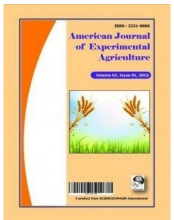

American Journal of Experimental Agriculture
9(2): 1-6, 2015, Article no.AJEA.19435
ISSN: 2231-0606

SCIENCEDOMAIN *international*
www.sciencedomain.org

Times of Potassium Application in Topdressing on the Soybean Crop

E. V. Zambiazzi[1*], A. T. Bruzi[1], I. O. Soares[1], G. Felisberto[2], A. M. Zuffo[1], G. L. D. Vilela[1] and P. M. de Rezende[1]

[1]*Department of Agriculture, Federal University of Lavras, Lavras, Minas Gerais, Brazil.*
[2]*Department of Plant Production, University of São Paulo, Piracicaba, São Paulo, Brazil.*

Authors' contributions

This work was carried out in collaboration between all authors. Author EVZ designed the study, wrote the protocol and wrote the first draft of the manuscript. Author EVZ reviewed the experimental design and all drafts of the manuscript. Authors ATB, IOS, GF, AMZ, GLDV and PMR managed the analyses of the study. Author EVZ identified the plants. Authors EVZ and ATB performed the statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2015/19435
Editor(s):
(1) Sławomir Borek, Department of Plant Physiology, Adam Mickiewicz University, Poland.
Reviewers:
(1) Anonymous, Mansoura University, Egypt.
(2) Raúl Leonel Grijalva Contreras, Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, Mexico.
Complete Peer review History: http://sciencedomain.org/review-history/10151

Short Research Article

Received 9th June 2015
Accepted 30th June 2015
Published 14th July 2015

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

*Corresponding author: E-mail: everton_zambiazzi@hotmail.com;

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

Soybean [*Glycine max* (L.) Merrill] is the main oilseed crop grown in the world. Brazil is the second largest producer and exporter worldwide, with a planted area of 31902.4 thousand ha^{-1} and mean grain yield of 3011 $kg\cdot ha^{-1}$ in the 2014/2015 crop year [1]. The Brazilian soybean production chain has gone through modernization processes, which have led to an increase in grain yield [2]. 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 [3]. 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 [4]. Low availability of potassium may reduce yield from one crop season to another [5]. 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 [6]. 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 [7]. Recommendations of the [8] indicate that in situations in which potassium application rates are greater than 50 $kg\cdot ha^{-1}$ 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. MATERIALS 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), in the municipality of Lavras, MG, Brazil, at a latitude of 21º12' S, longitude 44º58 W, and altitude of 955 m. According to [9], the climate in the municipality according to the Köppen classsification is Cwa, with mean annual temperature of 19.3°C and annual normal rainfall of 1530 mm. Rainfall and maximum and minimum monthly temperatures registered in Lavras over the period of the experiment are shown in Fig. 1.

Soil in the experimental area is classified as dystrophic red latosol. The chemical and physical composition of the soil is shown in Table 1.

Eight commercial soybean cultivars of different origins were used (BRS/MG 750S RR, BRS/MG 760 SRR, BRS/MG 850 GRR, Monsoy 7211 RR, NA 7255 RR, TMG 127 RR, TMG 801 RR, and TMG 1179 RR). The times for potassium application in topdressing were at 20, 30, 40, and 50 days after sowing (DAS). As suggested by [10], a single application of potassium was made at a rate of 120 $kg\cdot ha^{-1}$, with potassium chloride as a source. A randomized block experimental design with three replications was used, with treatments in an 8 x 4 factorial arrangement of eight cultivars and four application times. Each plot consisted of two 5-m rows, with a between-row spacing of 50 cm. Seeds were sown at the beginning of November 2012 at a density of 12 seeds per linear meter. Crop treatments performed in the experimental area were similar to those presented by [11], with the exception of the time of potassium application, which differed for the treatments. The traits assessed were grain yield (kg ha^{-1}), height of the lowest pod (cm), plant height (cm), lodging index according to the scale proposed by [12], and potassium content in the grain according to [13]. The data were subjected to analysis of variance, and the mean values were compared by the Scott & Knott [14] test at 5% probability. Statistical analysis was carried out with the assistance of the statistical package SISVAR [15].

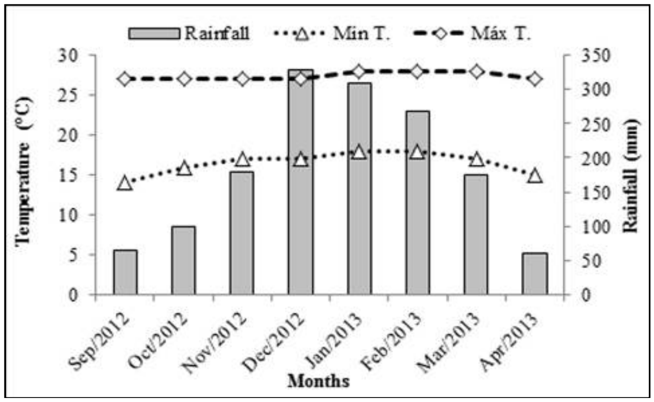

Fig. 1. Rainfall, minimum temperature, and maximum temperature from September 2012 to April 2013 in Lavras, MG, Brazil

Source: Adapted from INMET (2013)

Table 1. Chemical and physical composition of the dystrophic red latosol soil (0-0.20 m) before setting up the experiment. Lavras, MG, Brazil. 2012/13 crop season

pH	Ca^{2+}	Mg^{2+}	Al^{3+}	$H^{+}+Al^{3+}$	P	K	OM	V	Clay
H_2O	------------------ $cmol_c\ dm^{-3}$ ------------------				-- mg dm^{-3} --		dag/kg^{-1}	------- % -------	
5.9	4.7	1.3	0	2.9	7.21	118	2.61	69	64

H + Al: potential acidity; OM: organic matter; V: base saturation

3. RESULTS AND DISCUSSION

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 2).

In the summary of analysis of variance shown in Table 2, 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 [16]. In the same way, [17] 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 3. 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 $Kg \cdot ha^{-1}$.

Along with grain yield, other agronomic traits are of interest and desirable in the soybean crop, such as plant height, height of the lowest pod, and lodging index. These characteristics are dependent on the genotype, environmental factors, soil fertility, crop year, and moisture, among other things [18]. Explaining the data in regard to mean plant height, it may be seen that the cultivars showed significant differences for this trait. The greatest height estimates were observed in the cultivars Monsoy 7211 RR, TMG 127 RR, and BRS/MG 760 SRR, with mean values of 99.01, 95.50, and 95.16 cm, respectively; and the lowest plant height was observed in the cultivar TMG 801 RR, with a mean value of 66.64 cm. These mean values show that all the cultivars assessed in the municipality of Lavras in the 2012/13 crop season exhibited mean plant heights within the range recommended by [19], i.e., plant height ranging from 60 to 120 cm. Plant height is an essential characteristic since it is related to grain yield, weed control and also to losses during the operation of mechanized harvest. Variations in plant height may be affected by the time of sowing, plant spacing, moisture supply, temperature, soil fertility, and other general conditions of the environment, such as photoperiod [20]. For the height of the lowest pod, a variation of 16.86 cm for NA 7255 RR to 10.13 cm for the cultivar TMG 801 RR was seen. Aiming at greater operational yield from the harvester, associated with minimization of harvest losses, [21] recommend that, on flat land, soybean cultivars should show a height of the lowest pod equal to or not much greater than 10.0 cm. According to [22], the height of 12 to 15 cm is most adequate for mechanized harvest. Thus, in the present study, all the cultivars except for NA 7255 RR show appropriate height of the lowest pod, as described in the literature. It should also be noted that environmental factors (temperature, moisture, and others) or crop practices (plant density and sowing time) that affect plant height may also have an effect on the height of the lowest pod, degree of lodging, and grain yield [23]. During the period of carrying out the experiment, there were high rainfall amounts, above all in the months of December and January (Fig. 1). This fact led to greater vegetative development, thus resulting in greater plant height, greater height of the lowest pod, and, consequently, greater lodging. For lodging, results were obtained following the scoring scale suggested by [12], which show that the cultivar BRS/MG 750 SRR was that which showed greatest lodging, with a mean score of 3.08, i.e., it showed from 25 to 50% of lodged plants. The other cultivars obtained mean scores which ranged from 1.16 to 1.50, which indicates some lodged or slightly lodged plants. According to [24], lodging directly affects harvester performance since lodged plants mean losses in grain yield as the grains are unable to be harvested, as well as possible losses due to direct contact of the soil with the pods and the emergence of fungi and pests. Lodging is a characteristic which is greatly affected by soil type and by plant development conditions. In general, soybean plants show greater lodging in fertile and heavy soils with abundant moisture than in light and sandy soils. Another point to be considered is in regard to plant height; normally, high plants may lead to a greater lodging rate since they have finer stems and are subject to falling over through wind activity [19].

Table 2. 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	SM				
		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; DF - degree of freedom; QM - Square means*

Table 3. 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

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

4. CONCLUSION

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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. CONAB. Monitoring Brazilian crop: Grains, ninth survey in June 2015. National Supply Company, Brasília. 2015;104.
2. Zuffo AM, Zambiazzi EV, Gesteira, G de S, Rezende PM de, Bruzi AT, Soares IO, Gwinner R, Bianchi MC. Agronomic performance of soybean according to stages of development and levels of defoliation. Afr. J. Agric. Res. 2015;10(10): 1031-1042.
   Available:http://dx.doi.org/10.5897/AJAR2014.9369
3. Unifertil - Universal de Fertilizantes S.A. Nutrientes: Do Que As Plantas Precisam? 2012;1–10.
   Available:http://www.unifertil.com.br/admin/files/rc20121011151121.pdf (Accessed 30 April 2014).
4. Ahrens S. Soybean production technology central Brazil 2007 correction and maintenance from soil fertility. London, Soy Embrapa. Production System; 2007.
5. Lopes AA. Nitrogen and potassium coverage in soybean in red ultisol, derived from caiuá sandstone. 2007;46f. Thesis (Ms in Agronomy) - University Of West Paulista, Unoeste. Presidente Prudente – SP; 2007.
6. Vilela L, Souza DMG, Martha JR GB. Potassium and micronutrients fertilization. In: Martha Jr Gb, Vilela L, Souza Dmg. Cerrado: Efficient use of lime and fertilizer on pastures. Planaltina, Df: Embrapa Cerrado. 2007;179-188.
7. Oliveira FA, Carmello QAC, HAA Mascarenhas. Availability of potassium and its relations with calcium and magnesium in soybean grown in home-de-vegetation. Sci Agric. 2001;58(2):329-335.
8. EMBRAPA - Brazilian Agricultural Research Corporation. Soy production technologies region Brazil 2005. Central Embrapa Soja. Production System; 2005.
9. Dantas AA, LG Carvalho, Ferreira E. Classification and climate trends in mines, MG. Ciênc. Agrotec. 2007;31(6):1862-1866.
   Available: http://dx.doi.org/10.1590/s1413-70542007000600039
10. Pauletti V. Nutrients: Levels and interpretations. 2 Ed. ABC Foundation for Assistance and Disclosure Technical And Agricultural; 2004.
11. Oak ER, Rao PM, Ogoshii FGA, Botreli EP, Alcantara HP, JP Santos. Soybean cultivars performance [*Glycine max* (L) Merrill] in summer crop in southern Minas Gerais. Ciênc. Agrotec. 2010;34:892-899.
    Available: http://dx.doi.org/10.1590/s1413-70542010000400014
12. Bernard RL. Chamberlain DW, Lawrence RD. Results of the cooperative uniform soybean test. Washington: USDA; 1965.
13. Matos AT. Práticas de manejo e tratamento de resíduos agroindustriais. UFV: EAGRI/DEA. Série caderno didático; 2004.
14. Scott AJ, Knott MA. Cluster analysis method for grouping means in the analysis of variance. Biometrics. 1974;507-512.
15. Ferreira DF. Sisvar: A computer statistical analysis system. Ciênc. Agrotec. 2011;35(6):1039-1042.
    Available: http://dx.doi.org/10.1590/s1413-70542011000600001
16. Pettigrew WT. Potassium influences on yield and quality production for maize, wheat, soybean and cotton. Physiologia Plantarum. 2008;133(4):670-681.
    Available: http://dx.doi.org10.1111/j.1399-3054.2008.01073.x
17. FA Petter, et al. Agronomic performance of soybean doses and potassium application times in Piauí savanna. Rev. Cienc. Agrar. 2012;55(3):190-196.
    Available: http://dx.doi.org10.4322/rca.2012.057
18. Lambert ES, MC Meyer, Klepker D. Cultivar soy 2007/2008 region north and northeast. Embrapa Soja, Document 284; 2007.
19. Rezende PM de, Carvalho E de A. Evaluation of soybean cultivars [*Glycine max* (L.) Merrill] for the Southern of Minas Gerais State. Ciênc. Agrotec. 2007;31(6) 1:616-1623.

Available: http://dx.doi.org/10.1590/s1413-70542007000600003
20. Cartter JL, Hartwig EE. The management of soybean. In: Norman AG. (3d.). The Soybean. New York: [S.N.]; 1967.
21. Valadão Junior DD, Bergamin AC, Fortunate LDR, Schlindwein JA, Caron BO, Schmidt D. Phosphate fertilizer in soybean in Rondônia. Sci. Agrar. 2008;9 (3):369-375.
Available:http://dx.doi.org/10.5380/rsa.v9i3.11537
22. Son Mark J. Soybean production. Campinas: Cargill Foundation; 1986.
23. Guimaraes F. De S, et al. Soybean [*Glycine Max* (L.) Merrill] for summer cultivation in the region of Lavras-Mg. Ciênc. Agrotec. 2008;32(4):1099-1106.
Available: http://dx.doi.org/10.1590/s1413-70542008000400010
24. Shigihara D. Hamawaki OT. Selection of genotypes for juvenility soybean progeny. Rev. Horiz. Cient. 2005;4(1):1-26.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/10151