Influence of Potassium in the cultivation of the grape (*Vitis Labrusca*) cv. Isabella

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Abstract

Potassium (K^+) has an important role in the growth and production of the grape vine (*Vitis Labrusca*). To evaluate the influence of different dosages of Potassium Sulphate (K_2S0_4) in the yield and quality of the grapes harvested. A study was conducted in a cv. Isabella vine yard planted in the farm "El Yundecito", city of Palmira, department of Valle del Cauca, Colombia. The follow-up to the K^+ absorption was conducted through foliar analysis in 4 phenological stages of the cultivation process. The following response variables were evaluated: number of clusters per plant, cluster weight, cluster length, grapes per cluster, Brix graduation and yield. An experiment design of complete batches at random with 3 repetitions and 4 treatments: 0 (reference), 100, 150 and 225 g of K_2SO_4 per plant $^{-1}$. The obtained data were analyzed with the Duncan test, variability test, correlation test and regression test. The results show that the addition of 100g of K_2SO_4 per plant^{-1}, the yield increased in 24% in comparison to the reference. The higher the amount of potassium sulphate applied, the lower the yield decrease. The same situation was applied to the quality variables, which suggests that dosages higher than the analyzed imply unnecessary costs and is unfriendly to the environment.

Keywords: grape; potassium sulphate; nutrition.

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Introduction

Potassium (K^+) is considered the second most important nutrient in terms of demand after nitrogen (Tisdale et al., 1985), which is indispensable in the photosynthesis, enzymatic activation, protein synthesis and osmoregulatory processes (Marschner, 1995); therefore its deficiency can foster susceptibility to fungal attacks and reduce the growth rate (Marschner *et al*., 1986). The cultivation of grapevines (*V. labrusca*) presents a great demand of K^+, especially during the blooming-flowering stages and then by the pea berry- engorging (Hirzel, 2008), a limited availability is seen as little growth of the berries (Garcia, 2006), which reduces yield significantly. For FAO (1998), the efficient management of the nutrition in agriculture, is relevant to keep or augment productivity.

Researchs conducted by Palma (2003) in Chile, show that potassium increases yield, which is a positive correlation between the potassium content in leaves and pecioles with yield, however, it is evident that every time the K^+ is raised, the percentage of increase is reduced in comparison to the previous fertilization dosage; which suggests a nutrient absorption limit that is traduced in a good yield (Puentes *et al*., 2014).

In Brazil, the mineral composition and the export of nutrients in grams (gm) for a 15 ton production batch per hectare (t x ha^{-1}), shows that the most exported nutrient within the fruit is potassium (table 1).

For such motive, the nutrition of the plantation demands a higher amount of potassium in the fertilization programs (Villalba *et al*.,2006), since the extraction of K^+ in the fruit when compared to the other nutrients, shows its influence on the development and quality of the fruit, as affirmed by Gurovich and Herrera (2001), based on the function that the potassium has in the sugar content and the fruit skin serosity, considered as one of the most important elements in the quality of the grape; as well, Martinez *et al*., (2010) affirm that potassium favors the accumulation of soluble solids and increments the color of the grape; in the same manner , Lang (1983), related potassium to the sugar transport to the grapes. Therefore, it is evident, its influence in the grape quality and its contribution to a better yield.

Fieldwork conducted in Ginebra, Valle del Cauca, in a clay-like soil, of neutral pH, medium organic content and B, high K^+, Ca^{++}, Mg^{++}, Cu^{++}, Zn^{++} and P, the application of 150 kg ha^{-1} of potassium using as fertilization source, potassium chlorate and sulfate, increased the yield and improved the fruit's quality (Garcia, 2001), however, higher dosages were not analyzed to evaluate the plantation's behavior with higher and a lower fertilization dosage.

In Valle del Cauca, the nutrition studies for the cultivation of grapevines (*V. labrusca*) cv. Isabella, with scientific rigor are scarce, with the knowledge that nutrition is important to obtain better yields and specially potassium for the cultivation of grapevines. Therefore, this research's objective consisted in determining the potassium sulphate dosage which with the vine when planted in a vertisol-type soil of the flat part of Valle del Cauca, it responds to fertilization, evaluating its influence on yield and quality of the fruit.

Materials and methods

The research was conducted in the "El Yundecito" farm, located in the rural area of Guanabanal, city of Palmira, Valle del Cauca; at an altitude of 850m. The zone presents an annual precipitation rate of 900mm, an average temperature of 24°C and a relative humidity of 60% (Carbonell *et al*., 2001).

The vegetal material consisted of grapevines (*Vitis labrusca* L. cv Isabella with 3.5 years of age and grafted upon agraz (*Vitis titiaefolia* H.B.K.), used as reference for the Isabella grape variety in Valle del Cauca due to its rusticity and phytosanitary resistance, it is recommended as reference in commercial plantation of grapevines (Collazos, 2000). The plants are located in a 2.7 x 2.5 m grid, in a terrain with a homogeneous physical and chemical characteristics, for a density of 1.481 plants per hectare.

Table 1. Nutrient extraction per hectare a 15 metric ton production

Nutrient extraction (g)												
N	P	K^+	Ca^{2+}	Mg^{2+}	S^{2+}	B	Cl^-	Cu^{2+}	Fe^{2+}	Mn^{2+}	Mo	Zn^{2+}
875	292	1890	95	95	173	2.1	8	0.6	3	2.5	3	0.5

Source: Hiroce *et al*.. 1979

The soil was evaluated at the beginning of the research. For that purpose, a clay mineralogy study at the IGAC, "Instituto Geografico Agustin Codazzi", which showed a predominance of 46% 2:1 clay, mainly vermiculite, followed by montmorillonite, and classified taxonomically within the order of the vertisles. Besides, the physical and chemical properties of the soil, through standard methods available at the CORPOICA laboratory and interpreted with the fifth approximation. (ICA, 1992); the soil was sampled at a 40 cm depth and with a complete soil analysis, it was compared to the adequate parameters needed to cultivate grapevines (Galindo, 2006), which permitted the application of the proper and necessary correctives to avoid a nutritional imbalance in the cultivation and physical limits. The analysis showed a 7.2 ph value (neutral); low organic matter content (1.64%), a 1.52 $dS.m^{-1}$ electric conductivity, which a very susceptible soil to salt content, high content of P (66.38 mg kg^{-1}), K^{+} (0.53 C mol (+) kg -1), Mg^{+2} (9.97 Cmol (+) kg^{-1}), Ca^{+2} (28.87 Cmol (+) kg^{-1}) and high CIC (36.34 Cmol (+) kg^{-1}), as a desirable condition for the plants, originated by the vermiculite and montmorillonite according to the mineralogy analysis; it is low for N^{++}(0.17C mol (+) kg^{-1}) ; and presents limited availability of minor elements due to the pH conditions; texture (loamy, argillaceous, frank soil), effective depth (80 cm); and apparent density (1.70 $Mg.m^3$), which reveals a corroborated possible compaction with the hydraulic conductivity data of 0.65 cm/hour and porosity of 30%; however, this soil does not limit the development of the system of grape production.

The treatments (table 2) were established in compliance with the work done by Galindo (2006) in the Tropical Wine Research Center (Ceniuva) for Valle del Cauca. The source of potassium used was potassium sulfate (K_2 SO_4: (0-0-50-18S), with no application for the reference sample, (100 $g/plant^{-1}$ for treatment 2.50% more for treatment 3,150 $g/plant^{-1}$ and 50% more for the fourth treatment, 225$g/plant^{-1}$). These dosages were fractioned in 3 equal parts, to be applied on three different phenological stages of the vine's growth process, of four, that comprise the representative phases that occur in the plant from the moment of pruning for production. (Puerto *et al*., 2003). The first application was effectuated in rest period; 20 days after the pruning (DAP), the second, in pre-floration, 20 days after pruning (DDP) and the third in the filling of the fruit, 60 DDP, as suggested by Galindo (2006).

Table 2. Treatment description

Treatment	Applied fertilizer per plant (g)
	(g) Potassium Sulphate [k_2SO_4]
T1	0
T2	100
T3	150
T4	225

To monitor the potassium absorption in the plant for the effect of each treatment, foliar sampling was conducted 10 days after fertilization, in 4 phenological stages, prefloration (30 DDP) corresponding to the phenological stage 1 in the BBCH scale for grapevine (Lorenz et al.,1994), in this sense, curdled (45 DDP) and filling (70 DDP) correspond to the stage 7, and veraison (90 DDP) to the stage 8; the sampling kept the method from the AL Laboratory (2011), which consists of picking 50 opposite leaves to the grape cluster at random from the whole plant; the potassium content was determined following the standard procedures at *Providencia* laboratory. To evaluate the influence of the different treatments on the overall yield and quality of the grape, a Complete Random Batch experiment design with 4 treatments and 3 instances per treatment. The experimental unit consisted of 20 grape vine plants, from which, 6 were the data source to avoid the border effect.

Finally, the yield was determined with the total harvest weight by treatment of the Extra, 1st and 2nd grade grape according to the technical Colombian code NTC 5321 (2004) without including the rejected grape; the grape quality was evaluated with the same technical code, for which, the following variables were determined: number of clusters per plant, cluster weight, cluster length, number of berries per cluster and soluble solid content, represented in Brix grading.

The results were analyzed through variance analysis (ANOVA), Duncan comparison tests, correlations and regressions, with the statistical package SPSS 20 (IBM, 2011).

Results and discussion

The potassium content in the leaves due to the treatments applied, phenological stage and interaction treatment*stage, showed highly significant differences (table 3), in which a clearly defined influence of the potassium dosages on the vine, as suggested by Palma (2003).

Table 3. Variance analysis summary for variable potassium in leaves

Variation Source	K^+ CONTENT IN LEAVES
Stage	0.000**
Treatment	0.000**
Stage * Treatment	0.000**

* Significant variations (p<0,05); **Highly significant variations (p<0,01); NS, Non significant.

The content of potassium in the leaves, as response to the application of K_2SO_4 to the ground as treatment according to each phenological stage of the grapevine cultivation (*V. labrusca*) cv. Isabella, are shown in figure 1.

The notorious difference between T1 (4.18%) and the remaining treatments in the preflowering, shows the absorption capacity of the plant, after increasing the availability of the nutrient in the soil, however, this capacity is relevant until T3 (6.39%), after that value, the potassium content in leaves, starts to decrease, as it occurs in the Cocoa cultivation process (Puentes *et al*., 2014).

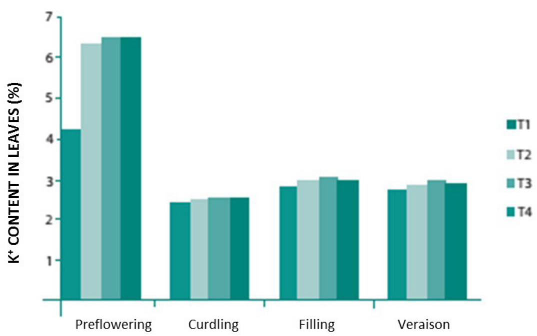

Figure 1. K^+ content in grapevine leaves in each phenological stage and treatment influence.

The preflowering stage shows the importance of the leaf potassium content, which suggests the importance of fertilization, previous to the flowering, for a proper nutrition of the grapevine. In the following phenological stages, even though highly significant differences (p<0. 01), a generalized tendency is to present less potassium in leaves, when compared to the preflowering. The curdling stage presents the least amount of potassium of the 4 stages evaluated, the contents sorted by treatment from lowest to highest: T1(2.45%), T2 (2.48%), T3 (2.51%) and T4 (2.54%). The filling stage coincides with the fertilization event, this evidences a slightly higher content of potassium, especially on the treatments fertilized in this manner: T1 (2.80%), T2 (2.97%), T3 (3.04) and T4 (2.97%). Finally, in the veraison stage, another decrease in the potassium content is registered: T1 (2.73%), T2 (2.85%), T3 (2.94%) y T4 (2.87%); which is consequent with the strenous demand of potassium in the flowering and ripening of the fruit (Hirzel, 2008; Hidalgo, 2002).

According to the variance analysis, the yield showed highly significant differences (p<0. 01) with the potassium sulphate dosage, as well as the quality variables of the fruit except Brix grading, which showed significant differences (p<0. 5) (Table 4).

The best yield was presented in the T2 and the lowest in the T1, however, it must be denoted that after T2, the yield is depressed. Similar results were found in sugar cane, in which after 120 kg.ha^{-1} of $K_2 0$, the yield diminishes. (Rasche *et al*., 2012). It is corroborated in such manner that each cultivation presents an absorption limit, as Puentes *et a*l., 2014; that the plant absorbs a higher amount of the nutrient, does not imply that the yield will increase.

Table 4. Treatment incluence response variables

Fruit quality variables						
Treatments	Yield (t*ha-¹)	Clusters per plant (#)	Weight per cluster (g)	Length of cluster (cm)	Brix grades (%)	Berries per cluster (#)
T1	19^d	124^d	100.4^c	9.37^c	12.2^a	28.6^d
T2	23^a	152^a	102.4^a	9.44^b	12.2^a	29.0^b
T3	22^b	148^b	98.4^d	9.46^a	12.0^{ab}	28.8^c
T4	20^c	131^c	101.7^b	9.43^b	11.9^b	29.3^a

Values within the same column with same letter, do not differ statistically (p<0,05), according to duncan test

The average production in Valle del Cauca is 16 t.ha^{-1} per year (MADR et al, 2006), the T2 exceeded this average in a 43%, showing clearly the influence of potassium, which in difference from Rasche *et al*., (2012), who assure that the application of potassium does not affect the production of sugar cane as well as the Brix grading, it is evidenced in their data that there is a decrease in the yield and Brix grading when more potassium was applied.

Regarding quality variables, the number of clusters per plant was between 124 and 152 in extra category (NTC 5321), this meaning 183 to 225 thousand clusters per hectare, which is considered a high number of clusters per plant (Puerto *et al*., 2003). The variables: number of clusters per plant and cluster weight presented their higher value in T2, the product of these corresponds to yield, being the highest in T2.

The variable cluster length presented its higher value in T3 and the lowest in T1; berries per cluster presented its highest in T4 and lowest in T1, and regarding Brix grading, the highest value presented for T1 and T2, the lowest in T4, which shows that the depression of Brix grading with the increase in potassium dose, as it happens with sugarcane from the application levels of 120 kg.ha^{-1} of K20 (Rasche *et al*., 2012).

The Pearson correlations show a highly significant positive correlation (p<0.01), between the number of clusters per plant and the length of the cluster with the yield, however, although an association with both variables, the variable number of clusters per plan, was the one with the highest value (152) consequently with the highest yield (23 t.ha^{-1}) in T2 (Table 5).

Table 5. Pearson´s correlations between quality variables and yield

	RESPONSE VARIABLES				
	Clusters per plant	Weight per cluster	Length of cluster	Brix grades	Berries per cluster
Yield	0.983**	0.141**	0.775**	0.098^{NS}	0.229^{NS}

**Correlations significant at 0,01 level, *Correlation is significant at 0,05 level, NS non significant correlations

The lineal regression between yield and the number of clusters per plant indicates a positive relation; meaning that, as the number of clusters increases, yield increases (figure 2). The correlations between the yield and the potassium content in each of the phenological stages, show a highly significant positive correlation for the preflowering stages (0.781) and filling (0.725); significant for the veraison (0.632) and non-significant for the curdling, which evidences that the application of potassium sulphate in the preflowering and veraison stage is of great relevance for the increase in yield, due to its large potassium requirements, as suggested by Hirzel (2008).

Conclusions

The application of potassium sulphate had an influence on the cultivation yield of the grapevine (*V. labrusca*) cv Isabella and the quality variables, evidencing that a lower nutritional doses lower and higher than 100gm. plant^{-1} of potassium sulphate, decreases the yield, as well the importance to fertilize in stages previous to flowering.

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