies.

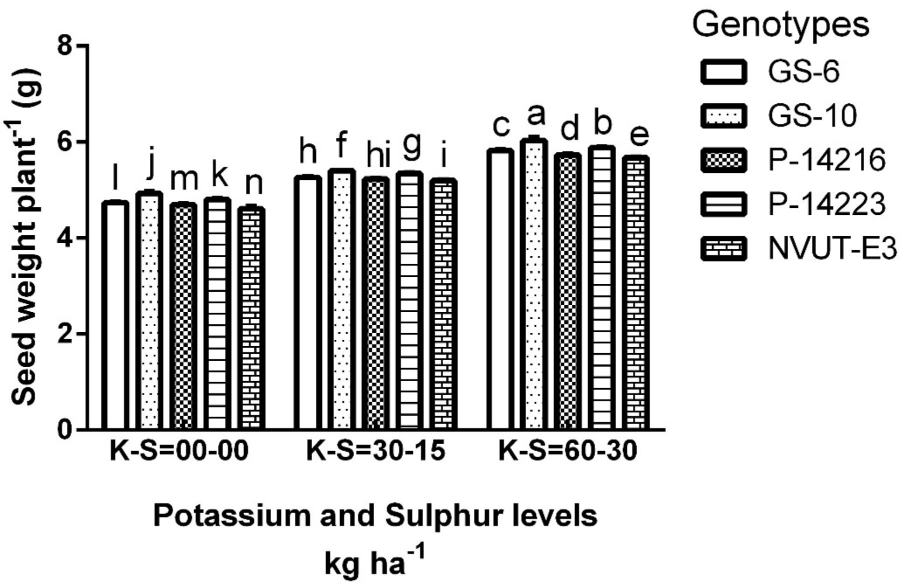

Fig. 5. Interactive impact of potassium and sulphur on seed weight plant^{-1} (g) of five genotypes (GS-6, GS-10, P-14216, P-14223, and NVUT-E3) of lentil crop. The various alphabetical signs show significant difference among different treatments (P≤0.05), and all of the results are presented as mean ± SD. Mean values were derived from the performance of three replicates.

3.6 1000-seed weight (g)

The lentil crop showed a consecutive improvement in 1000-seed weight (g) with each increment in potassium-sulphur level. The crop fertilized with K-S at 60-30 kg ha^{-1} significantly (*P*≤0.05, Fig. 6. Table 2.) resulted in the highest 1000-seed weight (g), while the lowest 1000-seed weight (g) was seemed in the plants grown in control (00-00 kg K-S ha^{-1}) conditions. In case of lentil genotypes, the maximum 1000-seed weight (g) was obtained in the genotype GS-10, followed by the normal 1000-seed weight (g) produced by the genotype P-14223. Statistically, there was no significant difference in 1000-seed weight of the genotypes GS-6 and P-14216 under K-S = 60-30, GS-6 and P-14223 under K-S = 30-15 and the genotypes P-14216 and NVUT-E3 under K-S = 00-00 kg ha^{-1}. However, the lower 1000-seed weight was detected in the genotype NVUT-E3 in each K-S level. 1000-seed weight is the key component for enhancing yield of any crop. It has been sorted out from previous studies that the potassium at 60 kilogram ha^{-1} and sulphur at 40 kilogram ha^{-1} have shown their positive response for increasing the weight of 1000 seeds in lentil crop[16,19].

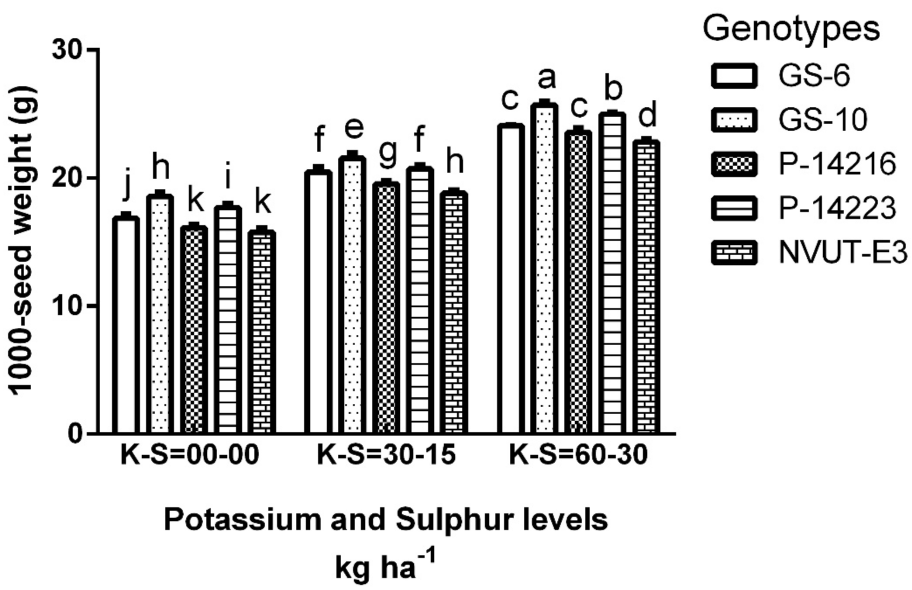

Fig. 6. Interactive impact of potassium and sulphur on 1000-seed weight (g) of five genotypes (GS-6, GS-10, P-14216, P-14223, and NVUT-E3) of lentil crop. The various alphabetical signs show significant difference

among different treatments (P≤0.05), and all of the results are presented as mean ± SD. Mean values were derived from the performance of three replicates.

3.7 Seed yield (kg ha^{-1})

The seed yield (kg ha^{-1}) of five genotypes was analysed to check the effect of K-S levels on lentil crop. The results of the lentil genotypes regarding seed yield were significantly (*P*≤0.05, Table 2.) enhanced by increasing the level of potassium and sulphur. The supreme seed yield was achieved in the treatments where 60-30 kg K-S ha^{-1} was applied. Whereas, control (00-00 kg K-S ha^{-1}) plots showed lowest seed yield in every genotype (Fig. 7.). In situations of the genotypes, it was observed that GS-10 produced highest seed yield under each K-S level and the genotype P-14223 ranked 2nd. However the statistics of the genotypes GS-6 and P-14223, P-14216 and NVUT-E3 showed that these genotypes were similar to each other in K-S = 60-30 kg ha^{-1} regarding seed yield. Overall, the lower performance was observed in the genotype NVUT-E3 for seed yield under each potassium-sulphur levels. Hamayun[23] reported that potassium can increase seed yield, no matter K is applied through soil or foliar spray. Our results are in agreement with several previous studies which reported that potassium and sulphur either alone or along with other elements have significantly improved the seed yield (kg ha^{-1}) in lentil crop[21,24-27].

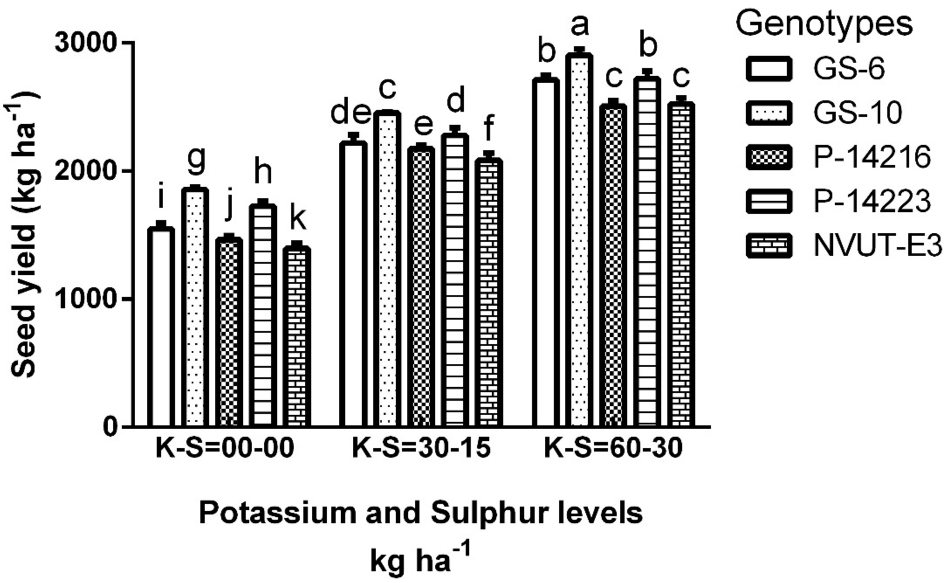

Fig. 7. Interactive impact of potassium and sulphur on seed yield (kg ha^{-1}) of five genotypes (GS-6, GS-10, P-14216, P-14223, and NVUT-E3) of lentil crop. The various alphabetical signs show significant difference among different treatments (P≤0.05), and all of the results are presented as mean ± SD. Mean values were derived from the performance of three replicates.

4. CONCLUSIONS

It was concluded from present research that interactive action of potassium and sulphur levels had significant (P≤0.05) positive impact on the growth and yield of lentil genotypes. The interactive potassium and sulphur supplement at 60-30 kg K-S ha^{-1} given highest growth and produced maximum seed yield, while genotype GS-10 appeared to be superior in all growth and yield parameters than other genotypes. In this regard, the genotype GS-10 along with K-S = 60-30 kg ha^{-1} is being recommended for cultivation in locality. On the basis of physical and chemical properties of soil, E.g. soil type, sand, silt, clay, pH, EC, organic matter and N content, further studies may be carried out under controlled and field environments to analyse material for more accurate impact.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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