Effect of potassium, applied during reproductive phase on seed yield and seed germination in Setaria sphacelata grown in a vertisol

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ABSTRACT

An experiment to study the response behaviour of potassium applied during reproductive phase on seed yield and germination percentage of Setaria sphacelata seeds was initiated in wet season of 2000-2001 at Central Research Farm, I.G.F.R.I. and Jhansi which continued for four years. Six levels of potassium (0.25, 50, 75,100 and 125 kgK₂O /ha) were incorporated at the beginning of the flowering initiation in all the four years and seed yield data was recorded to analyse the response behaviour of the crop to potassium. The seed yield increased with application of 75 kgK₂O/ha in all the four years. The potassium content of seeds also increased with increasing rates of potassium. This increase in potassium content could conclusively increase the germination percent of the seeds. The availability of potassium decreased with passage of time after application. The yield parameters and available K content exhibited an increase only at a rate of 75 Kg K₂O/ha and above. However, increasing the potassium levels further could not increase any of the parameters studied. Potassium applied through fertilizer remained in available form even after 60 days of application in a vertisol, initially medium in available K. It was concluded that minor increases in soil solution K did not increase the availability of potassium.

Key words: Setaria sphacelata, Potassium, Seed yield, seed germination Reproductive phase.

INTRODUCTION

The genus Setaria includes approximately 125 species of temperate, sub-tropical and tropical distribution (Rominger, 1962), and is of considerable agricultural importance. Since the release of cultivar Nandi in 1961 (Anon. 1967) and more recently Kazungula in 1962 (Anon. 1967), large areas have been planted to Setaria in Queensland and northern New South Wales and effort is being put into defining management practices for maximum production, studding nutrient requirements, introducing new genotypes and breeding for improvement of yield and quality. The taxonomy of the Setaria sphacelata complex is still in some doubt, and further investigation is necessary for a useful classification of this complex. The Setaria sphacelata complex is confined to the continent of Africa. Although widespread with in Africa it is rarely dominant over large areas. Setaria incrassata is dominant over large tracts of heavy black soil country in W. Angola, N.E. Uganda and Ethiopia but Setaria sphacelata dominant grassland is confined to areas of Ethiopia and is regarded as a transitional type of grassland (Rattray, 1960). The tropical forage grass Setaria sphacelata is used as a pasture grass for grazing of dairy and beef cattle throughout the world, and also as cut-and carry, silage, and hay. In some environments it has been reported to be high yielding (Singh et al. 1995), persistent (Gibson and Andrews 1985), palatable (Ghisi et al. 1994), high in crude protein (Alvim et al. 1986), possessing superior seasonal growth distribution (Pedreira and Mattos 1981), and supporting adequate animal production (Alvim et al. 1993 and Jank et al. 2002).

Setaria sphacelata has been grown commercially in Queensland and northern New South Wales since 1961 (Barnard, 1967). However, seed commands a high price
in comparison to pasture grass seed in temperate regions, and this could limit the acreage sown. The high
price of seed is related to low yields obtained (Vicary, 1970), quotes a mean figure of 29 IB per acre (33 kg per
ha). According to Hacker et al, 1971, the poor seed yield from setaria may results from a number of causes, such
as low fertility, poor recovery, irregular initiation of inflorescences and seed ripening or sub-optimal
management practices. In contrast yield of 300-900kg seed per ha may be expected from temperate grasses

The potassium content of the crops varies not only from one crop to another but also in the same crop with its
age. It is high during early stages but decreases subsequently. In a system where crop residues are
removed from the field after seed harvest will quickly induce potassium deficiency, especially in the case of
Setaria sphacelata which has a very high requirement for this element. This practice requires high level of
potassium fertilizer or the careful return of animal wastes. It is important that phosphorus, sulphur and potassium
remain in balance if a seed producer embarks on high nitrogen usage. The content of K and its removal by
grasses is much higher where NPK fertilizers are applied; the differences between fertilized and unfertilized crop
increases with time, because of the sharp decrease in yield as well as K content.

The present work aims to study effect of potassium on seed yield and seed germination in Setaria sphacelata
grown in a vertisol.

MATERIALS AND METHODS

An experiment to study the response behavior of potassium applied during reproductive phase on seed
yield and germination percentage of Setaria sphacelata seeds was initiated in wet season of 2000-2001 at
Central Research Farm, I.G.F.R.I and Jhansi which continued for four years. The rooted slips of Setaria sphacelata were collected from old stands and planted at
a distance of 75cm row-to-row and plant-to-plant in a vertisol having 200 kg K2O/ha. A basal application of 100
kg nitrogen /ha and 60kg P2O5 was made before transplanting of the rooted slips. Six levels of potassium
(0, 25, 50, 75,100 and 125 kg/ha) were applied at the beginning of the flowering initiation as per treatment.
The potassium treatments were incorporated at the time of flower initiation, in all the four years of investigation.

Seed collection and germination studies

The mature seeds from each treatment were collected separately for each replication and the leaf and other
plant parts were removed before the seeds were stored in clean cloth bags for further studies. During the season,
three collections were required to harvest all the produced seeds. The seed yield data were recorded in
the laboratory using an electric balance and a portion of the seeds was kept for germination studies.

The germination studies were performed in the laboratory in germination paper soaked in distilled water and kept in germination chamber. Germinating seeds were counted and the percent of germination was calculated.

Soil and plant analysis

The soil samples were collected thrice during reproductive phase- before incorporation of potassium
applications, 30 days after incorporation and 60 days after incorporation in polythene bags, dried in shade,
pulverized to pass a 2mm sieve and stored in clean plastic vials for chemical determinations. The plant
samples were collected, dried in air before putting them into the oven and dried at a temperature of 65°C. The
samples were removed after drying ground in a grinding mill and stored in plastic vials for total potassium
determination. The exchangeable potassium was determined using neutral normal ammonium acetate
solution as described by Black. The plant samples were digested in triacid mixture, filtered and diluted to an
appropriate volume before recording the readings on flame photometer. The reading of the sample was
compared with standard curve to work out the potassium content in plants.

Statistical analysis

The analysis of variance (ANOVA) was done in randomized complete block design in wet season. The
significance of treatment differences was tested by F (Variance ratio) test. Critical difference (CD) at 5 per cent
level of significance (P=0.05) was worked out for comparison and statistical interpretation of treatments as
per Gomez and Gomez (1988).

RESULTS AND DISCUSSION

Seed yield and germination percentage of seeds

The seed yield of Setaria sphacelata in the third and fourth year after planting was significantly affected by
fertilizer potassium applied at 75 Kg K2O/ha at the start of the flower initiation The potassium content of Setaria sphacelata seeds increased with application of 75 Kg
K2O/ha which was also reflected as an improvement in germination percentage of the seed. (Figure 1). As the
potassium is a mobile element, a fresh application increased the potassium content of the seeds. The seeds
require a minimum percentage of potassium for germination to be effective.

In a third year crop of Setaria sphacelata graded application of potassium at the initiation of flowering
increased the dry matter yield, seed yield and available K content of the soil. The yield parameters and available K content exhibited an increase only at a rate of 75 Kg K\(\text{O}_2/\text{ha}\) and above. However, increasing the potassium levels further could not increase any of the parameters studied. Potassium applied through fertilizer remained in available form even after 60 days of application in a vertisol, initially medium in available K. It was concluded that minor increases in soil solution K did not increase the availability of potassium.

In spite of fresh potassium fertilizer applications just before flowering, the dry matter yield, seed yield and available K content decreased in the fourth year. This is a general tendency of grasses that the yield levels are lowered in subsequent years. The dry matter yield data relate to February harvest of Setaria after collecting the seeds and the available K data correspond to just before the application of potassium in October and 30 and 60 days after. Differences in plant K content were not observed in plant samples collected before application of the potassium. After 30 days of application, 50 Kg K\(\text{O}_2/\text{ha}\) rate of application increased the K content and after 60 days of application, only 75 Kg K\(\text{O}_2/\text{ha}\) rate of application could increase the K content due to its decreasing availability with time. The results are supported by a decreasing availability of exchangeable potassium with time (Leffler and Tubertiny, 1976). (Table:1, 2 and 3).

The task of the seed producer is therefore to identify mineral deficiencies in his soil and to devise a balanced fertilizer application programme, which will avoid nutritional limitations to seed production in his environment. In the absence of potassium application, soils under fodder crops get rapidly depleted of their potassium reserves. There are indications that soils initially medium in available potassium may become low in few years under continuous cropping without potassium application, and begin responding to potassium. With the application of fertilizer potassium removal of soil K also increases. Fritz observed that potash removal by Setaria grass was 505 Kg K\(\text{O}_2/\text{ha}\) when no fertilizer potassium was applied. The potassium uptake increased to 758 and 842 Kg K\(\text{O}_2/\text{ha}\) when potassium was applied at 400 and 800 Kg K\(\text{O}_2/\text{ha}\). Potassium depletion from the soil is progressively narrowed as potassium application rates were stepped up.

The need for K increases dramatically when bolls are set on the cotton plant because bolls are a major sink for K (Leffler and Tubertiny, 1976). These 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 boll maturity. Such an undetectable deficient condition might affect many productive flowers of an inflorescence leading to drastic seed losses in a crop like Setaria which has a very high requirement for potassium. The research data on responses of fodder crops to fertilizers, especially potassium, are meager. Keeping in view the importance of fodder crops to the
Table 1: Effect of potassium application on dry matter yield, seed yield and ammonium acetate extractable K in a third year crop of *Setaria* *sphacelata*

<table>
<thead>
<tr>
<th>K levels (KgK₂O/ha)</th>
<th>Dry matter (Kg/ha) yield</th>
<th>Seed yield (Kg/ha)</th>
<th>(Kg K₂O/ha) before application</th>
<th>(Kg K₂O/ha) 30 days after application</th>
<th>(Kg K₂O/ha) 60 days after application</th>
</tr>
</thead>
<tbody>
<tr>
<td>K₀</td>
<td>5.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>61.43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>224&lt;sup&gt;a&lt;/sup&gt;</td>
<td>217&lt;sup&gt;a&lt;/sup&gt;</td>
<td>201&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₂₅</td>
<td>5.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>65.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>226&lt;sup&gt;a&lt;/sup&gt;</td>
<td>224&lt;sup&gt;a&lt;/sup&gt;</td>
<td>212&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₅₀</td>
<td>6.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>69.90&lt;sup&gt;a&lt;/sup&gt;</td>
<td>236&lt;sup&gt;a&lt;/sup&gt;</td>
<td>232&lt;sup&gt;a&lt;/sup&gt;</td>
<td>219&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₇₅</td>
<td>6.54&lt;sup&gt;b&lt;/sup&gt;</td>
<td>80.63&lt;sup&gt;a&lt;/sup&gt;</td>
<td>241&lt;sup&gt;b&lt;/sup&gt;</td>
<td>249&lt;sup&gt;b&lt;/sup&gt;</td>
<td>238&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₁₀₀</td>
<td>6.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>82.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>244&lt;sup&gt;b&lt;/sup&gt;</td>
<td>255&lt;sup&gt;b&lt;/sup&gt;</td>
<td>240&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₁₂₅</td>
<td>6.95&lt;sup&gt;b&lt;/sup&gt;</td>
<td>85.63&lt;sup&gt;b&lt;/sup&gt;</td>
<td>247&lt;sup&gt;b&lt;/sup&gt;</td>
<td>261&lt;sup&gt;b&lt;/sup&gt;</td>
<td>243&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*Means within the same column followed by the same letter are not significantly different based on L.S.D. (0.05) test.

Table 2. Effect of potassium application on dry matter yield, seed yield and ammonium acetate extractable K in a fourth year crop of *Setaria* *sphacelata*

<table>
<thead>
<tr>
<th>K levels (Kg K₂O/ha)</th>
<th>Dry matter yield(t/ha)</th>
<th>Seed yield (Kg/ha)</th>
<th>(Kg K₂O/ha) before application</th>
<th>(Kg K₂O/ha) 30 days after application</th>
<th>(Kg K₂O/ha) 60 days after application</th>
</tr>
</thead>
<tbody>
<tr>
<td>K₀</td>
<td>2.92</td>
<td>41.43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>203&lt;sup&gt;a&lt;/sup&gt;</td>
<td>186&lt;sup&gt;a&lt;/sup&gt;</td>
<td>180&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₂₅</td>
<td>3.08</td>
<td>45.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>203&lt;sup&gt;a&lt;/sup&gt;</td>
<td>198&lt;sup&gt;a&lt;/sup&gt;</td>
<td>185&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₅₀</td>
<td>4.05</td>
<td>50.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>208&lt;sup&gt;a&lt;/sup&gt;</td>
<td>213&lt;sup&gt;a&lt;/sup&gt;</td>
<td>193&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₇₅</td>
<td>4.20</td>
<td>60.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>217&lt;sup&gt;a&lt;/sup&gt;</td>
<td>228&lt;sup&gt;b&lt;/sup&gt;</td>
<td>206&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₁₀₀</td>
<td>4.34</td>
<td>62.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>223&lt;sup&gt;a&lt;/sup&gt;</td>
<td>239&lt;sup&gt;b&lt;/sup&gt;</td>
<td>223&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₁₂₅</td>
<td>4.48</td>
<td>65.63&lt;sup&gt;b&lt;/sup&gt;</td>
<td>226&lt;sup&gt;a&lt;/sup&gt;</td>
<td>243&lt;sup&gt;b&lt;/sup&gt;</td>
<td>227&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*Means within the same column followed by the same letter are not significantly different based on L.S.D. (0.05) test.

Table 3. Variations in potassium content (%) of *Setaria sphacelata* during reproductive phase as affected by its levels

<table>
<thead>
<tr>
<th>K levels (Kg K₂O/ha)</th>
<th>In plant</th>
<th>In seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before application</td>
<td>30 days after application</td>
</tr>
<tr>
<td>K₀</td>
<td>1.52</td>
<td>1.39&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₂₅</td>
<td>1.56</td>
<td>1.50&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>K₅₀</td>
<td>1.56</td>
<td>1.71b</td>
</tr>
<tr>
<td>K₇₅</td>
<td>1.67</td>
<td>1.78 b</td>
</tr>
<tr>
<td>K₁₀₀</td>
<td>1.67</td>
<td>1.85 b</td>
</tr>
<tr>
<td>K₁₂₅</td>
<td>1.71</td>
<td>1.98 b</td>
</tr>
</tbody>
</table>

*Means within the same column followed by the same letter are not significantly different based on L.S.D. (0.05) test.

The agricultural economy, more work needs to be done on their fertilizer requirements not only on vegetative yield but also on its different aspects, which affect the seed yield. The reproductive requirements of potassium are reported to be higher than vegetative requirements in many crops, and therefore an application at the beginning of the reproductive phase ensures the adequate supply and also the seed yields if this particular nutrient is limiting during flower initiation and seed formation.

**ACKNOWLEDGEMENT**

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REFERENCES


Anon (1967). Australian Herbage Plant Register, CSIRO, Division of Plant Industry, Canberra.

Barnard C (1967). Australian Herbage Plant Register, CSIRO, Division of Plant Industry, Canberra.


Rattray JM (1960). The grass cover of Africa. FAO. Agricultural Series No-49.

