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RESPONSE OF MUNGBEAN (*VIGNA RADIATA* L.) TO POTASSIUM APPLICATION RATES UNDER DESERT CLIMATE

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ABSTRACT

Potassium is instantly correlated to growth, biomass and yield of plants. In Pakistan, potassium deficiency in most of the areas is becoming a nutritional limiting factor for crops yield. A field experiment was performed in 2014 to study the response of mungbean (*Vigna radiata* L.) varieties to potassium application under arid climate. Five potassium application rates (0, 50, 75, 100, 125 kg ha^{-1}) were implicated on three mungbean varieties (NM-98, NM-2006 and NM-2011). The experiment was laid out in a Randomized Complete Block Design (RCBD) with split plot arrangement having three replications. Variable application of K on mungbean varieties showed positive effect on growth, physiological, water related and yield attributes. Transpiration rate, stomatal conductance and relative water contents (RWC) were found to be increasing with increasing K rates and maximum values were noted in NM-2011 while excised leaf water loss (ELWL) decreased gradually by applying K rates in all three varieties. Maximum seed yield, seeds per pod and 1000-seed weight was obtained in NM-98 with application of K at 100 kg ha^{-1}. Results of present study conclude that NM-98 gave higher yield and showed maximum response to K application at 100 kg ha^{-1} relative to other rates of potassium application.

Keywords: agronomic and physioligcal traits, mungbean

INTRODUCTION

Pulses play a vital role in fulfilling basic human nutrition. Mungbean (*Vigna radiata* L.) is a major pulse crop, with inflated nutritive value and annual production of 77.2 thousand tons. The seed contains 1.0-1.5% fat, 22-28% proteins, and 60-65% carbohydrates. It is an important conventional pulse. Among several factors, judicial use of NPK improves mungbean yield (Ali *et al*., 2010). Potassium contributes major role in photosynthesis, protein synthesis and resilience against abiotic stresses (Baligar *et al*., 2001; Arif *et al*., 2008). It helps in maintaining turgor pressure of cell and plays a vital role against drought stress

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and disease resistance (Gupta *et al*., 2013). Although it is not a part of any organic structure but helps in osmo-regulation and translocation of photosynthates in plants (Samiullah and Khan, 2003; Yang *et al*., 2004). Potassium improves plant water relationship and improves mungbean shoot growth (Kafkafi *et al*., 2001; Kabir *et al*., 2004).

Potassium concentration in soils of Pakistan varies with texture, structure and parent material. But due to higher food demand for rapidly growing population, increased cropping intensity and poor management practices, a significant drain in potassium concentration was reported (Anser and Hussain, 2012). Keeping in view the above stated facts, the present study was planned to investigate the effect of potassium application rates on growth and physiological traits of mungbean, characterization of various mungbean varieties to different potassium concentrations and to formulate recommendations about potassium application for mungbean under desert climate of Bahawalpur.

MATERIALS AND METHODS

The study was performed in year 2014 to study the effect of various potassium concentrations on different mungbean varieties under desert climate (loamy sand) at the research farm, Department of Soil Science, University College of Agriculture and Environmental Sciences, The Islamia University Bahawalpur. The minimum and maximum temperature during the whole experiment was 10ºC and 40ºC with an average of 25ºC. The pan evaporation rate was 7.86 millimeter (mm) and rainfall at 52 mm. Seeds of three varieties viz. NM-98, NM-2006 and NM-2011 were sown on seed beds by using hand drill @ 25 kg ha^{-1}. The soil selected was deficient in potassium. The nitrogen was applied at 25 kg ha^{-1}, while phosphorus at 50 kg ha^{-1}. Potassium was applied in six doses as treatments *viz. 0*, 25, 50, 75, 100 and 125 kg ha^{-1}. The sources of NPK were urea, di-ammonium phosphate and sulphate of potash. The experiment was performed in Randomized Complete Block Design (RCBD) with three replicates having split plot arrangement. Net plot size was 2 × 6 m with row to row distance of 30 cm and plant to plant distance of 10 cm. The data regarding crop was collected at different stages of the experiment. After 90 days of sowing (06 May, 2014), the crop was harvested and data regarding growth, physiological, water relations and yield parameters were determined.

Protocols for data recording

Leaf area index (LAI)

Leaf area was recorded at uniform interval by using leaf area meter (Delta MK-2). The measurement was initiated 21 days after sowing (DAS) and completed at harvesting and LAI calculated by using the formula of Watson (1947).

$$LAI = \text{Leaf area} / \text{Ground area}$$

Growth and yield attributes

After harvesting of plants (one square meter per plot), growth and yield attributes i.e plant height and number of branches per plant, number of seed per pod, grain yield, biological yield, and 1000-grain weight were measured using standard procedures.

Transpiration rate and stomatal conductance

Transpiration rate and stomatal conductance were calculated using portable infrared gas analyzer (ADC, London, United Kingdom).

Relative water contents

Relative water contents (RWC) were measured by standard formula of Lazcano-Ferrat and Lovatt (1999).

$$\text{Relative water conent (\%)} = \frac{\text{Leaf fresh weight} - \text{Leaf dry weight}}{\text{Leaf turgid weight} - \text{Leaf dry weight}}\ X\ 100$$

Excised leaf water loss

Excised leaf water loss (ELWL) was measured according to method of Clarke (1987).

ELWL (%) = (Fresh weight-Wilted weight)/Dry weight

Potassium concentration in plants

Potassium concentration in plants was measured using Flame photometer.

Statistical analysis

Data was analyzed statistically by using Statistix-9 software and presented in graph with standard error bars (Steel *et al*., 1997).

RESULTS

Leaf area index (LAI)

Under disparate potassium concentration, leaf area index (LAI) is presented in Figure 1. The LAI under various potassium levels show gradual increase from 23 to 44 DAS and then decreased. The maximum value (4.5) was found in variety NM-2011 under potassium application at 125 kg ha^{-1}, while it was least (2) for variety NM-98 where no potassium was applied. The trend of LAI continued with slight difference up to 44 DAS, however, a minor response of mungbean to potassium was noted at subsequent stages of crop development (65 DAS).

Plant height (cm)

By applying various potassium levels, the plant height in different varieties of mungbean varied non-significantly (Figure 2). Application of potassium at 100 kg ha^{-1} showed maximum plant height (69.8 cm) in NM-98, while least value (53.0 cm) with potassium at 50 kg ha^{-1} was observed in NM-2006.

Number of branches

The number of branches per plant showed a significant response to potassium application (Figure 3) and was significantly increased by increasing potassium levels. The maximum value (6.93) was recorded in NM-98 when potassium were applied at 100 kg ha^{-1}, while minimum values were observed in NM- 2006 in control treatment where no potassium was applied.

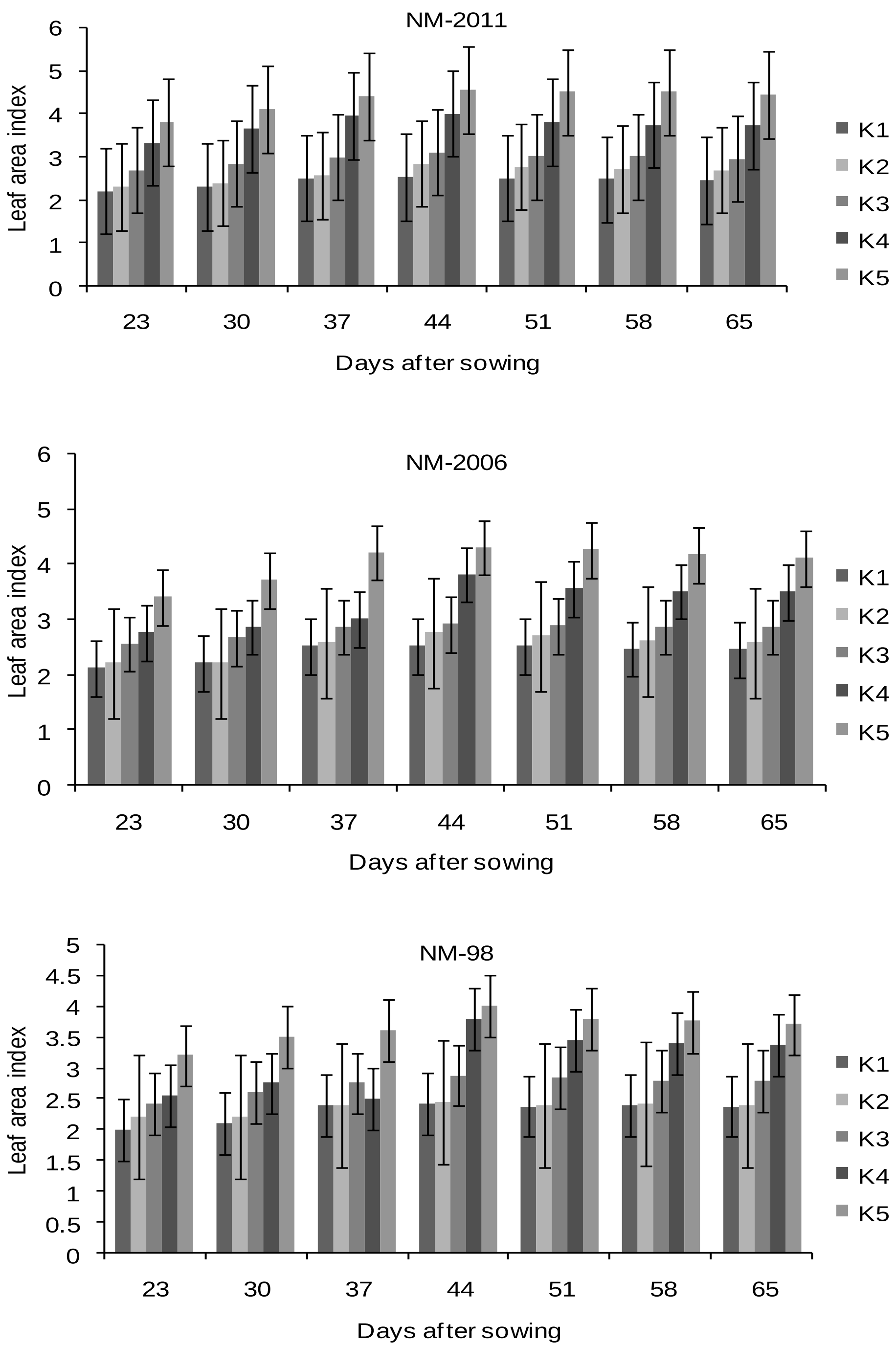

Figure 1. Effect of different potassium application rates on leaf area index (LAI)

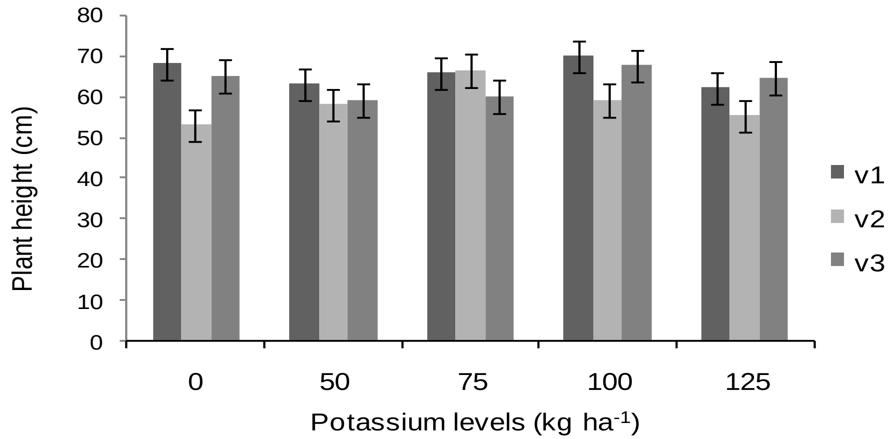

Figure 2. Effect of different potassium levels on plant height

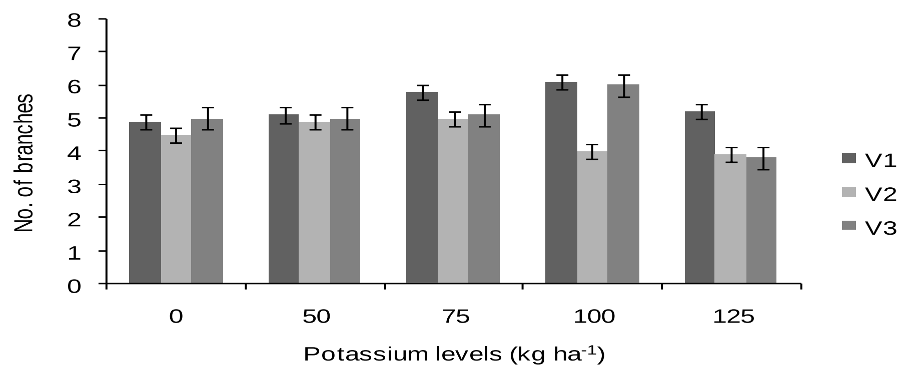

Figure 3. Effect of different potassium levels on no. of branches/ plant

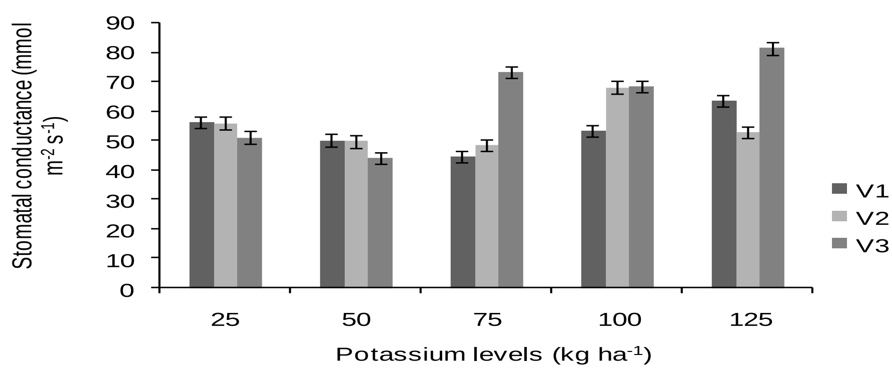

Figure 4. Effect of different potassium levels on stomatal conductance

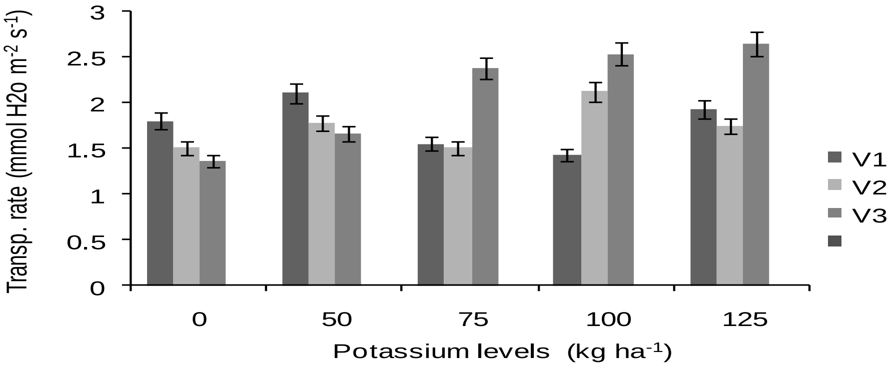

Figure 5. Effect of different potassium levels on transpiration rate

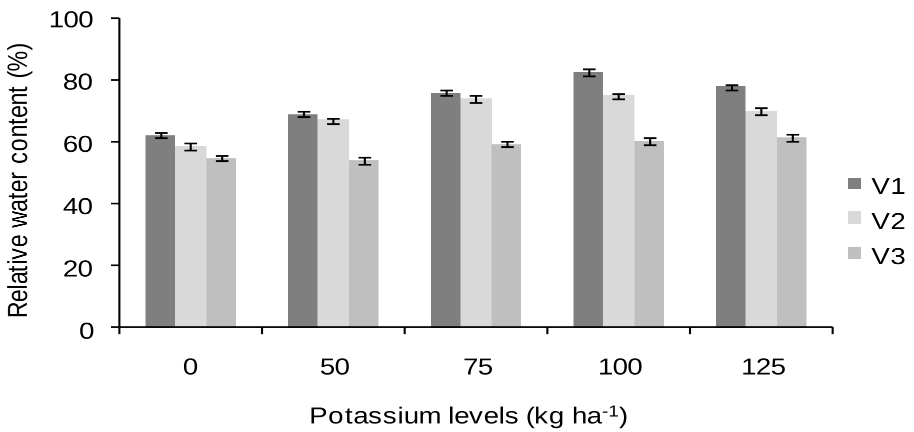

Figure 6. Effect of different potassium levels on relative water content

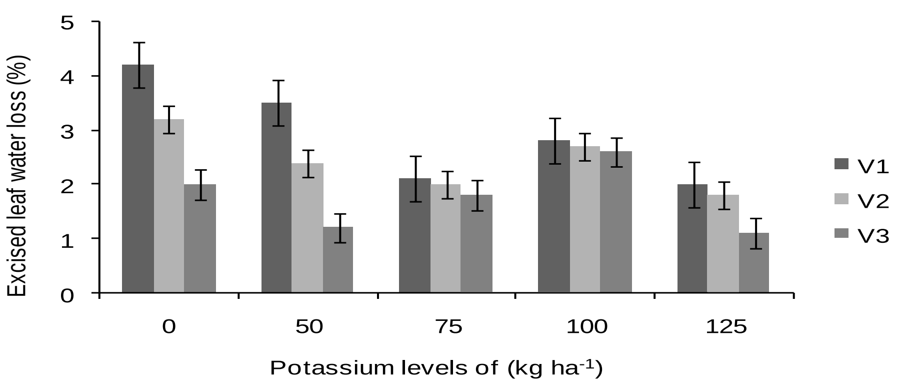

Figure 7. Effect of different potassium levels on excised leaf water loss

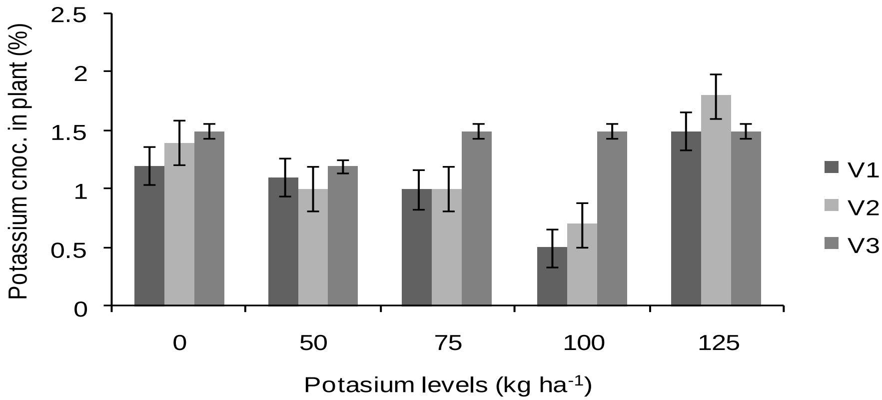

Figure 8. Effect of different potassium levels on plant potassium concentration

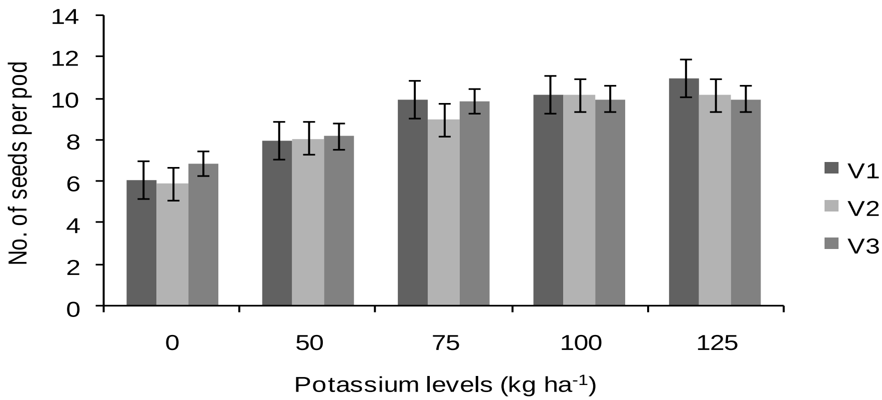

Figure 9. Effect of different potassium levels on seeds per pod

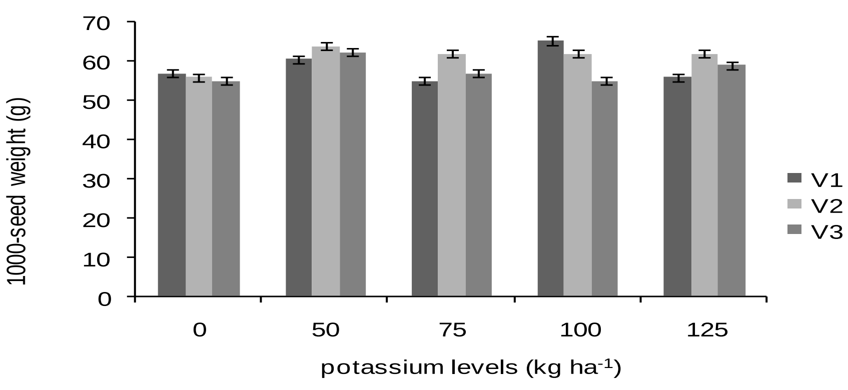

Figure 10. Effect of different potassium levels on 1000-seed weight (g)

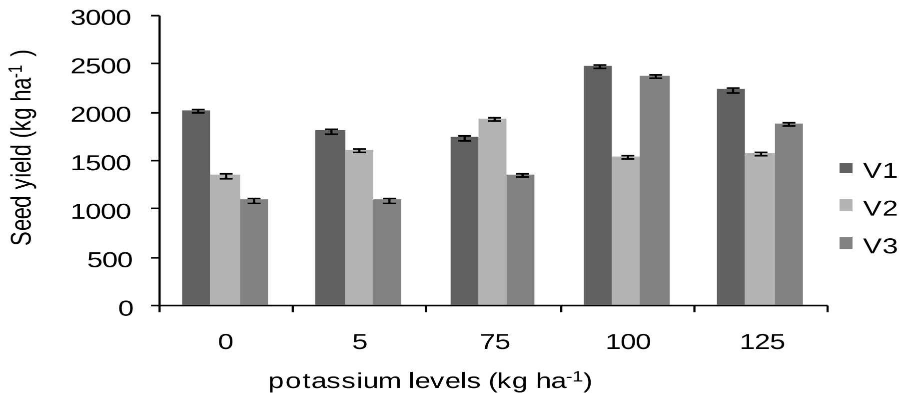

Figure 11. Effect of potassium application rates on grain yield

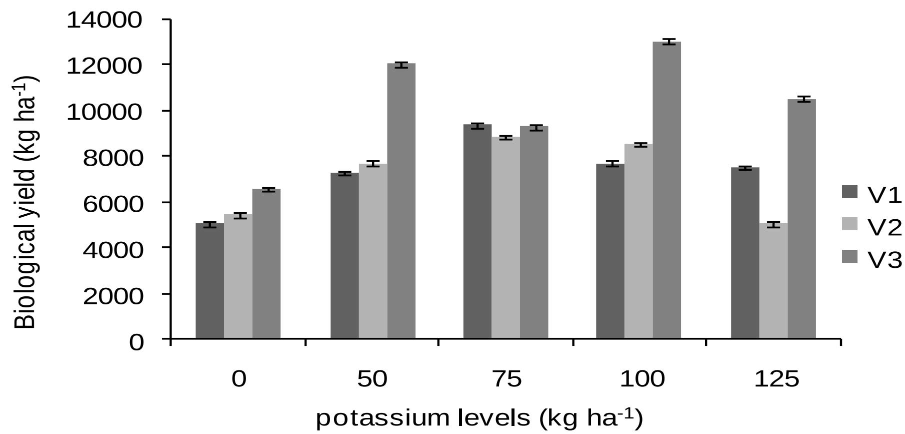

Figure 12. Effect of potassium application rates on biological yield

Stomatal conductance and transpiration rate (mmol m^{-2})
Potassium application influenced stomatal conductance significantly in mungbean varieties (Figure 4). Maximum value (81.1 m mol m^{-2}) was observed at 125 kg ha^{-1} K in NM-2011, while minimum stomatal conductance (34.4 mmol m^{-2}) was noted at 75 kg ha^{-1} K in NM-98. In case of transpiration rate (Figure 5), same trend was observed where maximum transpiration rate (2.6) under disparate potassium levels was recorded at 125 kg ha^{-1} K in NM-2011 while minimum 1.0 in NM-98 at 75 kg ha^{-1} K was noted.

Relative water contents (%)
Data regarding relative water contents under variable potassium levels in three different varieties are manifested in Figure 6. Results revealed that application of potassium significantly improved the relative water contents. Maximum improvement in RWC was observed at 100 kg ha^{-1} potassium level in NM-98

relative to other levels of potassium while minimum RWC was noted in control treatment in all these varieties.

Excised leaf water loss (%)

Results regarding ELWL depicted in Figure 7 revealed that maximum excised leaf water loss (0.43%) was noted at control in variety NM-98 where no potassium was applied while minimum value (0.12%) was noted at 125 kg ha^{-1} K in variety NM-2011.

Potassium concentration (%)

Considerable differences were observed for concentrations of potassium in all three varieties which are depicted in Figure 8. The concentration of potassium significantly increased with increasing potassium levels. Highest concentration of potassium (1.86%) was observed in NM-2006 at maximum level of potassium application 125 kg ha^{-1} while minimum potassium concentration (0.74%) was observed in NM-98 at 75 kg ha^{-1} potassium rate. The remaining variety NM-2011 showed potassium concentration in between these two varieties.

Number of seeds per pod

Number of seeds pod^{-1} was remarkably affected by different potassium concentrations (Figure 9). It was found to be increased with increasing potassium supply. Minimum number of seeds pod^{-1} (5.0) was observed in NM-2006 variety at control treatment where no potassium was applied while maximum value of number of seeds pod^{-1} (11) was noted at the rate of 100 kg ha^{-1} potassium level in NM-98.

1000-seeds weight (g)

Result also revealed the positive effect of potassium application rates on the 1000-seeds weight (Figure 10). Maximum 1000-seed weight (63.00 g) was found in NM-98 when plants were subjected to 100 kg ha^{-1} K, while least value (54.0 g) was calculated in NM-2011 at control condition where no potassium was applied.

Grain yield (kg ha^{-1})

Effect of various potassium application rates on seed yield in three different mungbean varieties are depicted in Figure 11. Varieties manifest a significant contrast in terms of seed yield. Results show maximum value (2486 kg ha^{-1}) in NM-98 with the application of 100 kg ha^{-1} K, while minimum value (1090 kg ha^{-1}) was observed in NM-2011 at control treatment.

Biological yield (kg)

Biological yield is the total dry matter accumulation and is the first prerequisite for high yield in plants. Biological yield in three mungbean varieties at different potassium levels is shown in Figure 12 which depicts that all varieties showed a significant difference in biological yield when exposed to different potassium concentrations. Maximum biological yield (12000 kg ha^{-1}) was obtained in NM-2011 under potassium level 100 kg ha^{-1} while least biological yield 5333 kg ha^{-1} was recorded in NM-98 at control treatment where no potassium was applied.

DISCUSSION

In present study, application of potassium at different rates significantly influenced the growth, physiological, ionic and yield attributes of mungbean varieties. Potassium application at proper level (100 kg K ha^{-1}) results in significant response to mungbean due to better growth of root and shoot, high transpiration rate and stomatal conductance as well as more uptake of potassium (Hussain *et al*., 2011; Abbasi *et al*., 2014). Leaf area index showed an increase from 23 to 44 days after sowing and then decreased gradually. The increase in leaf area index could be due to maintenance of nitrogen in leaf tissues and more photosynthetic activity under sustained supply of potassium (Mondal *et al*., 2011).

Maximum plant height was recorded with higher potassium application rate while a gradual decrease was noted with reducing potassium supply. It might be due to the reason that increase in leaf area index (LAI) results in higher nitrogen uptake that contributed in more plant height. High root shoot ratio under potassium application is related to increase in plant height (Yang *et al*., 2004).

Number of branches showed a remarkable increase under potassium application. Maximum number of branches with 90 kg ha^{-1} was observed by Arif *et al*. (2008). Potassium showed synergistic effect and improved the availability of nitrogen and phosphorus (Sahai, 2004), which ensure more branches and improved plant growth. Potassium plays a significant role in stomatal conductance, leaf relative water contents, transpiration rate (Shabala, 2013) and allows plant to uptake more water that results in accumulation of more K concentration in leaf which ultimately increase leaf turgor and RWC (Abbasi *et al*., 2014). Fertilizer application showed remarkable improvement in number of seeds per pod. The slender variation in number of seeds per pod depicts that this attribute depends upon genetic makeup or climatic condition of plant (Hussain *et al*., 2011). The increase in number of seeds per pod was possibly due to the enhanced availability of other nutrients, photosynthetic activity and transfer of photosynthates from source to sink under potassium application (Samiullah and Khan, 2003). Grain yield was remarkably increased by increasing potassium concentration. The highest grain yield resulted in more number of seeds per pod (Samiullah and Khan, 2003). With increasing level of potassium, 1000-grain weight increased and maximum value was noted at 100 kg K ha^{-1} compared to other levels. Hussain *et al*. (2011) illustrated that maximum 1000-seeds weight of mungbean was acquired when NPK was applied at 60-100-100 kg ha^{-1}. Similar findings were also reported by Damon and Rangel, (2007) that application of potassium at early growth stage under drought conditions increases seed yield and 1000-grain weight in mungbean.

CONCLUSION

Potassium application plays an important role in containing mungbean growth and yield. Variety NM-98 performed well in terms of growth growth, physiological and yield attributes compared to other varieties. Potassium at 100 kg ha^{-1} was depicted as best level of potash fertilizer for gaining maximum yield of mungbean under arid climate of Bahawalpur.

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