Effect of potassium application and crop geometries on seed yield, seed quality in berseem (Trifolium alexandrium L.) plants

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ABSTRACT

Potassium (K) availability to berseem (Trifolium alexandrium L.) during the reproductive phase in alfisols was the main objective of this study, which was also focused on availability to, and response behavior of the seed crop in three crop arrangements as affected by rate and time of potassium application. Three K levels (0, 40 and 80 kg K$_2$O/ha) were applied either as a basal application or after the last cut in three crop arrangements (Broadcasted, 20 cm row to row and 40 cm row to row). Exchangeable K in the soil and the K content in the plants was determined in the soil at the last harvest and at the time of final harvest. Results indicated that the seed yield and the test weight of the seeds increased with each successive increase in the K level in all three years but the number of seeds/head were not influenced by the levels of potassium in the first year. Forty cm rows gave the highest seed yield and it also produced a higher test weight. The maximum numbers of seed/head (47.5) were produced in 40 cm rows and the minimum numbers of seeds/head (42.3) were produced in 20 cm rows. First year seed yields were similar with both methods of potassium application, but in the 2nd and 3rd year, application after the last cut gave higher seed yield than basal application. The interaction effect between the crop geometry and the time of potassium application on seed yield indicated that, basal application of potassium was good for broadcasted and 40 cm rows but application after the last cut in 20 cm rows. Potassium applications maintained a higher plant population during reproductive phase in general but application after the last cut was more effective than basal application. Twenty cm spaced rows produced the highest dry matter yield among all the three crop arrangements.

Keywords: Berseem, Crop geometry, Potassium level, Reproductive phase, Seed yield, Seed quality.

INTRODUCTION

Potassium is not only an essential element for forage legumes but also these crops have a high level of uptake. Potassium plays a vital role in the nutrition and production of forage legumes in the temperate sub-tropical and tropical regions. Nevertheless, when adequate levels are available for optimal physiological activity, there appears to be little advantage to larger quantities of available K. Utilization the entire above ground plant parts and the relatively high K concentration of these parts, create a very dynamic K flux in berseem stands. Harvesting the crop for stored or direct feeding results in removal of the K from the field. The K concentration in forage legumes changes substantially with maturity. Baker and Reid (1977) in their survey found that K$^+$ concentration in alfalfa and red clover ranged from approximately 27.5g kg$^{-1}$ at late vegetative stage to 17.5g kg$^{-1}$ at seed. This decrease in K concentration at seed might be the result of increased demand for K during the reproductive phase coupled with a decrease in K supplies from soil reserves. The aim of K fertilizer application is to make up for the difference between the K status of the soil and the K demand of plants, to ensure
that sufficient nutrients are available at all developmental stages. Vertisols and associated soils with relatively low levels of this ratio have higher available K but, low to medium non exchangeable K which under long term cropping, may be depleted more quickly. In soils with low levels of both exchangeable and non exchangeable K, K application are required to realize the full yield potential of crops (Srinivasa Rao et al., 2010). Requirement for potassium has been reported to increase during the reproductive phase in some crops, even if the potassium content in the soil was sufficient to maintain good vegetative growth. If the requirement for K during the reproductive phases surpasses the supply from soil reserves seed yield may be included. Such a deficiency, might affect many productive flowers adversely, leading to losses in seed yield. Welch and Flannery (1985) found that 10 kg K2O ha⁻¹ day⁻¹ was absorbed before pollination in maize, whereas the absorption rate during the vegetative phase was as low as 3-5 kg K2O ha⁻¹ day⁻¹. This suggests that factors other than the level of available K in the surface soil can K uptake. Leffler and Tubertini (1976) found that the need for K increases dramatically when bolls are set on cotton plants. The authors showed that the total K in an individual boll increased from 0.19 mg/boll 10 days after flowering to 1.19 mg/boll, 56 days after flowering at ball maturity. Is a particular soil capable of releasing sufficiently rapidly the quantity of available potassium taken up by the plant at the expense of its own potential reserves? If the soil has a low K buffering capacity, one can hardly hope to increase crop yield. Therefore, K availability to plants of Berseem during the reproductive phase and its effect on seed yield and the seed quality parameters in alfisols was the objective of this study.

MATERIALS AND METHODS

The experiment was laid out as a split-split design in three replications to accommodate three levels of potassium (0, 40, and 80 kg K2O ha⁻¹), three crop geometries (Broadcasted, 20 cm row to row and 40 cm row to row spacing) and two times of potassium application (basal application and application after the last cut prior to seed production). Potassium levels x crop geometry interactions were incorporated in the main plots and the time of potassium application in the sub-plot. The experiment started in the winter season and was repeated for two more consecutive years in winter season. The sowing of Berseem was done in December, the first year and in November in the next the two years. A uniform application of 20 kg N and 80kg P2O5ha⁻¹ was made at the time of sowing. Potassium treatment due as a basal application was applied included along with nitrogen and phosphorus. Potassium treatments due after the last cut were made after two harvests in the first year and after the three harvests in the second and third year.

The crop was irrigated as needed and the weeds were removed once after the establishment of the crop.

RESULTS AND DISCUSSION

Seed yield, test weight and number of seeds/head as affected by potassium levels, crop geometry and time of potassium application

Effect of potassium levels

Seed yield increased with every successive increase in K level in all the three years. (Table 1). The results indicated that to maximise yields, the seed crop of berseem should be supplied with 80kg K2O/ha in alfisols, which are low in exchangeable K. The main mechanism of soil K supply is diffusion (William, 2008). The research has shown that when K fertilizer was applied to the soil, the K concentration in the fertilizer zone was several times higher than rest of the soil, and K moved in the soil through diffusion (Khajani et al 2012). The concentration of the K in the vicinity of the root surface is lowered in response to plant uptake and a gradual K diffusion from non-root zone to the root zone helps to meet the K requirement of the crop. Many crops are known to have a higher requirement for K during their reproductive phase as compared to their vegetative phase. Potassium applications based on vegetative requirements, therefore, may affect the seed yield adversely in many soil climatic conditions. As the crop of berseem is a heavy feeder of K and also, this nutrient is continuously being removed from the soil complex in each harvest, such an undetectable deficient condition might affect many productive flowers of an inflorescence adversely, leading to significant loss in seed yield. A close attention therefore needs to be paid towards its potassium requirement during reproductive phase.

Test weight of the seeds also increased with every successive increase in potassium level (Table 1). As potassium is known to exert a special influence on formation and translocation of photosynthetic material, any deficiency of this element will lead to either shrunken or undersize seeds. As the potassium levels are raised, escalated translocation of photosynthate to the young forming seeds leads to formation of larger seeds. There are a number of reports describing the role of potassium in improving the yield and quality of the seeds in many crops (Paricha and Bansal, 2002, and Tiwari et al., 2003).

In the first year, the number of seeds /head were not influenced by the levels of the potassium (Table1). As only two harvests were taken in the first year, before the crop was left for the seed, potassium removal was comparatively lower in comparison to year 2 and 3. As such, potassium responses were not observed on number of seeds/head. It appears that comparatively lower levels of K are required to increase the number
Table 1. Seed yield, test weight and number of seeds/head as affected by potassium levels (a), crop geometry (b) and time of potassium application (c)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Seed yield (q/ha)</th>
<th>Seed test weight (g)</th>
<th>No of seed/head</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Year</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Year</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Year</td>
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<tr>
<td>K&lt;sub&gt;0&lt;/sub&gt;</td>
<td></td>
<td></td>
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<td></td>
<td>4.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.21&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.02&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>K&lt;sub&gt;40&lt;/sub&gt;</td>
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<td></td>
<td></td>
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<td></td>
<td>5.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.29&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.54&lt;sup&gt;b&lt;/sup&gt;</td>
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<td></td>
<td>6.26&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.49&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.64&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean</td>
<td>5.31</td>
<td>5.33</td>
<td>6.40</td>
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<tr>
<td>Crop geometry</td>
<td></td>
<td></td>
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<tr>
<td>Broadcasted</td>
<td>5.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.52&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>20cm row to row</td>
<td>4.94&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.58&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.02&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>40cm row to row</td>
<td>5.76&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.14&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.66&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean</td>
<td>5.31</td>
<td>5.33</td>
<td>6.40</td>
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<tr>
<td>Time of application</td>
<td></td>
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<tr>
<td>Basal</td>
<td>5.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.1&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>After last cut</td>
<td>5.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.49&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.7&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>Mean</td>
<td>5.32</td>
<td>5.34</td>
<td>6.40</td>
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</tbody>
</table>

*Means within the columns of the same year followed by the same letter are not significantly different based on LSD (0.05) test

of seeds/head than for increase in the test weight. Modern maize cultivars respond to K application differently due to difference in its uptake, translocation, accumulation, growth and utilization (Nawaz, 2006; Nawaz et al., 2006; Minjian et al., 2007). The K-efficient phenotype is a complex one comprising a mixture of uptake and utilization efficiency mechanisms.

**Effect of crop geometry**

Among all the three crop arrangements, 40 cm rows gave the highest seed yield in each year. The mean seed yield in 40cm row arrangements, broadcasted crop geometry and 20 cm row arrangements was recorded as 6.52, 5.34 and 5.18q ha<sup>-1</sup> (Table 1). In years, when the climatic conditions was a favorable and the seed yield levels was high in general, 20 cm rows may give higher seed yield than broadcasted seed, but at lower seed yield levels, the differences were evident. Forty cm rows produced large seeds in all the three years in comparison to that other planting patterns. (Table). This crop geometry appears to be the best fit not only for greater seed yield harvests but also for producing heavier seeds. The results indicated that the test weight in 20cm row- to- row spaced crop geometry and broadcasted crop geometry, might not show significant variations in general but if the plant population is low, the 20cm spaced crop geometry may produce heavier seeds. In the second year of experimentation, the plant population in 20 cm rows was low compared to the other two years and therefore, more potassium was available to increase the test weight of the seeds. Minimum number of seed/head (42.3) was recorded in 20 cm rows followed by broadcasted seed (44.0).
Figure 1. Interaction effect of crop geometry x time of potassium application on seed yield

The maximum numbers of seed/head (47.5) were recorded in 40 cm spaced rows (Table 1). When competition for potassium is comparatively high as in the case of broadcast and 20 cm rows, the production of viable seeds/head may be reduced. Therefore, in these two crop arrangements application of potassium will be instrumental in increasing the number of seed/head in Alfisols. Thavaprakaash, N et al (2005) reported that raising baby corn at 60 cm row spacing with coriander and radish intercrops by following INM practices (50% NPK + poultry/goat manure + Azospirillum + phosphobacteria) would produce maximum baby corn and intercrops yields and also higher BEY and in turn increase the over all productivity of the system.

Time of potassium application

Seed yields were similar in both the methods of potassium application in the first year but in the 2nd and the 3rd year, application of potassium after the last cut gave higher seed yields than a basal application (Table 1). As only two cuts were taken in the first year, the potassium removal was not as high as in 2nd and the 3rd year when these were three harvests before the crop was left for seed. Due to this reason, the potassium supplied through fertilizer as basal dose, was also available and utilized during reproductive phase in the first year. It appears that the application after last cut, although increased the exchangeable K levels in the soil but was actually neither needed nor utilized for seed production in the first year.

The test weight of seeds was greater when the application of potassium was made after the last cut (Table 1). To achieve a significant increase in the test weight, application of potassium after the last cut is necessary as it ensures an adequate supply of this nutrient from beginning of the seed formation to the ripening of the seed. At higher potassium levels, a moiré efficient and continuous supply of potassium is maintained resulting into heavier seeds. Number of seed/head exhibited a similar trend as that of test weight (Table 1). A readily available source and adequate level of supply during seed formation is essential to harvest a good number of seeds/head. Application of potassium after the last cut therefore appears to be more effective than basal application in increasing the seed yield through increase in test weight and number of seeds/head.

Gupta et al., 2011 reported that to ensure maximum oil and protein yield and remuneration from Brassica species under semi and conditions of western Utter Pradesh, the oil content of mustard seed significantly varied among Brassica species, maximum being with B. napus (40.20%), which gave a difference of 0.50 and 0.89 unit over B. carinata and B. juncea. Application of nitrogen had an adverse effect on the oil content. Lower (40 kg N ha-1) fertilized crop showed maximum oil content of 39.98%, which progressively decreased with successive increase in the dose of nitrogen with lowest oil content, being in crop fertilized with 120 kg N ha-1 (38.51%). Maximum oil yield (882.88 kg ha-1) and protein yield (510.00 kg ha-1) were observed in case of B. carinata (PBC-9221) and minimum under B. napus. Higher dose of nitrogen 120 kg N ha-1 produced maximum oil and protein yield. Split application of potassium also produced...
higher oil and protein yield than basal dose of potassium. (Ravichandran et al., 2011).

**Interaction effect of crop geometry x time of potassium application on seed yield**

The interaction effect of crop geometry x time of potassium application on seed yield was significant only in the first year (Fig 1). The interaction indicated that basal application of potassium would give higher seed yield in broadcasted and 40 cm spaced crop geometries in a late sown crop but application of potassium after the last cut would be more effective in 20 cm spaced crop geometry under such situation. Because of higher plant population, 20 cm spaced crop geometry utilized comparatively more of the basal applied potassium. Application after last cut in this crop geometry therefore was more effective in increasing the seed yield as it ensured adequate potassium supply during seed formation and development. (Khajani et al 2012). (Figure 1)

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**REFERENCES**


