Indian Journal of Agricultural Sciences **89** (3): 551–5, March 2019/Short Communication
https://doi.org/10.56093/ijas.v89i3.87604

Influence of varying potassium levels on yield, water productivity, profitability and resource-use efficiency in *kharif* mungbean (*Vigna radiata*) under semi-arid conditions of Afghanistan

HAMDULLAH HAMIM[1] and ANIL K CHOUDHARY[2]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Received: 26 July 2018; Accepted: 24 October 2018

Key words: Mungbean, Optimum K dose, Precision K recommendation, Productivity, Production-efficiency, Resource-use efficiency.

Mungbean (*Vigna radiata* L. Wilczek) is an important pulse crop in arid and semi-arid regions of Afghanistan and acts as an excellent source of vegetable protein (Noorzai *et al.* 2017). It is a short duration crop grown during summer and *kharif* seasons (Noorzai and Choudhary 2017, Ibrahimi *et al.* 2017). Mungbean has a special importance in intensive crop production systems of Afghanistan due to its shorter growing period (Ehsan *et al.* 2017a). Summer mungbean can tolerate a high temperature not exceeding 40°C (Jalali *et al.* 2017). It is reported to be drought tolerant and can be cultivated in low rainfall areas of Afghanistan (Noorzai *et al.* 2017, Jahish *et al.* 2017). Being a legume crop, it has the capacity to fix atmospheric nitrogen, thus, it is suitable for soil fertility improvement both as grain and green manure crop (Ehsan *et al.* 2017b, Noorzai *et al.* 2017). Mungbean is an excellent source of proteins (25%) with high quality of lysine (460 mg/g) and tryptophan (60 mg/g) besides having remarkable quantity of ascorbic acid when sprouted and also bears riboflavin (0.21 mg/100 g) and minerals (3.84 g/100 g); thus, mungbean may prove as a boon to malnourished people of Afghanistan (Choudhary *et al.* 2015, Noorzai *et al.* 2017, Ibrahimi *et al.* 2017, Omran *et al.* 2018). In Afghanistan, mungbean is grown on marginal lands with poor fertility on residual soil moisture under rainfed conditions coupled with poor crop husbandry using low-yielding local mungbean genotypes (Noorzai *et al.* 2017). Thus, mungbean yield in Afghanistan is very low due to lack of improved management practices and proper fertilizer management. However to tackle these issues, the production potential of various promising mungbean varieties (Noorzai and Choudhary 2017, Ibrahimi *et al.* 2017), their planting geometry (Ibrahimi *et al.* 2017), crop establishment methods (Ehsan *et al.* 2017a), nitrogen (N) dose optimization (Jalali *et al.* 2017, Jalali and Choudhary 2018, Omran *et al.* 2018), phosphorus (P) dose optimization (Jahish *et al.* 2018, Ehsan *et al.* 2017a, Omran *et al.* 2018), have been standardized recently for semi-arid conditions of Afghanistan under a collaborative program of Government of India [Ministry of External Affairs (MEA), & Ministry of Agriculture and Farmers' Welfare, New Delhi] with Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan. Thus, the above technology package will definitely enhance the mungbean productivity in the nation. Although, still this crop lacks the potassium (K) recommendations to abridge the yield gaps at farm level. Among three major nutrients (NPK), no systematic work has been done so far on K management in mungbean in Afghanistan. Potassium mitigates the impact of water stress in legume plants besides its important role in increased mungbean shoot growth, plant water relations and photosynthetic rate (Choudhary *et al.* 2015). Thus, potassium fertilization could be considered as a significant factor in overcoming soil moisture stress in mungbean, K also plays a vital role in plant growth and sustainable crop production (Asghar *et al*. 1996). Potassium is essential in maintenance of osmotic potential and water uptake and has a positive impact on stomata closure which increases tolerance to water stress. Balanced potassium supply also enhances biological nitrogen fixation and protein content of pulse grains (Choudhary *et al.* 2015). Thus, it is important to devise and standardize the optimum K dose for mungbean in the country to enhance its productivity. Keeping in view the above facts, a field experimentation was undertaken at ANASTU–Kandahar, Afghanistan to enhance the productivity, profitability and resource-use efficiency besides assessing the optimum-K dose for mungbean in *kharif* season under semi-arid region of Afghanistan.

[1]Present Address: Research Scholar (e mail: hamdullah.hamim@gmail.com), Department of Agronomy, Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan; [2]Senior Scientist (e mail: anilhpau2010@gmail.com), Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi 110 012.

The field experiment was conducted during *kharif*-2015 at Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan (31°30' N Longitude; 65°50' E Latitude; 1010 m Altitude) to study the effect of different levels of potassium (K) nutrition, *viz*. 0, 20, 40, 60, 80, 100 and 120 kg K_2O/ha on productivity, profitability and resource-use efficiency in *kharif* mungbean under semi–arid conditions of Afghanistan in a randomized block design (RBD) replicated thrice. Experiment soil was sandy-clay loam and having slightly alkaline pH 7.2. Using LaMotte Garden Guide Soil Test Kit–5679-01, the soil was characterized as low in available N, medium in P_2O_5 and high in K_2O content. The 100% recommended dose of nitrogen (N) and phosphorus (P_2O_5) @30 and 60 kg/ha, respectively was added to all the above treatments except K dose being added as per treatment levels. Full amount of N and P as well as treatment-wise potassium were applied as basal at the time of sowing through urea, diammonium phosphate and potassium sulphate, respectively. Geographically, Kandahar is situated in southern part of Afghanistan having semi-arid hot climate with extreme cold and hot situations. The mean weather data were recorded from Meteorological Observatory located at Research Farm of ANASTU, Kandahar during crop season. During the crop growth season, the mean weekly maximum temperature varied from 33.8°C to 43°C with July as the hottest month while mean weekly minimum temperature varied from 13.5°C to 21.7°C with September as the coldest month (Fig 1). The average weekly relative humidity during crop growth period varied from 11.3 to 23%, the average weekly wind speed varied between 2.8 to 3.8 m/sec while average seasonal rainfall was 0.0 mm during this crop season. Mungbean variety NM-94 taken as the test variety was sown manually @ 30 kg/ha in rows at 30 cm distance keeping 10 cm plant to plant distance at 3-4 cm depth on 24th June 2015 and harvested on 21st September, 2015. This variety is recommended for both *kharif* and summer seasons. The gross plot size was 3 m × 4 m while net plot size was 2.1 m × 3.6 m. To have desired plant population, after 17 days after sowing (DAS) the thinning and gap filling were done so as to maintain the plant to plant distance of 10 cm between mungbean plants. Different intercultural operations were done as and when necessary following standard package of practices. To reduce crop-weed competition, pendimethalin (30 EC) was applied @1.0 kg a.i./ha in 750 liter water/ha as pre-emergence herbicide. Two hand-weedings were done during growing season at 30–35 and 50–55 DAS. Pre-sowing irrigation was given to aid land preparation for mungbean sowing. First irrigation was given at 25 DAS while 2nd and 3rd irrigation were provided at 50 DAS and 70 DAS, respectively.

The number of primary branches per plant was counted at crop maturity in five tagged plants in net plot. The number of pods/plant, pod length (cm), number of grains/pod, grains weight/plant and 1000-grain weight, grain yield, straw yield, biological yield and harvest index were computed using standard procedures as suggested by Rana *et al.* (2014). The grain yield was recorded at 12% moisture content. Finally, the production-efficiency (PE) (kg/ha/day) was computed using standard procedures as suggested by Kumar *et al.* (2015). The economic optimum dose for potassium levels (0, 20, 40, 60, 80, 100 and 120 kg/ha) was calculated through the formula of economic optimum dose estimation [optimum K dose = [(q/p-b)/2c] (Ehsan *et al.* 2017b). Here, q is the unit cost of fertilizer used in AFN/kg, p is the unit price of mungbean produce (grains) in AFN/kg and b and c are the constants determined from the Fig. 1 (Ehsan *et al.* 2017b). The regression equation was fitted for the yield variation in mungbean relation to different K-levels. The regression equation was quadratic in nature ($Y = 0.077\ x^2 + 11.78\ x + 1035$; $R^2 = 0.679$).

The gross returns were calculated using prevalent market price of the mungbean grains (AFN 65000/t) and straw (AFN 5000/t) in the market using standard procedure. One US dollar is equivalent to 72.82 AFN (Afghani–Afghanistan currency). The net returns and net benefit: cost ratio (B:C ratio) were then calculated using respective cost of cultivation. The monetary-efficiency (ME) (AFN/ha/day) were computed using standard procedures as suggested by Kumar *et al.* (2015). For estimation of seasonal water use, the profile water contribution (CS) was not taken into consideration in current study. Thus, the effective rainfall (0.0 mm) and irrigational water use [(3 irrigations (180 mm) and rainfall (0.0 mm)] was considered as the seasonal water use for mungbean by taking into account the respective crop growth period by following the procedure as suggested by Choudhary *et al.* (2006). During the study period, the water-use (180 mm) was uniform in all the treatments. The water use efficiency (WUE) was computed by using standard procedures as suggested by Choudhary *et al.* (2006). Partial factor productivity (PFP) of applied-K through inorganic fertilizers was calculated using standard procedures as suggested by Rana *et al.* (2014). The

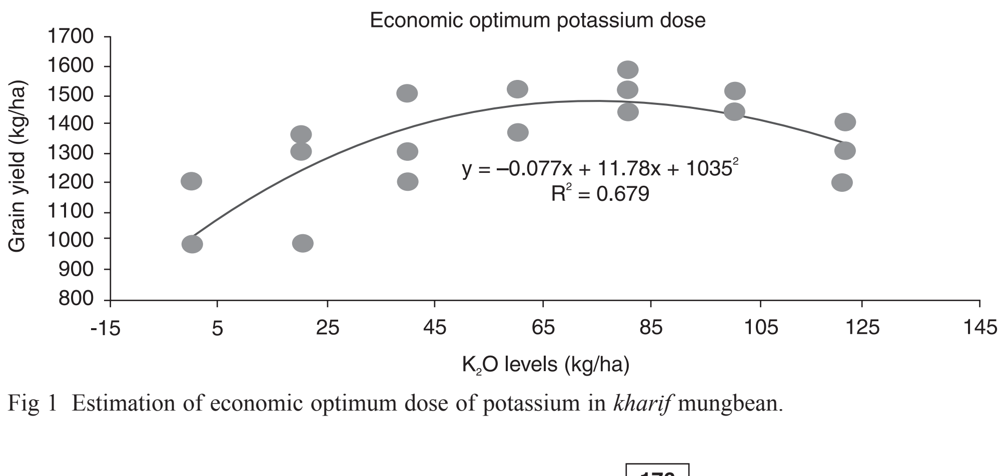

Fig 1 Estimation of economic optimum dose of potassium in *kharif* mungbean.

Table 1 Effect of varying K levels on yield attributes and yield of *kharif* mungbean

Treatment (Potassium levels kg/ha)	No. of primary branches/plant	Number of pods/ plant	Pod length (cm)	Number of grains/ pod	Grain weight/ plant (g)	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Control	3.8	18.3	6.8	8.1	7.7	47.2	1.07	2.94	4.00	26.7
20	4.4	20.0	7.7	8.5	9.1	48.2	1.22	3.01	4.22	28.8
40	4.7	22.2	7.9	8.8	10.5	49.3	1.33	3.10	4.43	30.1
60	4.8	23.4	8.1	8.9	11.7	50.0	1.47	3.22	4.69	31.3
80	4.9	24. 7	8.2	9.0	12.1	50.8	1.52	3.33	4.86	31.4
100	4.9	23.2	8.1	8.9	12.0	50.3	1.47	3.32	4.78	30.7
120	4.7	21.6	7.9	8.6	11.2	49.3	1.30	3.28	4.58	28.3
SEm (±)	0.2	0.9	0.2	0.4	0.6	0.6	0.06	0.09	0.10	1.4
CD (P = 0.05)	0.7	2.7	0.7	NS	1.9	1.8	0.20	0.28	0.30	NS

data obtained from different observation on yield attributing characters, yield, economics and resource-use efficiency indices were subjected to statistical analysis as per standard method suggested by Rana *et al.* (2014).

Data in Table 1 revealed that number of pods/plant, pod length (cm), grains weight/plant and 1000-grain weight were affected significantly by the potassium (K) fertilization; however, number of grains/pod did not show any significant effect due to applied K levels. Highest number of pods/plant (18.3) and grain weight/plant (12.1 g) were recorded with treatment 80 kg K_2O/ha both of which remained statistically at par with 40, 60 and 100 kg K_2O/ha. The number of grains per pod was also higher in treatment 80 kg K_2O/ha. The highest pod length (8.2 cm) and 1000-grain weight (50.8 g) were recorded in treatment 80 kg K_2O/ha which remained at par with treatments, viz. 40, 60, 100 and 120 kg K_2O/ha. Likewise, grain yield (1.52 t/ha) was significantly higher in treatment 80 kg K_2O/ha over 0, 20 and 120 kg K_2O/ha; however it remained at par with treatments, viz. 40, 60 and 100 kg K_2O/ha. The straw yield (3.33 t/ha) was also recorded significantly higher in treatment 80 kg K_2O/ha over 0 and 20 kg K_2O/ha; although remained statistically at par with 40, 60, 100 and 120 kg K_2O/ha. Biological yield was also higher in treatment 80 kg K_2O (4.86 t/ha) but it remained statistically at par with 60, 100 and 120 kg K_2O/ ha. Harvest index did not show any significant effect due to K-levels, although it was highest (31.7) under treatment 80 kg K_2O/ha. In general, there was a consistent increase in grain, straw and biological yield of mungbean with increase in K-levels from 0 to 80 kg K_2O/ha, but further increase in K-levels from 80 kg K_2O/ha to 100 and 120 kg K_2O/ha led to a slight decline. Increase in K-levels has been shown to enhance the photosynthetic rate, plant growth, yield, and drought resistance in different crops (Hamim and Choudhary 2018). The pulse crops have also shown the yield benefits due to increased K application, as the balanced K supply leads to enhanced biological nitrogen fixation (Choudhary *et al.* 2015). There was a consistent increase in the yield attributes, grain, straw and biological yield in current study upto 80 kg K_2O/ha. These results are similar to the findings of many researchers (Tariq *et al.* 2001). On the other hand, excessive K and supply is supposed to cause calcium (Ca) and magnesium (Mg) deficiencies and other nutritional imbalances in the plants which may adversely affect the plant processes, photosynthesis, growth and yield of plants (Roggatz *et al.* 1999, Mohidin *et al.* 2015). Moreover, the available-K in the experimental soil was high in status, thus, further increase in K-levels from 80 kg K_2O/ha to 100 and 120 kg K_2O/ha exhibited a slight reduction in the yield owing to above reasons in current study.

In present study, the cost of cultivation (COC) consistently increased with increase in K-levels with highest COC under 120 kg K_2O/ha (Table 2). It is apparent that high level of COC is always associated with high rates of farm inputs used (Ibrahimi *et al.* 2017). Effect of K-levels was significant on gross and net returns and net benefit: cost ratio (B:C ratio) of mungbean with highest gross returns under treatment 80 kg K_2O/ha followed by 60, 100, 40, 120 and 20 kg K_2O/ha, respectively. The gross and net returns and B:C ratio in mungbean followed the same trend as that of grain and straw yield in present study (Table 2). The regression equation was fitted for the yield variation in mungbean relation to different K-levels (Fig 1). Thus, by using the formula of economic optimum K dose estimation, the optimum K dose was calculated as 76.9 kg K_2O/ha in *kharif* mungbean (Fig 1).

Data pertaining to water-use efficiency (WUE), production-efficiency (PE), monetary-efficiency ME) and partial factor productivity of applied–K (PFP_K) as influenced by different K-levels, are presented in Table 2. The results showed that there was a consistent increase in the WUE, PE and ME with higher values of WUE (8.46 kg/ha/mm), PE (16.9 kg/ha/day) and ME (942.7 AFN/ha/day) in treatment 80 kg K_2O/ha which remained statistically at par with 40, 60 and 100 kg K_2O/ha, however, increase in K-levels from 80 kg K_2O/ha to 100 and 120 kg K_2O/ha resulted in a gradual decline and followed the same trend as that of grain yield (Table 1). The increase in WUE might have been contributed by efficient turgor regulation, osmotic adjustment and improved plant water relationships under K application (Kabir *et al.* 2004). Since, the K-fertilization significantly influenced the growth and yield, thus, the effect of K was

Table 2 Effect of varying K levels on profitability and resource-use efficiency in *Kharif* mungbean

Treatments (Potassium levels – kg/ha)	Crop profitability				Resource-use efficiency			
	Cost of cultivation (AFN/ha)	Gross returns (AFN/ha)	Net returns (AFN/ha)	B: C ratio	Monetary efficiency (AFN/ha/day)	Production efficiency (kg/ha/day)	Water use efficiency (kg/ha-mm)	Partial factor productivity of applied-K (kg/ha/kg of applied-K)
Control	27927	84483	56556	3.03	628.4	11.9	5.93	–
20	29127	95150	66023	3.27	733.6	13.5	6.76	61.0
40	30327	109500	79173	3.61	879.7	14.8	7.41	33.3
60	31527	111967	80440	3.55	893.8	16.3	8.15	24.5
80	32727	117567	84840	3.59	942.7	16.9	8.46	19.0
100	33927	111633	77706	3.29	863.4	16.3	8.15	14.7
120	35127	105567	70440	3.01	782.7	14.4	7.22	10.8
SEm (±)	–	3793	3793	0.13	42.1	0.71	0.35	1.8
CD (P = 0.05)	–	11689	11689	0.40	129.9	2.18	1.09	5.5

*Note: 1 AFN (Afghani, the Afghanistan currency) = 0.94 INR (Indian Rupee).

also more pronounced on PE and ME in the present study. Likewise, the excessive K supply may cause Ca and Mg deficiencies adversely affecting the plant processes and crop yield (Roggatz *et al.* 1999, Mohidin *et al.* 2015), which might have adversely affected the resource-use efficiency indices as well. On the other hand, the partial factor productivity of applied–K (PFP_K) was significantly higher under treatment 20 kg K_2O/ha (61.0 kg/ha/kg of applied–K) while further increase in K-levels upto 120 kg K_2O/ha led to consistent and significant decline in the PFP_K (Table 2), owing to decreasing rate of grain productivity in mungbean over the increase in K-rates (Kumar *et al.* 2015).

SUMMARY

The application of K_2O @ 80 kg/ha could be used as blanket recommendation for obtaining higher productivity, profitability as well as higher resource-use efficiency in *kharif* mungbean. As a site-specific precision recommendation, the economic optimum K_2O dose for *kharif* mungbean variety NM-94 was worked-out about 76.9 kg K_2O/ha which has great promises in saving the potassium fertilizer dose besides enhancing *kharif* mungbean productivity, profitability and resource-use efficiency under semi-arid conditions of Afghanistan.

ACKNOWLEDGEMENTS

Authors are thankful to Ministry of External Affairs (MEA), Government of India (GOI), New Delhi for financial assistance; and Indian Council of Agricultural Research (ICAR), Ministry of Agriculture and Farmers' Welfare, GOI, New Delhi for technical assistance to Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan to carry out above study under GOI-MEA-ICAR-ANASTU Program.

REFERENCES

Asghar A, Malik M A, Ahmad R and Atif T S. 1996. Response of mungbean (*Vigna radiata* L.) to potassium fertilization. *Pakistan Journal of Agriculture Science* **33**(4): 44–6.

Choudhary A K, Rana D S, Bana R S, Pooniya V, Dass A, Kaur R and Rana K S. 2015. *Agronomy of oilseed and Pulse Crops* pp 218. Post Graduate School, IARI, New Delhi and ICAR, DARE, New Delhi, India.

Choudhary A K, Thakur R C and Kumar N. 2006. Effect of integrated nutrient management on water use and water-use-efficiency in wheat (*Triticum aestivum*)–rice (*Oryza sativa*) crop sequence in north-western Himalayas. *Indian Journal of Soil Conservation* **34**(3): 233–6.

Ehsan Q, Rana D S and Choudhary A K. 2017a. Effect of crop establishment methods and phosphorus nutrition on growth and productivity of mungbean (*Vigna radiata* L. Wilczek) in semi-arid Afghanistan. *Annals of Agricultural Research* **38**(2): 200–27.

Ehsan Q, Rana D S and Choudhary A K. 2017b. Influence of crop establishment methods and phosphorus fertilization on production efficiency, profitability and resource-use efficiency of mungbean (*Vigna radiata* L. Wilczek) in southern Afghanistan. *Indian Journal of Agronomy* **62**(3): 367–70.

Hamim H and Choudhary A K. 2018. Effect of potassium nutrition on growth, development and yield of *Kharif* mungbean (*Vigna radiata* L. Wilczek) in semi-arid region of Afghanistan. *Annals of Agricultural Research* **39**(3): 238–45.

Ibrahimi F, Rana K S, Choudhary A K, Dass A, Ehsan Q, and Noorzai A U. 2017. Effect of varieties and planting geometry on growth, yield and profitability of *kharif* mungbean [*Vigna radiata* (L.) Wilezek] in southern Afghanistan. *Annals of Agricultural Research* **38**(2): 185–93.

Jahish F, Bana R S and Choudhary A K. 2017. Influence of different phosphorus levels on growth, productivity and profitability of mungbean in semi-arid regions of south Afghanistan. *Annals of Agricultural Research* **38**(3): 351–6.

Jalali M N, Choudhary A K, Mangle M Q, Omari M A, Hamayon H, Ghafari S R and Dass A. 2017. Response of different nitrogen levels on growth and yield of mungbean (*Vigna radiata* L. Wilczek) in semi-arid region of Kandahar, Afghanistan. *International Journal of Applied Research* **3**(10): 102–6.

Jalali M N and Choudhary A K. 2018. Influence of varying nitrogen levels on productivity, resource-use efficiency and profitability of summer mungbean (*Vigna radiata* L. wilczek) in Kandahar province of Afghanistan. *Annals of Agricultural Research* **39**(2): 180–6.

Kabir M E, Karim M A and Azad M A K. 2004. Effect of potassium on salinity tolerance of mungbean (*Vigna radiata* L.). *Journal of Biological Science* **4**(2): 103–10.

Kumar A, Choudhary A K and Suri V K. 2015. Influence of AM–fungi and applied phosphorus on growth indices, production efficiency, phosphorus–use efficiency and fruit–succulence in okra (*Abelmoschus esculentus*)–pea (*Pisum sativum*) cropping system in an acid Alfisol. *Indian Journal of Agricultural Sciences* **85**(8): 1030–7.

Mohidin H, Hanafi M M, Rafii Y M, Abdullah S N A, Idris A S, Man S, Idris J and Sahebi M. 2015. Determination of optimum levels of N, P and K of oil palm seedlings in solution culture. *Bragantia* **74**(3): 247–54.

Noorzai A U, Choudhary A K, Bana R S and Prasad R. 2017. Growth behaviour, productivity and profitability of promising mungbean varieties in semi-arid region of Afghanistan. *Annals of Agricultural Research* **38**(1): 78–86.

Noorzai A U and Choudhary A K. 2017. Influence of summer mungbean genotypes on grain yield and resource-use efficiency in Kandahar province of Afghanistan. *Annals of Agricultural Research* **38**(2): 194–9.

Omran H A, Dass A, Jahish F, Dhar S, Choudhary A K and Rajanna G A. 2018. Response of mungbean (*Vigna radiata* L.) to phosphorus and nitrogen application in Kandahar region of Afghanistan. *Annals of Agricultural Research* **39**(1): 57–62.

Rana K S, Choudhary A K, Sepat S, Bana R S and Dass A. 2014. *Methodological and Analytical Agronomy,* p 276. IARI, New Delhi.

Roggatz U, Mcdonald A J S, Stadenberg I and Schurr U. 1999. Effects of nitrogen deprivation on cell division and expansion in leaves of *Ricinus communis. Plant, Cell and Environment* **22**: 81–9.

Tariq M, Khaliq A and Muhammad U. 2001. Effect of different levels of phosphorus and potassium application growth and yield of mungbean. *Journal of Biological Sciences* **1**(6): 427–8.