Potassium Response and Fertiliser Application Economics in Oilseeds and Pulses in India

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A review of the published literature showed variable K response in oilseeds and pulses across India. Economic calculations, using current prices of crop commodities and potash fertiliser, revealed significant return on investment to fertiliser K application in these crops. An approach based on yield response to K fertiliser application has been proposed to improve the yield of oilseeds and pulses and maintain K fertility levels of soils.

India is the largest producer of pulses and second largest producer of oilseeds in the world. The majority of the Indian population is vegetarian, and pulses provide a major source of protein while oilseeds provide a major source of fat and oil supplement for carbohydrate intake through cereals, millets and tuber crops (Tiwari et al., 2012). As principal sources of dietary lipid and protein, pulses and oilseeds assume great importance for food, nutrition and agricultural sustainability in the country.

In order to meet the growing demand, India has to import 2 to 3 million tonnes (Mt) of pulses every year. The projected pulse requirement for the year 2030 is 32 Mt, which necessitates an annual growth rate of 4.2% in pulse production (Nadarajan et al., 2013). The edible oilseeds demand is projected to grow at 12.6% per year during the 12th Five-year Plan on account of the increase in population and economic growth. This projected growth rate is 2.5 times higher than that experienced in domestic production of oilseeds during the previous decade. This clearly indicates that the production of pulses and oilseeds in the country has to be improved considerably to meet the growing demand (Jha et al., 2012).

Potassium requirement of pulses and oilseeds is quite high. Apart from fulfilling other major physiological and biochemical requirements for plant growth, K is a key nutrient element in the biosynthesis of oil in oilseeds and protein in pulse crops. In general, pulses require 16 kg K_2O (e.g., for pigeon pea grain) to as high as 73 kg K_2O (e.g., for greengram grain) from the soil to produce 1 t of grain. For oilseeds, uptake ranges from 16 kg K_2O (e.g., for castor seed) to 126 kg K_2O (e.g., for sunflower seed) per t of seed. However, fertiliser use, particularly K fertiliser use, is limited in pulse and oilseed crops. In general, farmers apply low rates of N and P, but K is frequently absent from their fertiliser schedule. Recent estimates suggest that only 41% of the cropped area under pulses and 77% under oilseeds receive about 6.3 and 9.3 kg K_2O/ha, respectively. Lack of K use in oilseeds and pulses is one of the major reasons for their low yields and poor crop quality in India (Tiwari et al., 2012).

It is generally perceived that Indian soils have high soil K status and that K application in pulses and oilseeds may not be economic at the current K fertiliser cost due to low response levels. The present review was initiated to assess the reported K responses in pulses and oilseeds. Four major scientific journals, viz., Journal of the Indian Society of Soil Science, Indian Journal of Agronomy, Indian Journal of Agricultural Sciences and Indian Journal of Fertilisers were used for this effort for a decadal period between 2003 and 2012. There were 72 studies reported on K responses in oilseeds, while 32 studies reported on K responses in pulses. Besides this, 23 and 14 K response studies in oilseeds and pulses, respectively, conducted by the International Plant Nutrition Institute (IPNI) were included in this review. The studies that reported grain yield responses due to K were chosen for analysis, while the ones that reported the effect of K application on quality parameters like oil content and protein percentages were ignored for this paper.

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium.

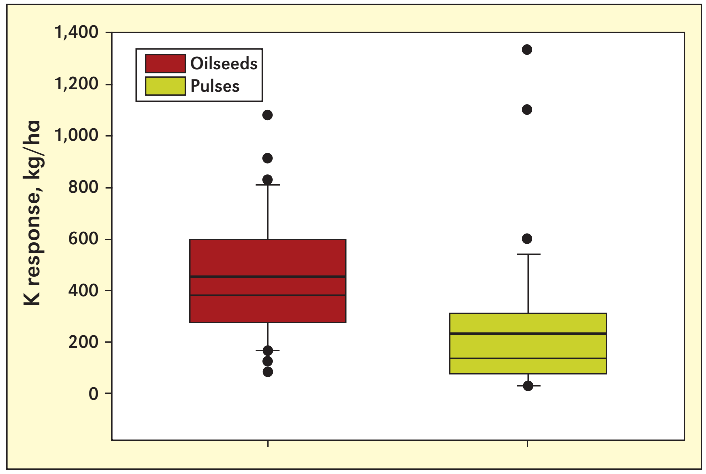

Figure 1. Range of grain yield response to potassium application in oilseeds and pulses. Boxes represent data within the first and third quartiles (interquartile range). The thin line denotes the second quartile or median, and the thick line denotes the mean. Lines extending beyond the interquartile range denote the 10th to 90th percentile of the data. Statistical outliers are plotted as individual points outside these lines.

The studies were well-distributed across major pulse and oilseeds growing areas of the country and covered major soil types. The reported studies were from Assam, Andhra Pradesh, Bihar, Jharkhand, Orissa, West Bengal, Uttar Pradesh, Punjab, Himachal Pradesh, Haryana, Madhya Pradesh, Gujarat, Rajasthan and Maharashtra states. However, it was not possible to show a spatial distribution of the study locations on a map due to the absence of geographic coordinates in most of the reported studies.

Information on crop yield responses to applied K levels were collated from the reviewed papers to estimate potassium yield response as follows:

K response = Yield of the crop at the applied K level - Yield of the crop at no K application

Current value of the crop commodities, cost of K fertiliser, and minimum support price (MSP) (Majumdar et al., 2012) were used to estimate the return on investment (ROI) in K application to oilseeds and pulses as follows:

Table 1. Distribution of reviewed data in yield response classes.

	Oilseeds		Pulses	
Yield Response for K, kg/ha	Number of samples (total = 59)	% samples	Number of samples (total = 38)	% samples
<300	17	29	27	71
300-600	26	44	7	19
>600	16	27	4	10

ROI on K fertiliser = [Yield increase due to K fertiliser (kg/ha) X MSP of crop (₹/kg)]/[K fertiliser application (kg/ha) X cost of K fertiliser (₹/kg)]

K Response in Oilseeds and Pulses

Figure 1 shows the extent of K response in oilseeds and pulses across the reviewed studies. Potassium response in oilseeds was higher than pulses. Average grain yield response of oilseeds was approximately 500 kg/ha, while average K response in pulses was about 250 kg/ha. The response range of the reviewed data was classified in three yield response classes (**Table 1**). In oilseeds, 29% of the studies showed K response of < 300 kg/ha, 44% showed a response of 300 to 600 kg/ha, while 27% of the studies showed greater than 600 kg/ha of grain response to fertiliser K application. In pulses, majority of the studies (71%) showed K response of < 300 kg/ha, while 19% and 10% studies showed 300 to 600 kg/ha and > 600 kg/ha of yield response to fertiliser K application, respectively.

We also estimated the average yield response and the ROI to fertiliser K application for each crop using MSP for each crop and the current cost of K fertiliser. **Table 2** showed that K response in oilseeds ranged from 3.7 to 10.4 kg of grain per kg of applied potash. The ROI on fertiliser K in oilseeds was 3.5 to 9.8 rupees per rupee invested on K. The results showed that ROI was reasonably high even at the perceived high cost of K fertiliser and generally low K response of oilseeds. In other words, farmers can make a significant profit from fertiliser K application in oilseeds. Potassium response of pulses was lower than oilseeds with a range of 1 to 11.5 kg per kg of K_2O application (rejecting the high K response in one experiment in cowpea as an outlier) (**Table 3**). The ROI on fertiliser K application in pulses was between 1.2 to 13.8 rupees per rupee invested on potash.

Potassium application rates varied widely within and between crops in the reviewed literature. While calculating the ROIs (**Tables 2 and 3**), the application rates in different experiments for an individual crop were averaged to reach at a common application rate. This has an inherent weakness of data redundancy, which might lead to inappropriate representation of ROI. Besides, such average application rates, combining different experimental data from varied locations, may not provide guidance to the user to achieve a particular yield response or ROI.

To avoid data redundancy, the K response data were classified in quartiles within the observed range of K response data in the reviewed literature. This is expected to help guide K application based on yield response and crop uptake. The first, median and third quartile of K responses in oilseeds and pulses were estimated and are given in **Table 4**.

Return on investment was re-calculated based on the response levels in **Table 4** and at three chosen K application rates. The three K application rates were selected on the basis of current state-recommended K application rates in pulses and oilseeds in different states of India (Tandon, 2002). In the case of oilseeds, the application rates used were 25, 50 and 75 kg K_2O/ha for determining ROI values, while for pulses, the rates used were 20, 40 and 60 kg K_2O/ha (**Table 5**). The data showed that in all cases, except for 60 kg K_2O/ha application rate at 275 kg/ha response in pulses, the application of K_2O provides reasonable to high return when application rate is

Table 2. Economics of K application in oilseed crops.

Oilseeds (No. of locations)	K_2O applied, kg/ha	Mean yield increase due to fertiliser K application, kg/ha	Net return due to fertiliser K application**, ₹/ha	ROI for K fertiliser#	Response per kg of K applied, kg/kg
Mustard (27)	78	479 (±43.22)*	13,408	6.8	7.3
Linseed (2)	66	436 (±54.5)	12,194	6.1	6.6
Sesame (9)	100	363 (±66.8)	10,172	3.5	3.7
Sunflower (7)	96	567 (±122.78)	15,880	5.3	5.7
Soybean (8)	54	416 (±99.31)	11,648	9.0	9.7
Groundnut (5)	43	419 (±52.07)	11,732	9.8	10.4
Castor (1)	50	214	5,992	4.0	4.3

*± Standard Error in parenthesies; **Price of Potash = ₹30/kg K_2O; #Average MSP of oilseeds used for calculating ROI = ₹28/kg of grain.

Table 3. Economics of K application in pulse crops.

Pulses (No. of locations)	K_2O applied, kg/ha	Mean yield increase due to fertiliser K application, kg/ha	Net return due to fertiliser K application**, ₹/ha	ROI for K fertiliser#	Response per kg of K applied, kg/kg
Chickpea (10)	50	385 (±127.6)*	13,849	9.3	7.8
Urdbean (3)	36	46 (±16.6)	1,668	1.9	1.5
Lentil (4)	32	89 (±8.3)	3,186	3.8	3.2
Pigeonpea (5)	38	115 (±32.2)	4,140	4.4	3.6
Pea (3)	36	105 (±21.4)	3,792	4.1	3.4
Mungbean (2)	30	30 (±0.50)	1,062	1.2	1.0
Green gram (4)	25	265 (±44.2)	9,549	13.8	11.5
Black gram (4)	85	302 (±10.3)	10,863	4.8	4.0
Cluster-Bean (1)	40	160	5,760	4.8	4.0
Cowpea (1)	50	1,100	39,600	26.4	22.0
Guar bean (1)	30	170	6,120	6.8	5.7

*± Standard Error in parenthesies; **Price of Potash = ₹30/kg K_2O; #Average MSP of pulses used for calculating ROI = ₹36/kg of grain.

Table 4. Classes of K response in oilseeds and pulses.

	Yield response, kg/ha	
	Oilseeds	Pulses
1st Quartile	275	76
Median	381	137
3rd Quartile	600	312

guided by yield response. For example, the application of 25 kg K_2O/ha in oilseeds gave ROI values of 10.3, 14.2 and 22.4 rupees per rupee invested in potash at 275, 381 and 600 kg/ha K responses, respectively. Increasing application rates to 50 and 75 kg/ha in oilseeds decreased the ROI, and the lowest ROI of 3.4 was observed at 275 kg/ha response level and at 75 kg application rate. Similarly for pulses, ROIs of 4.6, 8.2 and 18.7 were achieved at 76, 137 and 312 kg/ha K_2O response levels with an application rate of 20 kg K_2O/ha. The economic return from K application in pulses was lower than oilseeds due to lower K responses as evident from the reviewed literature.

Table 5. Return on Investment (ROI) in K fertiliser in oilseeds and pulses at different crop response levels and application rates.

Yield response classes of Oilseeds, kg/ha	275	381	600
ROI (Oilseeds)			
25 kg K_2O/ha application rate	10.3	14.2	22.4
50 kg K_2O/ha application rate	5.1	7.1	11.2
75 kg K_2O/ha application rate	3.4	4.7	7.5
Yield response classes of Pulses, kg/ha	76	137	312
ROI (Pulses)			
20 kg K_2O/ha application rate	4.6	8.2	18.7
40 kg K_2O/ha application rate	2.3	4.1	9.4
60 kg K_2O/ha application rate	1.5	2.7	6.2

*Prices: Potash = ₹30/kg K_2O, Average MSP of oilseeds = ₹28/kg of grain, Average MSP of pulses = ₹36/kg of grain.

Table 5 clearly showed that applying fertiliser K based on K response of oilseeds and pulses is economically viable at current prices of fertiliser K. The generally low K response of oilseeds and pulses, because of low yields in these crops and high cost of potash, makes it important that K fertiliser is applied based on critical assessment of yield response.

Table 5 also poses an important question that, at 600 kg/ha K response in oilseeds, how would a farmer decide the appropriate application rate? All the three K application rates, at 600 kg/ha K response, gave significant ROI in fertiliser K. The highest return is always the most attractive for a farmer, but are there other considerations that needs to be taken into account before choosing the appropriate rate. It seems that while deciding about the right K applicaton rate, one has to consider plant biomass production. Potassium is usually accumulated in the aboveground parts of a crop, with very little amount of K stored in the grains. This is reflected in the uptake of K in oilseed or pulse crops (e.g., 16 kg K_2O is needed for a tonne of castor seed, while 126 kg K_2O is required to produce a tonne of sunflower seed). This is because sunflower requires more K_2O to support higher biomass production than castor. This suggests that K application rates should also be based on biomass production besides the expected response to K application. A crop producing relatively higher biomass than other crops would require a higher application rate to limit K mining from the soil. Soils showing higher K response suggest low availability of K, and a higher K application rate in a high biomass producing crop in such a soil would ensure reasonably high return and maintainence of K fertility levels of the soil. Similar logic could be extended to other K response levels in **Table 5**, where more K should be applied to high biomass producing oilseeds or pulses than crops producing less biomass, even if the response levels are similar.

Summary

Improving the production of oilseeds and pulses in India is required to meet their growing demand. Area expansion is possible in these crops as relative prices with competing crops are favourable and relative profitability is higher. Crop intensification in underutilized farming situations like rice fallows can contribute to an increase in area under oilseeds and pulses. However, there are ample opportunities to improve productivity of these crops in existing areas through proper nutrient management. This will lead to sustainable intensification, without sacrificing the area under other crops, while meeting the national requirement. BC-SA

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