Effect of split application of potassium on yield and yield attributes of soybean [Glycine max (L.) Merrill]

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ABSTRACT

A field experiment was conducted at Punjab Agricultural University, Regional Research Station, Gurdaspur (Punjab) during kharif 2016-17, to study the effect of split application of potassium on yield and yield attributes of soybean. The experiment was conducted in randomized complete block design with seven treatments applied at sowing and as split application of potassium T1: Recommended fertilizer dose (12.5 kg N, 32 kg P2O5 and no potassium application), T2: 15 kg K2O ha-1 (at sowing), T3: 30 kg K2O ha-1 (at sowing), T4: 60 kg K2O ha-1 (at sowing), T5: 7.5 kg K2O ha-1 (at flowering), T6: 15 kg K2O ha-1 (at sowing) + 15 kg K2O ha-1 (at flowering), T7: 30 kg K2O ha-1 (at sowing) + 30 kg K2O ha-1 (at flowering). Results revealed that significantly higher grain yield (25.2 q ha-1) was obtained in T6 (30 kg K2O ha-1 (at sowing) + 30 kg K2O ha-1 (at flowering) as compared to all other treatments but it was statistically at par with the split application of potassium @ 15 kg K2O ha-1 (at sowing) + 15 kg K2O ha-1 (at flowering) (T5) with grain yield of (22.6 q ha-1). Split application of potassium significantly increased soybean grain yield over the basal application with highest benefit cost ratio (7.1). Among the split application of potassium, grain yield of soybean was increased significantly by 15.6 % in T6 treatment over T5. Split application of potassium was more beneficial than applying full dose of potassium at the time of sowing due to higher number of pods and pod weight plant-1.

Key words: B:C ratio, Grain yield, Potassium, Soybean, Yield attributes.

INTRODUCTION

Soybean [Glycine max (L.) Merrill] is one of the major oilseed crop of India. Soybean is a high value crop with multiple food, feed and industrial uses. Its edible oil, soymilk and its bakery products and fresh green beans are some of its major uses. Soybean seed consists of 35 % carbohydrate, 5 % ash, 40 % protein and 20 % oil and is a major source of protein and oil for commercial product. About 40 % of world’s edible vegetable oil comes from soybean (Sinclair, 1982). It has contributed toward supporting the national economy and meeting the edible oil requirement of the nation in the past two decades. Soybean meal is a valuable ingredient in formulated feed for poultry and fish. The contribution of India in the world soybean area is 10 % but the contribution to total world soybean grain is only 4 % indication the poor level of productivity of this crop in India as compared to other countries (Agarwal et al 2013). The rice-wheat cropping system is one of the widely practiced system in India and almost 90-95% of the cultivated rice area in Punjab is under intensive rice wheat system (RWS). Rice wheat system has some constraints like high water requirement which is the main reason for decline of underground water in Punjab and second one is paddy straw management which is again a big problem facing by Punjab from more than one decade. (Sharma et al 1996) So, soybean has a potential to play an important role in crop diversification in the state because soybean requires less water and its residue biomass is less and it degrades easily as compared to paddy straw (Darko et al 2009).

For higher production, fertilizer application is very important in all the crops. In general higher yields have been obtained from high fertility soils, but on poor/average fertility soils, high yields may be obtained by applying adequate amount of fertilizer. High soybean yields demand high fertilizer doses, applied directly to the crop or accrued through preceding crop. Soybean crop take up and removes large amount of potassium from soil than any other nutrient (Tiwari et al 2001). Potassium application have shown to increase the number of pods as well as exerted a beneficial influence on retaining pods until harvest in soybean. The conventional way to apply potassium to the soil is before planting (pre planting) and larger quantity may improve soil fertility for subsequent produce. Although soil (basal) and split application have been used to maintain optimum level of nutrients in crop, there is limited information on the effect of basal and split application of potassium fertilizer (Fernandez, 2012). Soybean has high potassium requirement and it removes more potassium than cereals. Potassium accumulates in soybean crop throughout all the growing season and potassium uptake is highest during the vegetative season.
grows and slows as seed formation begins. Potassium is one of the most important element in soil as it plays a major role in the activation of enzymes, transportation of assimilates, water economy of the plant and in photosynthesis. Potassium application increases the yield as well as improves the quality of soybean crop (Bansal et al 2001). Keeping in view the importance of potassium to soybean crop, a research experiment was conducted to study the effect of split application of potassium on yield and yield attributes of soybean.

**MATERIALS AND METHODS**

A field experiment was conducted at the Research Farm of Punjab Agricultural University, Regional Research Station, Gurdaspur (Punjab) during the kharif season of year 2016-17. The climate of Gurdaspur is sub-humid, semi-arid with annual rainfall of 890 mm, of which about 80% is received during June to September with mean monthly temperature varied from 28.1°C to 33.0°C. Before sowing of crop initial soil sample were taken at 0-15 cm depth for determining physico-chemical properties of soil. The soil of the experimental field was tested normal in reaction (pH 7.3) with low in organic carbon (0.34 %) and potassium (103 kg ha⁻¹) and medium in phosphorus (20.9 kg ha⁻¹). The experiment was laid out in randomized complete block design with seven treatments applied at sowing and as split application (T₁: Control, T₂: 15 kg K₂O ha⁻¹ (at sowing), T₃: 30 kg K₂O ha⁻¹ (at sowing), T₄: 60 kg K₂O ha⁻¹ (at sowing), T₅: 7.5 kg K₂O ha⁻¹ (at sowing) + 7.5 kg K₂O ha⁻¹ (at flowering), T₆: 15 kg K₂O ha⁻¹ (at sowing) + 15 kg K₂O ha⁻¹ (at flowering), T₇: 30 kg K₂O ha⁻¹ (at sowing) + 30 kg K₂O ha⁻¹ (at flowering). The Recommended dose of fertilizers 32 kg N ha⁻¹ and 80 kg P₂O₅ ha⁻¹ to soybean were applied at the time of sowing as per package of practices for field crops of Punjab Agricultural University, Ludhiana. Nitrogen and phosphorus were applied in the form of urea and single superphosphate. Soybean variety “SL-958” was sown in mid-June during 2016 in rows 45 cm apart using seed rate of 62.5 kg ha⁻¹. The data on plant height was recorded at harvest. Yield attributes (number of pods plant⁻¹, pod weight plant⁻¹, number of grains pod⁻¹ and 100 seed weight) and yield observations were recorded at harvest and subjected to statistical analysis. The economics of the system was worked out considering the prevailing cost of inputs and outputs. All the results were then analyzed statistically for drawing conclusion using Analysis of Variance (ANOVA) procedure.

**RESULTS AND DISCUSSION**

Growth and yield attributes: The data revealed that the split application of potassium had significant effect on number of pods and pod weight plant⁻¹. The data presented in Table 1, showed that significantly higher number of pods plant⁻¹ were recorded in T₄ treatment where split application of potassium @ 30 kg K₂O ha⁻¹ at sowing and 30 kg K₂O ha⁻¹ at flowering stage. However, total number of pods plant⁻¹ was statistically at par with T₃ (7.5 kg K₂O ha⁻¹ applied at sowing + 7.5 kg K₂O ha⁻¹ applied at flowering) and T₅ (15 kg K₂O ha⁻¹ applied at sowing + 15 kg K₂O ha⁻¹ applied at flowering) treatment with per cent increase of 4.9 % and 2.0 %, respectively. It has also been depicted in Table 1, that potassium application increased number of pods plant⁻¹ significantly even in basal application but the basal application of potassium is not beneficial as compared to split application of potassium. The per cent increase in pods plant⁻¹ in basal application of potassium was 8.5 % than no application of potassium (control treatment). Potassium application increased the number of pods as well as exerted a beneficial influence on retaining pods until harvest in soybean (Coale et al 1990). Similarly, pod weight plant⁻¹ was increased with the application of potassium as both basal and split dose. However, increase in pod weight plant⁻¹ was significantly higher in T₄ treatment (30 kg K₂O ha⁻¹ applied at sowing and 30 kg K₂O ha⁻¹ applied at flowering) with 34.8 (g) as compared to the recommended dose of fertilizer (T₁) where potassium was not applied. The pod weight and number of pods plant⁻¹ were significantly increased with increase in potassium application as compared to no application. Increase in soybean pod number and pod weight was also recorded by Grewal et al (1994)when potassium applied @ 50 kg ha⁻¹ followed by nitrogen (N) application and 25 kg ha⁻¹ potassium was applied in the absence of N in loamy sand soils of Punjab.

Table 1: Effect of various levels of potassium on growth and yield attributes of soybean.

| Treatments | Plant Height (cm) | Number of pods plant⁻¹ | Pod weight plant⁻¹(g) | Number of grains pod⁻¹ | 100 seed weight(g) |
|------------|------------------|------------------------|-----------------------|------------------------|-------------------|
| T₁:        | 35.5             | 59.0                   | 26.4                  | 2.17                   | 10.87             |
| T₂: 15 kg K₂O ha⁻¹ (at sowing) | 36.0 | 59.7 | 28.2 | 2.20 | 10.93 |
| T₃: 30 kg K₂O ha⁻¹ (at sowing) | 37.0 | 62.3 | 29.8 | 2.23 | 10.97 |
| T₄: 60 kg K₂O ha⁻¹ (at sowing) | 37.0 | 64.0 | 30.3 | 2.27 | 11.20 |
| T₅: 7.5 kg K₂O ha⁻¹ (at sowing) + 7.5 kg K₂O ha⁻¹ (at flowering) | 37.5 | 68.3 | 31.6 | 2.30 | 11.37 |
| T₆: 15 kg K₂O ha⁻¹ (at sowing) + 15 kg K₂O ha⁻¹ (at flowering) | 37.5 | 70.3 | 34.4 | 2.37 | 11.57 |
| T₇: 30 kg K₂O ha⁻¹ (at sowing) + 30 kg K₂O ha⁻¹ (at flowering) | 38.0 | 71.7 | 34.8 | 2.43 | 11.67 |
| C.D. @ 5% | NS               | 3.6                    | 2.7                   | NS                     | NS                |
| SEm        | 0.56             | 1.17                   | 0.86                  | 0.11                   | 0.31              |
Table 2: Effect of different levels of potassium application on grain yield and economics returns of soybean.

| Treatments                          | Grain yield (kg ha\(^{-1}\)) | Cost of cultivation (Rs ha\(^{-1}\)) | Net Returns (Rs ha\(^{-1}\)) | B:C ratio |
|-------------------------------------|------------------------------|-------------------------------------|-------------------------------|----------|
| T\(_1\): Recommended (32 kg N ha\(^{-1}\), 80 kg P\(_2\)O\(_5\) ha\(^{-1}\) and no potassium application at sowing) | 1670                         | 22,550                             | 1,03,735                  | 4.6      |
| T\(_2\): 15 kg K\(_2\)O ha\(^{-1}\) (at sowing) | 1750                         | 22,750                             | 1,09,585                  | 4.8      |
| T\(_3\): 30 kg K\(_2\)O ha\(^{-1}\) (at sowing) | 1910                         | 22,950                             | 1,21,484                  | 5.3      |
| T\(_4\): 60 kg K\(_2\)O ha\(^{-1}\) (at sowing) | 2140                         | 23,350                             | 1,38,476                  | 5.9      |
| T\(_5\): 7.5 kg K\(_2\)O ha\(^{-1}\) (at sowing) + 7.5 kg K\(_2\)O ha\(^{-1}\) (at flowering) | 2180                         | 22,900                             | 1,41,951                  | 6.2      |
| T\(_6\): 15 kg K\(_2\)O ha\(^{-1}\) (at sowing) + 15 kg K\(_2\)O ha\(^{-1}\) (at flowering) | 2260                         | 23,100                             | 1,47,801                  | 6.4      |
| T\(_7\): 30 kg K\(_2\)O ha\(^{-1}\) (at sowing) + 30 kg K\(_2\)O ha\(^{-1}\) (at flowering) | 2520                         | 23,500                             | 1,67,062                  | 7.1      |
| C.D. @ 5%                           |                              |                                     |                               |          |
| SEM                                 | 314.84                       | -                                  | -                            |          |
|                                     | 101.06                       | -                                  | -                            |          |

Fig 1: Effect of basal and split application of potassium on grain and Stover yield of soybean.

When potassium was applied as basal dose the number of pods and pod weight plant\(^{-1}\) was significantly higher in T\(_1\) (60 kg K\(_2\)O ha\(^{-1}\) at sowing) as compared to T\(_3\) (recommended) and T\(_2\) (15 kg K\(_2\)O ha\(^{-1}\) applied at sowing). However, it was statistically at par with T\(_3\) (30 kg K\(_2\)O ha\(^{-1}\) applied at sowing). So, these results clearly depicts that potassium application is beneficial in increase yield attributes soybean when applied at 30 kg K\(_2\)O ha\(^{-1}\) applied at sowing and 60 kg K\(_2\)O ha\(^{-1}\) at sowing than no application. But, the split application of potassium @ 30 kg K\(_2\)O ha\(^{-1}\) at sowing and 30 kg K\(_2\)O ha\(^{-1}\) at flowering stage as well as @ 15 kg K\(_2\)O ha\(^{-1}\) at sowing and 15 kg K\(_2\)O ha\(^{-1}\) at flowering stage is more beneficial as compared to the basal application. The per cent increase in pod weight and pod number plant\(^{-1}\) was 12 % and 14.8 % in T\(_4\) (split application of potassium at basal and flowering) as compared to T\(_3\) (basal application of potassium), respectively.

Plant height, number of grains pod\(^{-1}\) and 100 seed weight (g) were not significantly affected with potassium application. But, the data presented in Table 1, showed that maximum plant height, number of grains pod\(^{-1}\) and 100 seed weight (g) were maximum in T\(_5\) treatment (30 kg K\(_2\)O ha\(^{-1}\) applied at sowing and 30 kg K\(_2\)O ha\(^{-1}\) applied at flowering) and minimum number of grains pod\(^{-1}\) was observed in recommended dose of fertilizer with no potassium application.

Grain yield: Results of the study (Table 2 and Fig 1) indicated that potassium application increased the grain yield of soybean at its varying levels. However, split application of potassium had an edge over basal application. Highest grain yield of soybean was recorded under T\(_7\) treatment (30 kg K\(_2\)O ha\(^{-1}\) at sowing and 30 kg K\(_2\)O ha\(^{-1}\) at flowering) followed by T\(_6\) treatment (15 kg K\(_2\)O ha\(^{-1}\) at sowing and 15 kg K\(_2\)O ha\(^{-1}\) at flowering). While the lowest grain yield was recorded in control i.e. recommended dose of fertilizer where nitrogen and phosphorus was applied only. Split application of potassium at the rate of 30 kg K\(_2\)O ha\(^{-1}\) at sowing and 30 kg K\(_2\)O ha\(^{-1}\) at flowering significantly increased grain yield by 50.8 % over recommended dose of fertilizer.

The basal application of potassium also had a significant role in increasing yield of soybean over recommended practice. The treatment T\(_8\) where potassium was applied @ 60 kg ha\(^{-1}\) increased the yield of soybean by 28.4 % over the control but it was statistically at par with the treatment of T\(_7\) where potassium was applied @ 30 kg ha\(^{-1}\). However, the basal application helps in increasing the yield of soybean but split application was more effective in yield enhancement of soybean. Split application of potassium half at planting and half at flower initiation (two splits) or applying one third at planting, one third at flower initiation and one third at pod development (three splits) resulted in highest soybean grain yield was reported by (Kolar et al 1994).

Application of potassium as basal and split had also significant effect on stover yield of soybean (Fig 1). Similar to grain yield basal application of potassium @ 60 Kg ha\(^{-1}\) and T\(_5\), where 30 kg ha\(^{-1}\) T\(_5\) increased stover yield by 27.4 % and 15.2 % over control, respectively. Even though, soybean respond to basal application of potassium but the response of split application of potassium in soybean was much higher than recommended as well as than basal application. Highest grain yield with split application of potassium might be due to higher uptake by soybean plant throughout its growing season and split application might have created the
favourable environment for the potassium accumulation in the plant system. According to (Bansal et al 2001) the uptake rate of potassium is highest during rapid vegetative growth and slower at seed formation stage because soybean takes up and accumulates potassium throughout the growing season. Young seedlings of soybean do not use much potassium, but the rate of uptake climbs to a peak during the period of rapid vegetative growth. The potassium in vegetative parts is transferred to seed during pod fill process. The mature soybean seed contains nearly 60 % of the total potassium in plant as reported by (Hoeft et al 2000). (Kundu et al 2001 and Kolar et al 1994) also reported that split application of potassium at sowing and flowering gave the maximum seed yield over basal and foliar application of potassium.

Benefit cost ratio is a tool for appraising the worthiness of investment and it helps to ascertain the profitability of an enterprise (Table 2). Split application of potassium @ 30 Kg ha⁻¹ at sowing and 30 kg ha⁻¹ at flowering recorded the higher net returns (Rs 1,67,062) and higher benefit cost ratio (7.1) as compared to all other treatments. It was due to higher response of soybean to split application of potassium by virtue of higher number of pods and pod weight increases and ultimately higher yield of soybean.

CONCLUSION
The results of the present investigation revealed that the split application of potassium had an edge over basal application. Highest grain yield of soybean was recorded in T₇ treatment (30 kg K₂O ha⁻¹ at sowing and 30 kg K₂O ha⁻¹ at flowering) followed by T₆ treatment (15kg K₂O ha⁻¹ at sowing and 15 kg K₂O ha⁻¹ at flowering) while the lowest grain yield was recorded under control treatment. However, the yield increment was significantly higher in split application of potassium in soybean but the basal application of potassium also assisted in yield increment over no application of potassium. It can be concluded that potassium application as basal and split both helped in increase growth and yield of soybean. A similar crop trend was also observed in case of yield attributes viz. number of pods plant⁻¹, pod weight plant⁻¹, grains pod⁻¹ and 100 seed weight.

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