

Original Research Article

Times of potassium application in topdressing on the soybean crop

ABSTRACT

Potassium is exported in large amounts through grain harvest and this, together with the low availability of potassium in Brazilian soils, leads to an evident need for restoration of this nutrient. When the application rates of potassium are greater than 50 kg·ha⁻¹, the most effective manner of utilizing the potassium is through topdressed fertilization after sowing. As such, the aim of this study was to establish the best time for topdressed application of potassium after sowing, as well as to study the effect of this nutrient on grain yield, on agronomic traits, and on potassium content in the grain. The experiment was carried out in the municipality of Lavras in the 2012/13 crop season. A randomized block design in an 8 x 4 factorial arrangement was used, composed of eight cultivars and four different periods of topdressed potassium application (20, 30, 40, and 50 days after sowing) for a total of 32 treatments with three replications. Potassium chloride at the rate of 120 Kg·ha⁻¹ of potassium was used as a source. The results show that there was no effect of the time of topdressed application of potassium on the soybean crop for grain yield, for agronomic traits, and for potassium content in the grain.

Keywords: Glycine max L. Merrill; Topdressed fertilization; Macronutrient; Yield.

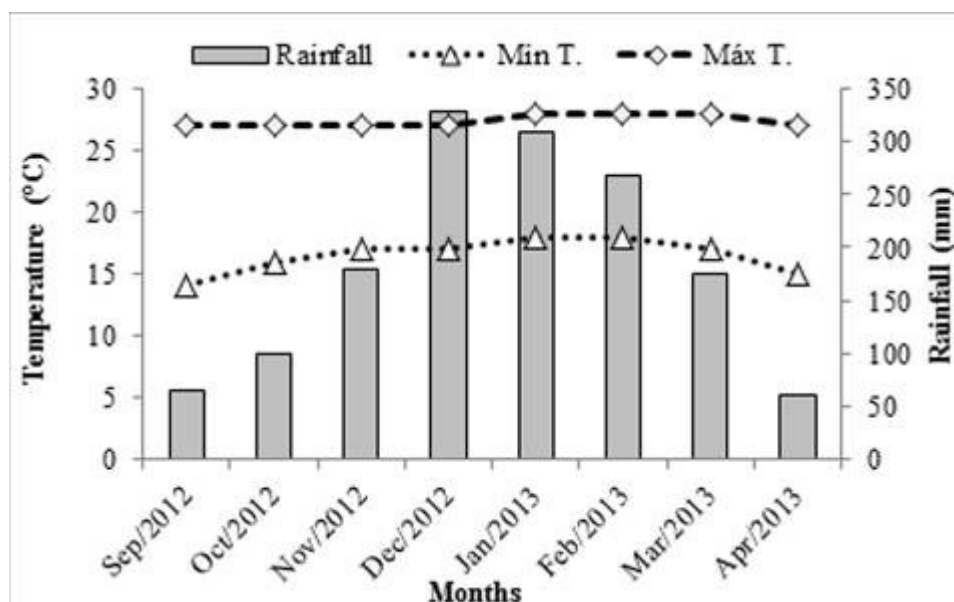
1. INTRODUCTION

The importance of potassium in Brazilian agriculture is unquestionable, and this is also the case in the soybean crop. Potassium is second only to nitrogen in terms of the nutrients most required and exported by the crop [1]. On average, thirty-three kilograms are extracted from the soil to produce 1000 kg of grain, and twenty kg of the nutrient are exported in the form of grain [2]. Low availability of potassium may reduce yield from one crop season to another [3]. To compensate low availability, nutrients must be replenished through fertilization to compensate export by the crops and also losses from leaching and erosion, thus avoiding the risk of limiting grain yield due to potassium deficiency [4]. In annual crops, potassium fertilization is carried out at sowing or in topdressing. As potassium is a salt-based fertilizer that is easily leached to lower soil layers, the most effective manner of taking advantage of this nutrient is through topdressed fertilization after sowing the crop. In soybean, the period of greatest demand for potassium occurs in the vegetative growth stage, in which the maximum rate of uptake occurs at thirty days before flowering [5]. Recommendations of the [6] indicate that in situations in which potassium application rates are greater than 50 kg·ha⁻¹ or when the cropped soil has a clay content of less than 40%, potassium application should be carried out through topdressing after sowing. Therefore, studies should be carried out to evaluate the best time for potassium application in topdressing. Thus, the aim of this study was to establish the best time for potassium application in topdressing after sowing, as well as to study the effect of this nutrient on grain yield, agronomic traits, and potassium content in the grains in the soybean crop.

2. MATERIAL AND METHODS

The study was conducted in the Crop and Livestock Scientific and Technological Development Center of the Universidade Federal de Lavras (Federal University of Lavras),

36 in the municipality of Lavras, MG, Brazil, at a latitude of 21°12' S, longitude 44°58 W, and
 37 altitude of 955 m. According to [7], the climate in the municipality according to the Köppen
 38 classification is Cwa, with mean annual temperature of 19.3°C and annual normal rainfall of
 39 1530 mm. Rainfall and maximum and minimum monthly temperatures registered in Lavras
 40 over the period of the experiment are shown in Figure 1.



41 **Fig. 1. Rainfall, minimum temperature, and maximum temperature from September**
 42 **2012 to April 2013 in Lavras, MG, Brazil. Source: Adapted from INMET (2013)**
 43

44 Soil type in the area in which the experiment was carried out is Oxisol, and the results of
 45 chemical characteristic analysis at the 0-20 cm depth were: organic matter of 2.61 dag/kg;
 46 pH (H₂O) of 5.9; P, K, Ca, Mg, H+Al, and Al of 7.21 mg/dm³, 118 mg/dm³, 4.7 cmol/dm³, 1.3
 47 cmol/dm³, 2.9 cmol/dm³, and 0 cmol/dm³, respectively; base saturation of 69%; and clay
 48 content of 64%. Eight commercial soybean cultivars of different origins were used (BRS/MG
 49 750S RR, BRS/MG 760 SRR, BRS/MG 850 GRR, Monsoy 7211 RR, NA 7255 RR, TMG 127
 50 RR, TMG 801 RR, and TMG 1179 RR). The times for potassium application in topdressing
 51 were at 20, 30, 40, and 50 days after sowing (DAS). As suggested by [8], a single
 52 application of potassium was made at a rate of 120 kg ha⁻¹, with potassium chloride as a
 53 source. A randomized block experimental design with three replications was used, with
 54 treatments in an 8 x 4 factorial arrangement of eight cultivars and four application times.
 55 Each plot consisted of two 5-m rows, with a between-row spacing of 50 cm. Seeds were
 56 sown at the beginning of November 2012 at a density of 12 seeds per linear meter. Crop
 57 treatments performed in the experimental area were similar to those presented by [9], with
 58 the exception of the time of potassium application, which differed for the treatments. The
 59 traits assessed were grain yield (kg ha⁻¹), height of the lowest pod (cm), plant height (cm),
 60 lodging index according to the scale proposed by [10], and potassium content in the grain
 61 according to [11]. The data were subjected to analysis of variance, and the mean values
 62 were compared by the Scott & Knott [12] test at 5% probability. Statistical analysis was
 63 carried out with the assistance of the statistical package SISVAR [13].

65 3. RESULTS AND DISCUSSION

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The coefficient of variation (CV) obtained from analysis of variance indicates the degree of precision in carrying out the experiment. Based on the CV obtained, it may be observed that the traits assessed had high to good precision, with the exception of the plant lodging trait (Table 1).

Table 1. Summary of analysis of variance for grain yield (Yield), lodging (Lodg), height of the lowest pod (LP), plant height (Hei), and potassium content (K) as a function of cultivars and times of potassium application in topdressing. UFLA, Lavras, MG, Brazil, 2014

SV	DF	QM				
		Yield	Lodg	LP	Hei	K
Cultivars (C)	7	1339587.66 [*]	4.85 [*]	59.15 [*]	1276.46 [*]	0.05 ^{ns}
Times (T)	3	65519.18 ^{ns}	0.36 ^{ns}	4.95 ^{ns}	37.10 ^{ns}	0.02 ^{ns}
C x T	21	335472.53 ^{ns}	0.32 ^{ns}	5.71 ^{ns}	19.75 ^{ns}	0.04 ^{ns}
Error	62/31 ¹	633109.03	0.46	5.72	40.34	0.04
Overall mean		3935.03	1.54	14.09	88.21	1.23
CV (%)		20.00	44.00	17.00	7.00	16.00

* significant at 5%, and (ns) not significant according to the F test. ¹ Degree of freedom associated with analysis error of potassium content in the grain

In the summary of analysis of variance shown in Table 1, it may be observed that there was a significant difference ($p \leq 0.05$) for grain yield and for the traits of lodging, height of the lowest pod, and plant height, for the cultivar source of variation (SV). These results confirm the existence of variation for these traits. Through the application times SV, it may be seen that the application of potassium in topdressing did not affect grain yield and the other traits. The lack of response to the times of application of potassium fertilization may be explained by the fact of high natural fertility of the soil in the area of carrying out the experiment [14]. In the same way, [15] did not observe significant responses for grain yield and the other characteristics assessed. Interaction between the cultivars and the times of potassium application was non-significant, thus showing the independent behavior of the different times of application and the cultivars assessed. The mean values of the agronomic traits obtained for the soybean cultivars assessed are shown in Table 2. For grain yield, better performances were observed for the cultivars NA 7255 RR, TMG 127 RR, Monsoy 7211 RR, and TMG 801 RR. The other cultivars, BRS/MG 850 GRR, BRS/MG 760 SRR, TMG 1179 RR, and BRS/MG 750 SRR showed lower performance; however, the mean values obtained were greater than the mean Brazilian yield in the 2012/13 crop season, which was 2903 Kg·ha⁻¹.

Table 2. Mean values of the traits of grain yield (Yield - Kg·ha⁻¹), lodging (Lodg), height of the lowest pod (LP - cm), plant height (Hei - cm), and potassium content (K - %) for the cultivars assessed. Lavras, MG, Brazil, 2014

Cultivars	Yield	Lodg	LP	Hei	K
TMG 127RR	4246.29 a	1.33 a	15.28 a	95.50 a	1.21
NA 7255 RR	4304.00 a	1.25 a	16.86 a	91.00 b	1.23
BRS/MG 850 GRR	3806.30 b	1.50 a	11.45 b	90.35 b	1.22
TMG 1179 RR	3611.15 b	1.33 a	14.53 a	86.61 b	1.31
TMG 801 RR	4163.09 a	1.50 a	10.13 b	66.64 d	1.14
BRS/MG 750 SRR	3410.81 b	3.08 b	14.53 a	81.41 c	1.36
BRS/MG 760 SRR	3748.20 b	1.16 a	14.35 a	95.16 a	1.12
MONSOY 7211	4190.39 a	1.16 a	15.61 a	99.01 a	1.25

98 Mean values followed by the same letter belong to the same group by the Scott & Knott
99 (1974) test at the 5% probability level

100
101 Along with grain yield, other agronomic traits are of interest and desirable in the soybean
102 crop, such as plant height, height of the lowest pod, and lodging index. These characteristics
103 are dependent on the genotype, environmental factors, soil fertility, crop year, and moisture,
104 among other things [16]. Explaining the data in regard to mean plant height, it may be seen
105 that the cultivars showed significant differences for this trait. The greatest height estimates
106 were observed in the cultivars Monsoy 7211 RR, TMG 127 RR, and BRS/MG 760 SRR, with
107 mean values of 99.01, 95.50, and 95.16 cm, respectively; and the lowest plant height was
108 observed in the cultivar TMG 801 RR, with a mean value of 66.64 cm. These mean values
109 show that all the cultivars assessed in the municipality of Lavras in the 2012/13 crop season
110 exhibited mean plant heights within the range recommended by [17], i.e., plant height
111 ranging from 60 to 120 cm. Plant height is an essential characteristic since it is related to
112 grain yield, weed control and also to losses during the operation of mechanized harvest.
113 Variations in plant height may be affected by the time of sowing, plant spacing, moisture
114 supply, temperature, soil fertility, and other general conditions of the environment, such as
115 photoperiod [18]. For the height of the lowest pod, a variation of 16.86 cm for NA 7255 RR to
116 10.13 cm for the cultivar TMG 801 RR was seen. Aiming at greater operational yield from the
117 harvester, associated with minimization of harvest losses, [19] recommend that, on flat land,
118 soybean cultivars should show a height of the lowest pod equal to or not much greater than
119 10.0 cm. According to [20], the height of 12 to 15 cm is most adequate for mechanized
120 harvest. Thus, in the present study, all the cultivars except for NA 7255 RR show appropriate
121 height of the lowest pod, as described in the literature. It should also be noted that
122 environmental factors (temperature, moisture, and others) or crop practices (plant density
123 and sowing time) that affect plant height may also have an effect on the height of the lowest
124 pod, degree of lodging, and grain yield [21]. During the period of carrying out the experiment,
125 there were high rainfall amounts, above all in the months of December and January (Figure
126 1). This fact led to greater vegetative development, thus resulting in greater plant height,
127 greater height of the lowest pod, and, consequently, greater lodging. For lodging, results
128 were obtained following the scoring scale suggested by [10], which show that the cultivar
129 BRS/MG 750 SRR was that which showed greatest lodging, with a mean score of 3.08, i.e.,
130 it showed from 25 to 50% of lodged plants. The other cultivars obtained mean scores which
131 ranged from 1.16 to 1.50, which indicates some lodged or slightly lodged plants. According
132 to [22], lodging directly affects harvester performance since lodged plants mean losses in
133 grain yield as the grains are unable to be harvested, as well as possible losses due to direct
134 contact of the soil with the pods and the emergence of fungi and pests. Lodging is a
135 characteristic which is greatly affected by soil type and by plant development conditions. In
136 general, soybean plants show greater lodging in fertile and heavy soils with abundant
137 moisture than in light and sandy soils. Another point to be considered is in regard to plant
138 height; normally, high plants may lead to a greater lodging rate since they have finer stems
139 and are subject to falling over through wind activity [21].

140

141 4. CONCLUSION

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143 There was no effect of the time of topdressed application of potassium on the soybean crop
144 for grain yield, agronomic traits, and potassium content in the grain.

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