Research Article **Open Access**

Hussain et al., 2022. 24(3&4) :23-28. J. Environ. Agric. Sci. (ISSN: 2313-8629)

Application of Sulphate of Potash Enhances Mungbean (*Vigna radiata*) Yield under Agroclimatic Conditions of Thal, Pakistan

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Received
September 12, 2022
Accepted
November 7, 2022
Published Online
December 28, 2022

Abstract: Mungbean (*Vigna radiata*) is an important pulse crop that has high nutritive value. Its seed is protein rich and plants can fix atmospheric nitrogen. Potash not only increases the yield of mungbean but also improves the quality of mungbean. The effect of different doses of potash (0, 25, 50, 75, and 100 kg ha^{-1}) was studied at Adaptive Research Farm Karor, Layyah, Pakistan. The field experiment was performed during Kharif seasons (2019 and 2020) using a randomized complete block design having three replications. The performance of mungbean was the best with the application of SOP @75 kg ha^{-1} with 1000-grain weight (63 g), the number of grains per pod (11), number of pods per plant (19.33) and grain yield (803 kg ha^{-1}) during crop season 2020. In nutshell, 75 kg ha^{-1} SOP should be applied during the soil preparation for maximum yield of mungbean in the Thal region of Punjab, Pakistan.

Keywords: Arid conditions, Pulses, Nutrients, AZRI-2006, Fertilizers, NPK, Pakistan

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Cite this article as Hussain, I., G. Abbas, J. Hussain, Z. Abbas, T. Mehmood, M. Amer, Q. Maqsood and I. Rasool. 2022. **Application of sulphate of potash enhances mungbean (*Vigna radiata*) yield under agroclimatic conditions of Thal, Pakistan**. Journal of Environmental & Agricultural Sciences. 24(3&4):23-28.

1. Introduction

Mungbean (*Vigna radiata*), also known as green gram, is an important legume crop of the Fabaceae family. It is widely cultivated around the world, especially in Asian countries, including India, Pakistan, and Iran (Hou et al., 2019; Burlyaeva et al., 2019; Mishra et al., 2022). Being a legume crop, it is a rich source of proteins, amino acids, carbohydrates, minerals, vitamins, antioxidants, and other bioactive compounds like flavonoids (Amitrano et al., 2020; Lu et al., 2019; Supasatyankul et al., 2022). Its seeds comprise protein (26.7%), fibre (0.9%), ash (3.7 %), and fat (0.6%) (Potter and Hotchkiss, 1997). Mungbean is an important legume crop because of its flavor, easy digestibility, and good price in the market (Mandal et al., 2009). Bioactive compounds and therapeutic properties of mungbean provide health benefits and overcome several chronic degenerative disorders (Ganesan and Xu, 2018; Ma et al., 2022; Matemu et al., 2021).

Mungbean has the ability to fix atmospheric nitrogen through symbiotic association with *Rhizobium* (Mott et al., 2022), leading to the addition of nitrogen (58-109 kg ha^{-1}) in the soil (Concha and Doerner, 2020; Favero et al., 2022; Hakim et al., 2021), therefore, requires less nitrogenous fertilizers. Mungbean is a short-duration crop, adapted to a wide range of agroclimatic conditions has wider adaptability and can survive low input conditions (Bell et al., 2021; Islam et al., 2022; N'Danikou et al., 2022). Therefore, it can be grown in both irrigated and rain-fed areas and provide better yield in short gaps between two crops (Al-Zahrani et al., 2021; Rehman et al., 2022).

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Mungbean ranks second to chickpea in Pakistan in the grain legumes crops (Government of Pakistan, 2018; Ullah et al., 2020). The total cultivated area for mungbean in Pakistan is 0.3018 million hectares annually with a total yield of 0.2638 million tonnes (Government of Pakistan, 2022).

In Pakistan, the mungbean crop gives lesser production per area than its potential, which needs the attention of crop experts (Ullah et al., 2020). There are several reasons for the low productivity of mungbean including poor varieties and conventional management practices especially imbalanced fertilizer application (Iqbal et al., 2021; Jackson, 2001; Ullah et al., 2020). Crop intensification has multiplied the need for supplementation of macro- and micro-nutrients in the soils (Cassman and Grassini, 2020; Malakouti, 2004; Tillman et al., 2011). The deficiency of macro- and micro-nutrients in agricultural soils causes metabolic and physiological disturbances in the plants (Babaeian et al., 2011; Koritschoner et al., 2023; Mueller et al., 2012). Supplementation of macronutrients like, NPK plays a vital role in increasing the yield of mungbean (Ali et al., 1996; Ali et al., 2010). Climatic changes have worsened the situation with unprecedented rainfalls and a rise in temperature (Hussain et al., 2018; Hussain et al., 2020; Ullah et al., 2020; Hussain et al., 2021).

Potassium (K) application plays a key role in mungbean production. It increases plant immunity and reduces pest attacks and diseases, enhances the availability of other nutrients, and helps in the synthesis of proteins (Arif et al., 2008). K is essential as a macronutrient in the growth of the plant and the good production of the crop (Baligar et al., 2001). It is critically involved in maintaining the cell's turgor pressure, which is necessary for cell expansion. It helps in the process of osmoregulation, which helps in stomata closing and opening. It plays is essential for activation of more than 60 enzymes (Tisdale et al., 1990; Bukhsh et al., 2011). Keeping in view the importance of K in mungbean, this study was designed to investigate optimum the K dose for enhancing mungbean yield in the marginal soils of the Thal region, Punjab, Pakistan.

2. Materials and Methods

2.1. Experimental site

A field experiment was conducted in 2019 and 2020 at Adaptive Research Farm Karor (31° N, and 71°E at an altitude of 145 m (above sea level) of Layyah. The region has a desert climate and hot summers (25.2 °C - 48 °C) and dry cool winters (0 °C-2 °C) (Hussain et al., 2020). Most of the rainfall was received during (January-March) with a mean value of 120 mm. Details of soil analysis have been given in Table 1.

2.2. Weather data

Standard weather data (minimum and maximum temperature (ºC), relative humidity (%) and rainfall (mm) were collected (Table 2) from Karor Meteorological Station, Karor, Layyah, Pakistan Meteorological Department, Govt of Pakistan.

Table 1. Soil Physico-chemical Properties at Adaptive Research Farm Karor Laal Esan

Parameter	Quantity
Sand	40.89%
Silt	38.46%
Clay	22.03%
pH	8.55%
Organic matter	0.891%
$CaCO_3$	6.88%
EC	1.6 ds/m
Available N	0.58 g/kg
Available P	11.05 mg/kg
Exchangeable K	123.80 mg/kg
AB-DTPA Extractable Zn	0.99 mg/kg
AB-DTPA Extractable Fe	2.87 mg/kg
AB-DTPA Extractable Mn	1.17 mg/kg

Table 2. Monthly Averages of Weather of Experimental Site During Crop Seasons (2019 and 2020)

Month	Monthly Rainfall (mm)		Monthly Mean Tmax (°C)		Monthly Mean Tmin (°C)		Monthly Mean RH (%)	
	2019	2020	2019	2020	2019	2020	2019	2020
April	66.0	16.8	33.74	32.78	18.25	18.50	54.55	56.00
May	84.0	9.5	37.45	38.18	19.35	23.30	58.35	49.95
June	5.2	45.4	37.52	39.40	22.34	26.09	40.27	51.32
July	69.0	58.6	38.50	39.66	27.41	27.69	62.54	49.51
August	93.0	86.5	38.29	38.12	27.18	28.17	68.48	72.54
September	0.0	28.0	38.50	37.03	26.60	24.60	65.73	74.26
October	33.0	0.0	32.23	34.19	18.36	16.56	75.98	65.85

Tmax, daily maximum temperature; Tmin, daily minimum temperature; RH, relative humidity.

2.3. Experimental detail

The experiment was laid out in a randomized complete block design (RCBD). The mungbean seed was sown keeping the row-to-row (R×R) 30 cm distance through the line sowing method with five treatments and three replications. Treatments were comprised of five levels of potash T_1 = 0 kg K_2O ha^{-1}, T_2 = 25 kg K_2O ha^{-1}, T_3 = 50 K_2O kg ha^{-1}, T_4 = 75 kg K_2O ha^{-1}, and T_5 = 100 kg K_2O ha^{-1} with recommended N (24 kg ha^{-1}) and P_2O_5 (30 kg ha^{-1}). Seeds of AZRI-2006 were sown (@ 25 kg ha^{-1}) during 1st week of July (2019 & 2020).

Following the harvest of previous crops, the land was plowed twice with tractor–drawn moldboard plow and the seed was sown with the dribbling method, and 1st irrigation was applied 14 days after sowing. Subsequently, 2nd irrigation was applied at the flowering stage and 3rd irrigation at the pod formation stage. Mungbean was fertilized following the local recommendations for N (25 kg ha^{-1}), P_2O_5 kg ha^{-1} (50 kg ha^{-1}) using urea (46% N), and diammonium phosphate (18:46. N:P_2O_5) as fertilizer sources, respectively. The fertilizer was applied with two equal splits at the flower stage and pod formation stages. A selective broad-spectrum pre-emergence herbicide (Pendimethalin) was applied to control weeds. Moreover, minor attacks of leaf wrinkles and thrips were observed during the early crop growth stage, these were controlled using WP Buprofezin @ 1600 ml ha^{-1}. At lateral crop growth stage Pyrilla attack was controlled by the application of two sprays of Coragen@100 ml ha^{-1}. The crop was harvested during the first week of October (2019 & 2020).

2.4. Sampling and analysis

At physiological maturity, the crop was harvested from an area of 3 m^2 avoiding the border area to calculate the grain yield and converted into kilograms per hectare through unit area. Plant height was calculated by measuring the height of plants randomly. The number of pods was calculated by counting the number of pods per plant through randomly selected plants. Then, ten randomly selected pods were harvested manually, and the number of seeds was counted. Finally, 1000 grains were counted, and their weight was recorded through weight balance to find the 1000-grain weight.

2.5 Statistical analysis

All the data collected were statistically analyzed using software Statistix-8.1 with Fisher's analysis of variance technique and least significant difference test at 5% probability level applied to compare treatment means.

3. Results and Discussion

3.1. Plant height (cm)

The plant height was significantly affected by the different levels of potash at ARF Karor during both years 2019 and 2020 presented in Tables 3 & 4. Maximum plant height (84 cm) was recoded with the application of potash 75 kg ha^{-1} during 2019 while minimum plant height was recorded during the same year in the treatment without potash application. Plant heights of T_4 and T_5 were at par during 2019 and 2020 while significantly different from T_1, T_2 and T_3. The application of potash enhances the plant height of mungbean due to plant growth through cell enlargement, protein synthesis and enzyme activation (Baligar et al., 2001; Arif et al., 2008). Oad et al. (2003) reported that potash and phosphorus had significant effect on plant height. Hussain et al., (2011) also observed a significant impact on plant height same as reported by the study under discussion.

3.2. Number of pods per plant

Pod formation is a key yield contribution factor in legumes. Analysis of data showed that the number of pods per plant was significantly influenced by the application of potash during both experimental years (2019 and 2020) at ARF Karor Tables 3, Table 4). The maximum number of pods per plant (19.33) was recorded in T_4 (75 kg/ha potash) during 2020 followed by T_5 (18.93) during 2020 (18.93) and T_4 during 2019 (18.93). The increase in the number of pods per plant with the application of potash is due to enzyme activation for pod formation in the mungbean plant. The same results have been found in different studies that potash is important for pod formation (Oad et al., 2003; Hussain et al., 2011).

Table 3. Effects of Different Levels of Sulphate Of Potash (SOP) on Mungbean at ARF Karor During 2019

Potash Treatments (kg K_2O ha^{-1})	Plant Height (cm)	No. of Pods plant^{-1}	No. of grains pod^{-1}	1000-Grain Weight (g)	Grain Yield (kg ha^{-1})
T_1 (0 kg)	76 b	14.86 b	8.32 c	49.64 c	632 c
T_2 (25 kg)	77 b	17.40 a	9.53 b	53.15 bc	647 b
T_3 (50 kg)	80 ab	17.73 a	10.23 a	57.62 ab	689 b
T_4 (75 kg)	82 a	18.93 a	11.00 a	61.13 a	764 a
T_5 (100 kg)	84 a	18.07 a	10.80 a	60.16 a	722 a

Means with different letters (in each column) are significantly different from each other ($P < 0.05$), while means with the same letters are not significantly different ($P > 0.05$).

Table 4. Effects of Different Levels of Sulphate Of Potash (SOP) on Mungbean at ARF Karor During 2020

Potash Treatments (kg K_2O ha^{-1})	Plant Height (cm)	No. of pods plant^{-1}	No. of grains pod^{-1}	1000-Grain weight (g)	Grain Yield (kg ha^{-1})
T_1 (0 kg)	77 b	15.00 b	7.67 b	51.0 c	653 c
T_2 (25 kg)	78 b	17.00 b	8.33 b	55.0 bc	667 b
T_3 (50 kg)	80 b	18.80 a	9.53 a	59.0 ab	677 b
T_4 (75 kg)	84 a	19.33 a	10.84 a	63.0 a	803 a
T_5 (100 kg)	83 a	18.93 a	11.13 a	62.0 a	787 a

Means with different letters (in each column) are significantly different from each other ($P < 0.05$), while means with the same letters are not significantly different ($P > 0.05$).

3.3. Number of grains per pod

The number of grains per pod is the most important yield component. Data analysis revealed that the number of grains per pod was significantly affected by different levels of potash during both years at ARF Karor as mentioned in Tables 3 & 4. The maximum number of grains per pod (11.13) was recorded with the application of 75 kg ha^{-1} (T_5) during 2020 but statistically at par with T_3 and T_4 during both years. While the minimum number of grains per pod was observed during 2020 when no potash was applied (T_1). Two treatments (T_1 and T_2) were statistically the same while significantly different between T_3, T_4 and T_5 during both years. The same results were reported from different studies at different locations (Khan et al., 2002; Shahi, 2002). The application of K facilitates grain development in the pods (Yin et al., 2018).

3.4. 1000-Grain Weight (g)

Thousand-grain weight (g) is an important component among yield parameters. The grain size was significantly affected by potash levels as shown in Tables 3 & 4. Maximum grain yield (63 g) was recorded in T_4 during 2019 where 75 kg ha^{-1} potash was applied while minimum grain size (49.64 g) was observed where no potash (T_1) was applied during 2019. Grain weight is significantly affected by potash levels because potash plays the most significant role as a glucose transporter during the grain filling stage of every crop (Mulghani et al., 2010; Hussain et al., 2011).

3.5. Grain Yield (kg ha^{-1})

Grain yield was significantly affected by different levels of potash at ARF Karor during the years 2019 and 2020 as shown in Tables 3 and 4. The maximum grain yield was observed in T_4 (764 kg ha^{-1}) during the year 2019 and during the year 2020 (803kg ha^{-1}) at ARF Karor where potash (75 kg ha^{-1}) was applied. The minimum grain yield was observed in T_1 where 0 kg potash was applied in both years 2019 (632 kg ha^{-1}) and 2020 (653 kg ha^{-1}). In T_2, grain yield was 647 and 667 kg ha^{-1} during 2019 and 2020, respectively. While the grain yield which was observed in T_3 was 689 kg ha^{-1} and 677 kg ha^{-1} during the years 2019 and 2020. Grain yield was also significantly affected by changing the dose of potash per unit area (Arif et al., 2008; Yin et al., 2018).

4. Conclusion

It is concluded that application of potash @75 kg ha^{-1} should be applied to the mungbean crop to obtain a good yield (803 kg ha^{-1}) in arid conditions of the Thal zone. Other yield parameters such as the number of pods per plant, number of grains per pod and 1000-grain weight (g) were enhanced significantly with the application of potash @75 kg ha^{-1}. Phosphorus and nitrogen should be applied at @57 kg ha^{-1} and 23 kg ha^{-1}, respectively, with 75 kg ha^{-1} Potash at the time of sowing. The grain yield of T_4 was enhanced by 17.5% during both years as compared to where SOP was not applied.

Competing Interest Statement: The authors have no conflict of interest. All authors have read and agreed to the published version of the manuscript.

Author's Contribution: I. H. and G.A. gave the idea and supervised the research. J.H. and Z.A. conducted the research and analyzed the data. J.H. and T.M. drafted the paper. M.A. and Q.M. helped with paper collection and reviewed the paper. I.R and J.H. inserted the suggestions and finalized the final manuscript.

Acknowledgment: Authors acknowledge the funding of the Government of Punjab for conducting this research article.

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