

## Economic optimum dose of potassium fertilization for enhancing productivity and profitability of hybrid maize (*Zea mays*) under semi-arid condition of Kandahar

SHARIFULLAH SHARIFI<sup>1</sup>, Y.S. SHIVAY<sup>2</sup>, S.L. JAT<sup>3</sup> AND HIKMATULLAH OBAID<sup>4</sup>

Afghanistan National Agricultural Sciences and Technology University, Kandahar, Afghanistan

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### ABSTRACT

A field experiment was carried out at the main block of Tarnak Farm of Afghanistan National Agricultural Sciences and Technology University, Kandahar during the summer season of 2015, to determine the effects of different potassium fertilizer levels on yield and economics of hybrid maize (*Zea mays* L.). The experiment consisted seven potash application treatments of 30, 60, 90, 120, 150, 180, 210 kg K<sub>2</sub>O/ha and a control in a randomized complete block design (RCBD) and replicated thrice. Grain and stover yields were significantly affected by 90 kg K<sub>2</sub>O/ha which were at par up to 210 kg K<sub>2</sub>O/ha. Significantly higher net returns (108.6 × 10<sup>3</sup> Afghani/ha) and benefit: cost ratio (1.16) were observed by the application of 180 and 60 kg K<sub>2</sub>O/ha, respectively. However, a dose of 157.7 kg K<sub>2</sub>O/ha was found as economic optimum dose for growing maize in semi-arid condition in Kandahar province of Afghanistan.

**Key words :** Economic optimum dose, Maize, Net returns, Potassium, Yield

Maize (*Zea mays* L.) is the third most important cereal crop species in the world after rice and wheat. Worldwide maize occupies 197 million hectare cultivated area with annual production of 1,134 million tonnes with productivity of 5.75 tonnes/ha (FAOSTAT, 2019). In Afghanistan maize is sown on an area of 0.142 million hectares with total annual production of 0.312 million tonnes, its average seed yield is 2.20 tonnes/ha which is less than half of the global productivity. Out of this, 0.055 million tonnes is used as human food and 0.20 million tonnes for animal feed while losses and seed provision are 0.047 and 0.008 million tonnes, respectively (Afghanistan Statistical Yearbook, 2013–14). Afghanistan imports large quantities of maize from neighbouring countries, as the harvest of 0.312 million tonnes is not sufficient to meet the internal requirements. Currently, the main constraints to maize production for small-scale farmers in Afghanistan are lack of improved adapted varieties, and adequate fertilization

(Jilani *et al.*, 2013). Due to the poor inherent soil fertility in Afghanistan, the use of fertilizer is quite common and desirable for obtaining the higher yields. After nitrogen and phosphorus, potassium (K) limits plant growth.

Potassium is needed for energy metabolism, starch synthesis, photosynthesis, nitrogen fixation, and sugar degradation and it is not currently considered a threat to water quality; however, K fertility management is important because plants with optimum K levels are more resistant to environmental stresses, including drought. Application of potassium up to 375 kg/ha increased grain yield and biological yields (Ali *et al.*, 2004). Maize grain yields increased steadily as potassium doses were increased and reached their optimum values at 155.8 and 144.8 kg/ha (Kenyan *et al.*, 2014). Application of 90:60:40 NPK kg/ha in combination with 6 t/ha FYM accrued a maximum B:C ratio of 1:1.59 (Lone *et al.*, 2013). However, there is no scientific information available on the response of the potassium application to hybrid maize in Afghanistan. Therefore, it was being felt to optimize the dose of potassium for hybrid maize in the Afghanistan in order to maximize yield and profitability.

A field experiment was conducted in the main block of Tarnak Farm of Afghanistan National Agricultural Sciences and Technology University, Kandahar, Afghanistan

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<sup>3</sup>Corresponding author's Email: sliari@gmail.com

<sup>1,4</sup>M.Sc. Scholars, ANASTU, Kandahar; <sup>2</sup>Principal Scientist and Ex-Professor, ICAR-Indian Agricultural Research Institute; <sup>3</sup>Scientist, ICAR-Indian Institute of Maize Research, New Delhi 110 012

during the summer season of 2015. The rainfall received during crop growing period from May to August was 9.6 mm. The soil of the experimental site was sandy clay loam with 7.4 pH and was low in nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in randomized block design with three replications consisting of the treatments, viz. control, 30, 60, 90, 120, 150, 180 and 210 K<sub>2</sub>O/ha. All these potassium levels were applied as basal dose to all plots except control. Nitrogen and phosphorus were applied equally to all plots as per recommended dose of N @ 150 and P<sub>2</sub>O<sub>5</sub> @60 kg/ha. However, nitrogen was applied in 3 equal splits i.e. 1/3 at sowing, 1/3 at knee height stage and 1/3 at tasseling stage, respectively. Maize cultivar CS-200 was sown using seed rate of 25 kg/ha. Other standard agronomic packages of practices were followed to raise the maize crop. The grain and stover yields of maize were recorded from the net plot area of 12 m<sup>2</sup> based on the harvested net plot size. The grain yield of each plot was adjusted at 15% moisture content and was expressed in t/ha, while sun-dried weight of the stover was recorded after 10 days of drying in the field and expressed in t/ha. The plant height, leaf area and dry matter accumulation was recorded using the standard procedures. Pearson correlation coefficient of grain and stover yield was studied using the MS-excel tool and presented in figures. The economics of maize hybrid, viz. cost of cultivation (Afghani/ha), net returns (Afghani/ha) and benefit: cost ratio were calculated using standard procedure and formula. The economic optimum dose for potassium levels (0, 30, 60, 90, 120, 150, 180 and 210 kg/ha) was calculated through the formula of economic optimum dose [optimum K dose = [(q/p-b)/2c]. Here, q is amount of fertilizer used in kg, p is yield of maize in fertilized plot in kg/ha and b and c are the constants.

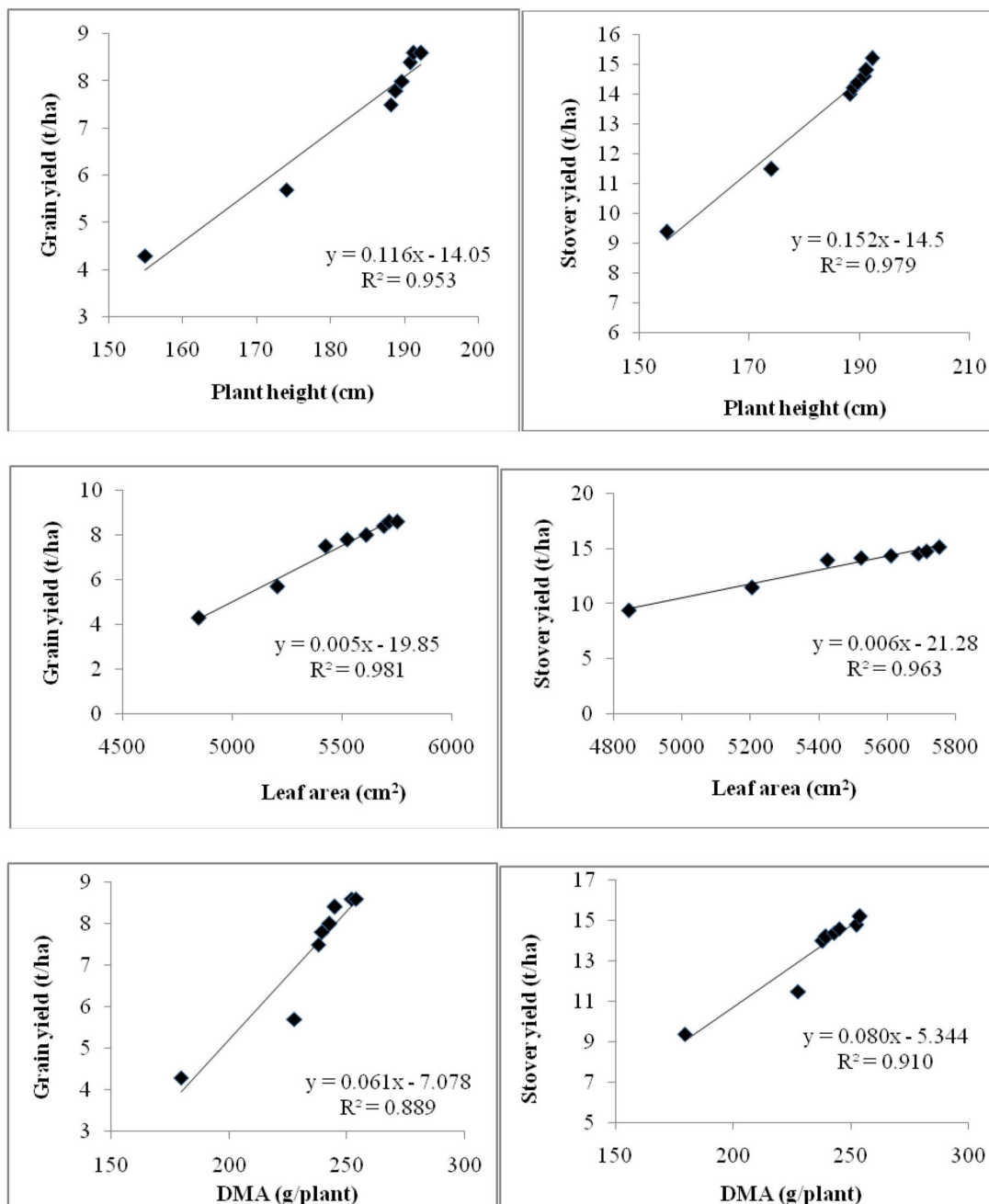
The maize yield was significantly influenced by different levels of potassium application (Table 1). The highest grain yield (8.6 t/ha) were recorded by the application of

potassium dose of 180 or 210 kg K<sub>2</sub>O/ha over control (4.3 t/ha). The grain yield (t/ha) was found statistically at par beyond the 90 kg K<sub>2</sub>O/ha which gave 3.5 t/ha more yield over control in the study. Stover yield (15.2 t/ha) recorded the highest with the application of 210 kg K<sub>2</sub>O/ha. However, in control only 9.4 t/ha stover yield was fetched. The application of the lower doses of potassium i.e. 30 and 60 kg K<sub>2</sub>O/ha increased stover yield by 22.3% and 26.3% over control. However, stover yield was statistically at par beyond 60 kg K<sub>2</sub>O/ha to up to 210 kg K<sub>2</sub>O/ha potassium levels. A good partitioning of the photosynthates might have increased the grain and stover yields of maize significantly in our study and also thereby increased photosynthesis and balanced the internal nutrient status. Moreover, potassium application helps in decreasing abscisic acid (Battal *et al.*, 2003) and better Na:K ratios in saline soils (Wang *et al.*, 2013) with significant improvement in most of the beneficial physiological processes (Wang *et al.*, 2013). These results corroborate our findings that the enhancement in growth and yield attributes by K application gave significantly higher yields in maize. Similar to our study, Maqsood *et al.* (2013) also reported that highest grain and biological yields (4.94 and 11.15 t/ha, respectively) were achieved with fixed-furrow irrigation + 120 kg K/ha treatment in similar agro-ecology. Application of higher levels of potassium fertilizer might have lead to increased leaf area and dry matter accumulation that in turn increased plant height in maize. The positive correlation amongst the growth parameters with grain and straw yield (Fig. 1) and of yield attributes with grain yields in our study further confirms that enhancement of these parameters lead to increased yield of maize due to K application.

Application of 60 kg K<sub>2</sub>O/ha resulted in significant enhancement of net returns by 57.6 × 10<sup>3</sup> Afghani/ha over control and gave the highest benefit: cost ratio of 1.16 and it remained at par with succeeding doses of potassium up

**Table 1.** Effect of potassium levels on yield and economics of hybrid maize under semi-arid condition of Kandahar province of Afghanistan

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Cost of cultivation (×10 <sup>3</sup> Afghani /ha)	Net-returns (×10 <sup>3</sup> Afghani/ha)	Benefit: cost ratio
Control	4.3	9.4	68.0	40.3	0.59
30 kg K <sub>2</sub> O/ha	5.7	11.5	75.8	66.4	0.87
60 kg K <sub>2</sub> O/ha	7.5	14.0	84.6	97.9	1.16
90 kg K <sub>2</sub> O/ha	7.8	14.2	87.6	100.7	1.15
120 kg K <sub>2</sub> O/ha	8.0	14.4	90.7	103.3	1.14
150 kg K <sub>2</sub> O/ha	8.4	14.6	94.2	108.3	1.15
180 kg K <sub>2</sub> O/ha	8.6	14.8	96.8	108.6	1.12
210 kg K <sub>2</sub> O/ha	8.6	15.2	99.3	108.4	1.09
SEm±	0.32	0.48	2.72	6.64	0.054
CD (P=0.05)	0.96	1.46	8.24	20.15	0.162



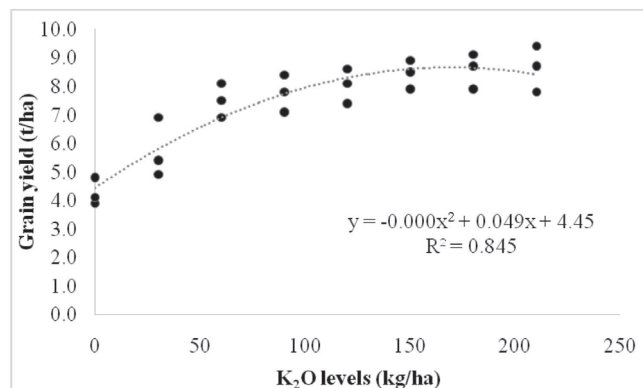
**Fig. 1.** Correlation among the grain and stover yields with growth parameters in maize under semi-arid condition of Kandahar province of Afghanistan (DMA, dry-matter accumulation)

to 210 kg K<sub>2</sub>O/ha. However, the highest cost of cultivation was recorded with 210 kg K<sub>2</sub>O/ha (Table 1). The enhancement in the yield of maize with K nutrition for both grain and stover led to higher net returns and benefit : cost ratio in maize for our study. The four basic principles of applying nutrients at the right rate, at the right time, using the right source and by the right method would ensure higher economic returns from fertilizer use as well as increased maize productivity to meet the food security goal in the

Afghanistan. Almost similar results were recorded when a crop was planted on ridges with the medium fertilizer dose on clay loam soil of Faisalabad, Pakistan (Rehman *et al.*, 2011). Application of 60:40 kg P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O/ha and 180 kg N/ha gave comparatively higher net returns and benefit: cost ratio (Baral *et al.*, 2015), it shows that hybrid maize needs better K nutrition for enhancement of monetary return from maize cultivation.

Based upon the regression equation, the maximum

grain yield (8.63 t/ha) was obtained at 210 kg K<sub>2</sub>O/ha but economic optimum dose of potassium was worked out to be 157.7 kg K<sub>2</sub>O/ha (8.43 t/ha grain yield) (Fig. 2). Boldea *et al.* (2015) also obtained almost similar results.



**Fig. 2.** Economic optimum dose of potassium for hybrid maize under semi-arid condition of Kandahar province of Afghanistan

Based on our results it was concluded that the application of 60 kg K<sub>2</sub>O/ha resulted in significant enhancement of grain and stover yields of hybrid maize, net returns and benefit : cost ratio. However, a dose of 157.7 kg K<sub>2</sub>O/ha was found to be the most economic optimum for hybrid maize in Kandahar ecological conditions.

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