Effect of Potassium Fertilization on Yield, Quality and the Mineral Composition of Leaves of Apricot (*Prunus armenica* L.)

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ABSTRACT

Apricot *cv*. Hacihaliloglu (*Prunus armenica* L.), which is consumed fresh as well as dry, is widely grown in the environs of Malatya with a very special economic value. Regarding its production from the field to the market, variety of agricultural practices take place among which nutrition needs particular emphasis as in other crops. In fact, production and quality can be controlled by the application of right techniques at right time, which is very significant to prevail a consistent position on the world as a prime producer country.

The current project is conducted to determine the potassium fertilization program of apricot of the mentioned cultivar and the area in two years. Four enhanced doses of potassium were applied in Randomized Block Design with four replications. The doses were arranged according to the soil potassium content and were control, 600, 1200, 1800 g K_2O tree^{-1}. Nitrogen and phosphorus were given in constant amounts. Leaf and fruit nutrient elements, yield and some quality parameters were examined.

Results showed that leaf and fruit nutrient element contents were generally increased with enhanced potassium doses, the first year leaf K and fruit Mg, Zn and the second year leaf N, K, Fe were statistically significant. Yield data were showed a significant increasing trend parallel to the enhanced doses in the second year.

In order to calculate the K requirement of an apricot tree with K requirement for a target yield of 200 kg tree^{-1}, the equation "y=2040.2-4.0803x" is put forth. In this regard, "x" stands for available K in the soil and "y" for the amount of K_2O that will be given. In the case of expected yield above or below 200 kg tree^{-1}, 50 g K_2O must be added or disregarded for each of 10 kg from the calculated amount.

Key Words: Potassium, fertilizer recommendation, apricot, *Prunus armenica* L., nutrient elements

1. Introduction

Turkey has a great potential to produce many different kinds of fruits as a result of the wide variety of soil and environmental conditions. Apricot (*Prunus armenica* L.) is one of them by 200 to 350 thousand ton yearly production. Turkey is the prime producer of apricot in the world. Apricot used to be produced in Turkistan, Middle Asia and China five thousand years ago and its agriculture started in Anatolia Fourth Century BC (Asma, 2000). Today the main

production center in Turkey is Malatya and its environs, the eastern part of the country. 73 % of the apricot trees in Malatya region is covered by *cv*. Hacihaliloglu. This region produces 50 % of the production of which 90% is dried and the majority exported (Eryuce et al, 2001).
Fertilization is significant one of the cultural practices for the agricultural production. In order to prepare fertilizer program, soil properties are as important as the cultivar and environmental conditions. Generally N, P and K are taken into consideration to prepare the program. Potassium has a special place in it because of its effects on the quality parameters, stress coping and yield. The K content of apricot leaf is reported to vary from 2.26-4.28 % by Guleryuz et. al. (1995) for the Salak and from 2.13-3.31 % by Eryuce et. al. (2002) for Hacihaliloglu varieties. Aksoy et. al. (1995) discovered that leaf K content change between the years as do the N, Ca and Mg. Das (1998) searched the relations between leaf and soil and uptake amounts for the same variety in this region.
The objective of the study was to investigate the potassium fertilizer recommendation of this locally grown worldwide famous fruit's based on leaf, fruit and soil analyses in the two experimental years.

2. Material and methods

The materials of the experiment were 2 soil samples taken from two depths (0-30; 30-60 cm), 32 yield measurements, 32 leaf and 32 fruit samples representing two of the experiment years. The orchard was 21-year-old and the potassium doses applied were control, 600, 1200 and 1800 g tree^{-1} K_2O (K_0, K_1, K_2, K_3). Potassium content in the volume of 60 cm soil depth for each tree was calculated by taking into consideration the results of the soil analyses and this amount (160 g tree^{-1} K_2O) was subtracted from the experimental doses to calculate the amount to the applied. Potassium source was potassium sulfate (K_2SO_4) and applied in autumn, accompanied with phosphorus as 800 g tree^{-1} triple super phosphate. The first portion of nitrogen was incorporated in the spring as 1280 g tree^{-1} in the form of ammonium sulfate and the second part was applied before the first irrigation as 490 g tree^{-1} in the form of ammonium nitrate.

Nitrogen fertilizers were applied by broadcasting under the canopy, phosphorus and potassium fertilizers were banded around the canopy nearly in 30 cm depth.
Soil samples collected around from the canopies before the experiment set up as a mixture of two of the depths each.

At the harvest, fruit samples (early July), at the end of the harvest (late July) leaf samples were collected and yield was measured.
Soils were examined for their physical and chemical properties. Nutrient of the dried leaves and fruits were analyzed. Moreover, some physical and chemical characteristics of the fruits were also determined. On the other hand, in the second year fruit nutrient elements were not analyzed since it was a low productive year (Kacar, 1972).

The data were statistically analyzed to determine the effects of potassium rates (Acıkgoz, et. al., 1993). Depending upon the data, an equation and a graphic were obtained to use for the K fertilizer recommendations.

3. Results and Discussion

The orchard soil was moderately alkaline, clay loam in texture, very rich in $CaCO_3$ and had no salinity problem, the organic matter, total N, available Cu and Mn were sufficient, available Ca and Mg high, available Fe medium in both of the soil layers. The available P high, K sufficient in the top 30 cm, poor and medium respectively in the second layer (Table-1). Uslu et. al., (1995) carried out an experiment around Malatya on the apricot orchards. The authors investigated similar results and reported that the soil physical and chemical properties of the representing area were suitable for apricot production.

Table-1. Initial characteristics of the experimental soil

Soil Properties	Unit	Results		Evaluation	
		First Depth (0-30 cm)	**Second Depth (30-60 cm)**	**First Depth (0-30 cm)**	**Second Depth (30-60 cm)**
pH		7.91	7.89	Moderately alkaline	Moderately alkaline
Total Soluble Salt	%	0.060	0.069	No salinity problem	No salinity problem
$CaCO_3$	%	33.42	30.65	Very rich	Very rich
Sand	%	41.44	37.44		
Silt	%	40.00	32.00		
Clay	%	28.56	30.56		
Texture		Clay loam	Clay loam		
Organic Matter	%	3.60	2.32	Sufficiency	Sufficiency
Total N	%	0.204	0.112	Sufficiency	Sufficiency
Available P	mg kg^{-1}	11.90	1.02	High	Poor
Available K	mg kg^{-1}	255	180	Sufficiency	Medium
Available Ca	mg kg^{-1}	5760	5940	High	High
Available Mg	mg kg^{-1}	760	1380	High	High
Available Fe	mg kg^{-1}	4.2	3.6	Medium	Medium
Available Cu	mg kg^{-1}	2.3	1.7	Sufficiency	Sufficiency
Available Zn	mg kg^{-1}	1.4	0.4	Sufficiency	Insufficiency
Available Mn	mg kg^{-1}	19.3	12.8	Sufficiency	Sufficiency

Leaf nutrients were in the reference ranges given for the variety Hacihaliloglu in Malatya Region in both of the experimental years. Iron contents were around the lower, and Zn contents higher levels of the references (Table-2, Table-3). Compared to the other experiment results (Das, 1998), leaf N contents (2.4-3.0 %), leaf K contents of control and K_1 doses (2.5-3.0 %) and leaf Fe contents (100-250 mg kg^{-1}) were under however leaf Ca contents (1.20-2.50 %) over the findings for the same variety.

The effect of the enhanced K doses increased the entire leaf nutrient in different levels in the first experimental year (Table-2). Nitrogen and K tendencies were more evident then the others and K data have shown a significant relation at 1% level (Table-7).

As for the second year, the trends of the leaf nutrient elements were similar excluding P and Mg. Phosphorus was in the same level in all of the doses, Mg was the same in the first two doses but slightly decreased in the last two (Table-3). The increases in N, K, Fe and Cu with the increasing K rates were also statistically significant at 1% level (Table-8).

Table -2. Leaf nutrients in the first year

Rates	%					mg kg^{-1}			
	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
K_0	1.960	0.14	2.29	2.68	0.44	73.63	7.00	23.20	46.20
K_1	1.983	0.14	2.47	2.69	0.45	75.73	7.05	23.53	46.88
K_2	2.038	0.15	2.60	2.69	0.46	75.28	7.15	23.45	46.80
K_3	2.050	0.15	2.90	2.69	0.45	75.70	7.20	23.70	46.80
Min.	**1.960**	**0.14**	**2.29**	**2.68**	**0.44**	**73.63**	**7.00**	**23.20**	**46.20**
Max.	**2.050**	**0.15**	**2.90**	**2.69**	**0.46**	**75.73**	**7.20**	**23.70**	**46.88**
Mean	**2.008**	**0.14**	**2.56**	**2.69**	**0.45**	**75.08**	**7.10**	**23.47**	**46.67**
Reference* Values	**1.466**	**0.110**	**2.134**	**2.030**	**0.343**	**72.0**	**5.8**	**10.0**	**38.0**
	2.521	**0.173**	**3.309**	**3.093**	**0.622**	**160.0**	**12.1**	**24.0**	**75.1**

*Eryuce et al, 2002

Table -3. Leaf nutrients in the second year

Rates	%					mg kg^{-1}			
	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
K_0	1.952	0.14	2.29	2.60	0.45	76.06	6.78	22.31	45.99
K_1	1.978	0.14	2.46	2.63	0.45	78.88	7.20	22.86	47.55
K_2	2.018	0.14	2.65	2.62	0.44	78.66	7.28	22.94	48.01
K_3	2.026	0.14	2.85	2.62	0.44	78.73	7.58	22.93	48.14
Min.	**1.952**	**0.14**	**2.29**	**2.60**	**0.44**	**76.06**	**6.78**	**22.31**	**45.99**
Max.	**2.026**	**0.14**	**2.85**	**2.63**	**0.45**	**78.88**	**7.58**	**22.94**	**48.14**
Mean	**1.994**	**0.14**	**2.56**	**2.62**	**0.45**	**78.08**	**7.21**	**22.76**	**47.42**
Reference* Values	**1.466**	**0.110**	**2.134**	**2.030**	**0.343**	**72.0**	**5.8**	**10.0**	**38.0**
	2.521	**0.173**	**3.309**	**3.093**	**0.622**	**160.0**	**12.1**	**24.0**	**75.1**

*Eryuce et al, 2002

Results showed that fruit nutrients were in the reference ranges' excluding Fe which was seriously under the ranges, P a bit higher excluding the control dose and Mg a bit lower only in the control dose (Table-4). However Das (1998) have found the fruit Fe contents for the same variety for the same region in between 12-87 mg kg $^{-1,}$ which confirms results of the present study.

All of the examined fruit nutrients increased in different levels compared to the control treatment. This tendency was consistent and statically significant (1%) in K (Table-7). Nitrogen and Zn contents were stable at the last two doses (K_2, K_3) and Zn was statically significant at 5% level. Phosphorus, Ca, Mg and Mn contents similarly showed a very small increase compared to the control and no change occurred in their contents in all of tree of the potassium treatments. The nutrient content of fruits is significant as do the fruit organic compounds in human diet. Apricot, especially dried one has a special place in the human nutrition with its high K content. It is reported that 100 g dried apricot contains 979 and 1378 mg K (Yucecan, 1994 and Yildiz, 1994). Potassium fertilization on fruits could explain the affirmative effect.

Table -4. Fruit nutrients in the first year

Rates	%					mg kg^{-1}			
	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
K_0	0.363	0.08	1.53	0.07	0.04	16.70	6.33	7.15	6.25
K_1	0.375	0.09	1.59	0.08	0.05	17.28	6.78	7.55	6.48
K_2	0.380	0.09	1.66	0.08	0.05	17.40	7.00	7.65	6.48
K_3	0.380	0.09	1.82	0.08	0.05	17.13	6.88	7.65	6.48
Min.	**0.363**	**0.08**	**1.53**	**0.07**	**0.04**	**16.70**	**6.33**	**7.15**	**6.25**
Max.	**0.380**	**0.09**	**1.82**	**0.08**	**0.05**	**17.40**	**7.00**	**7.65**	**6.48**
Mean	**0.374**	**0.09**	**1.65**	**0.08**	**0.05**	**17.13**	**6.74**	**7.50**	**6.42**
Reference* Values	**0.33**	**0.04**	**1.40**	**0.06**	**0.05**	**27.00**	**4.40**	**5.00**	**3.00**
	0.87	**0.08**	**2.11**	**0.12**	**0.12**	**98.00**	**16.00**	**12.00**	**11.00**

*Eryuce et al, 2002

Yield results were reflected the unfavorable climatic conditions of the second year. The mean value was 218 kg tree^{-1} in the first experimental year (Table-5) but in the second year decreased to 74 kg tree^{-1} (Table-6) as a result of stress conditions.

Regarding K treatments yield increased in the first year up to K_1, in the second year up to K_2 rate and the second year results were statistically significant (1%) in the relation with the treatments (Table-8).

Fruit pomological properties were in between the ranges compared with the reference values of the same variety in this region except fruit weight in three of the K treatments and total soluble solids in the K_2 treatment of the second year which were over then those values. Year and stress effects have seen on the fruit measurements (except titratable acidity) and all the parameters were higher in the second year contrary to that of the yield.

The result of the some related studies regarding the fruit measurements showed that the lowest and the highest fruit weights were between 24.3-66.9 g, seed weight 3.38-3.77 g, total soluble solids 8.93-26.8 %. The results obtained in this experiment were in between these specified ranges (Yalcinkaya et. al., 1995; Ayanoglu et. al., 1995; Paydas et. al., 1995).

First year pomological measurements did not show significant relation with the treatments with the exception of total soluble solids which was significantly (1%) the highest in the K_1 rate (Table-7).

Table -5. Yield and fruit measurements in the first year

Rates	Yield (kg tree^{-1})	Fruit Weight (g)	Seed Weight (g)	Total Soluble Solids (%)	Firmness (kg cm^{-2})	Titratable Acidity (%)	Fruit Volume (cm^3)
K_0	206	30.15	2.12	19.50	5.60	0.42	25.93
K_1	233	25.98	1.85	22.75	4.58	0.47	24.70
K_2	206	26.69	2.16	18.95	5.48	0.43	27.75
K_3	227	29.90	2.06	18.37	5.50	0.45	25.50
Min.	**206**	**25.98**	**1.85**	**18.37**	**4.58**	**0.42**	**24.70**
Max.	**233**	**30.15**	**2.16**	**22.75**	**5.60**	**0.47**	**27.75**
Mean	**218**	**28.18**	**2.05**	**19.89**	**5.54**	**0.44**	**25.97**
Reference* Values	**-**	**20.14**	**-**	**15.70**	**2.68**	**0.27**	**18.66**
	-	**34.73**	**-**	**27.10**	**7.15**	**0.78**	**32.66**

*Eryuce et al, 2002

In the second year, fruit measurements showed higher contents compared to that of the control treatments except firmness. The mentioned variations were not systematic but the variations of seed weight; total soluble solids, firmness, acidity and fruit volume by treatments were statistically significant in 1% level each (Table-8).

Table -6. Yield and fruit measurements in the second year

Rates	Yield (kg tree^{-1})	Fruit Weight (g)	Seed Weight (g)	Total Soluble Solids (%)	Firmness (kg cm^{-2})	Titratable Acidity (%)	Fruit Volume (cm^3)
K_0	59	33.66	2.24	24.25	5.55	0.43	32.00
K_1	68	37.60	2.56	25.00	4.55	0.44	38.00
K_2	85	35.96	2.38	27.50	3.39	0.50	35.00
K_3	85	36.14	2.44	26.00	5.50	0.46	35.25
Min.	**59**	**33.66**	**2.24**	**24.25**	**3.39**	**0.43**	**32.00**
Max.	**85**	**37.60**	**2.56**	**27.50**	**5.55**	**0.50**	**38.00**
Mean	**74**	**35.84**	**2.40**	**25.69**	**4.75**	**0.46**	**35.06**
Reference* Values	**-**	**20.14**	**-**	**15.70**	**2.68**	**0.27**	**18.66**
	-	**34.73**	**-**	**27.10**	**7.15**	**0.78**	**32.66**

*Eryuce et al, 2002

Table -7. LSD test results of the first year data

Rate	Leaf K	Fruit K	Fruit Zn	Total Soluble Solids
K_0	2.285 **d**	1.525 **d**	7.150 **b**	19.500 **b**
K_1	2.470 **c**	1.590 **c**	7.550 **a**	22.750 **a**
K_2	2.595 **b**	1.662 **b**	7.650 **a**	18.945 **b**
K_3	2.898 **a**	1.823 **a**	7.650 **a**	18.375 **b**
LSD (0.01)	0.099	0.030	-	2.219
LSD (0.05)	-	-	0.348	-

Figures followed by the same letter in a column are not significantly different

Table -8. LSD test results of the second year data

Rate	Leaf				Yield
	N	K	Fe	Cu	
K_0	1.952 **b**	2.285 **d**	76.063 **b**	6.775 **c**	58.500 **b**
K_1	1.978 **b**	2.460 **c**	78.875 **a**	7.200 **b**	68.250 **ab**
K_2	2.018 **a**	2.648 **b**	78.663 **a**	7.275 **b**	85.000 **a**
K_3	2.026 **a**	2.853 **a**	78.725 **a**	7.575 **a**	84.750 **a**
LSD (0.01)	**0.027**	**0.054**	**1.622**	**0.243**	**19.167**

Rate	Seed Weight	Total Soluble Solids	Firmness	Acidity	Fruit Volume
K_0	2.240 **c**	24.250 **d**	5.550 **a**	0.430 **c**	31.875 **c**
K_1	2.555 **a**	25.175 **c**	4.550 **b**	0.440 **c**	38.000 **a**
K_2	2.375 **b**	27.750 **a**	3.390 **c**	0.500 **a**	35.000 **b**
K_3	2.443 **b**	25.825 **b**	5.495 **a**	0.462 **b**	35.250 **b**
LSD (0.01)	**0.079**	**0.598**	**0.574**	**0.020**	**1.429**

Figures followed by the same letter in a column are not significantly different

Nitrogen, P, and K total content of the leaves of all of the treatments were in between the reference ranges and increased with the K doses since excluding P in the second year, N and K contents increased (Table-9). The N percentage in the total N, P, K was higher than the references in K_0 and K_1 but increased K doses to K_2 and K_3 this ratio decreased in between the ranges in the both of the experimental years. Phosphorus nearly showed a similar trend and K an opposite. The balances of the each nutrient came close to the reference ranges as the K doses increased.

Table -9. Nitrogen, P, K total content and their ratio in the leaves

Year	Rates	Leaf (%)				Ratio		
		N	P	K	Total	N	P	K
First	K_0	1.960	0.14	2.29	4.39	44.65	3.19	52.16
	K_1	1.983	0.14	2.47	4.59	43.17	3.05	53.78
	K_2	2.038	0.15	2.60	4.79	42.56	3.13	54.30
	K_3	2.050	0.15	2.90	5.10	40.20	2.94	56.86
Second	K_0	1.952	0.14	2.29	4.38	44.55	3.19	52.26
	K_1	1.978	0.14	2.46	4.58	43.21	3.06	53.74
	K_2	2.018	0.14	2.65	4.81	41.97	2.91	55.12
	K_3	2.026	0.14	2.85	5.02	40.39	2.79	56.82
Reference Values*		**1.466**	**0.110**	**2.134**	**3.710**	**39.51**	**2.97**	**57.52**
		2.531	**0.173**	**3.309**	**6.003**	**42.00**	**2.88**	**55.12**

*Eryuce et al, 2002

Regarding the K, Ca, Mg total contents of the leaves results showed that, all of the treatments were in between the reference ranges, but increased with the K doses as a result of increasing amounts of each like in the above mentioned ratios for N, P, K (Table-10). The ratio came closer to the reference ranges as K doses enhanced.

In a study on the nutrition of figs, K applications over 150 g per tree together with constant amount of N, P and Mg caused an imbalance in K, Ca, Mg ratio, getting away from the optimal values (Eryuce et al, 1995) however it was inside in the lover doses. The present and above mentioned studies showed that increased amount of K affect leaf nutrient ratios and to keep it in proper rate balanced fertilization programs are essential.

Table-10. Potassium, Ca, Mg total content and their ratios in the leaves

Year	Rates	Leaf (%)				Ratio		
		K	Ca	Mg	Total	K	Ca	Mg
First	K_0	2.29	2.68	0.44	5.41	42.33	49.54	8.13
	K_1	2.47	2.69	0.45	5.61	44.03	47.95	8.02
	K_2	2.60	2.69	0.46	5.75	45.22	46.78	8.00
	K_3	2.90	2.69	0.45	6.04	48.01	44.54	7.45
Second	K_0	2.29	2.60	0.45	5.34	42.88	48.69	8.43
	K_1	2.46	2.63	0.45	5.54	44.40	47.47	8.12
	K_2	2.65	2.62	0.44	5.71	46.41	45.88	7.71
	K_3	2.85	2.62	0.44	5.91	48.22	44.33	7.45
Reference Values*		**2.134**	**2.030**	**0.343**	**4.507**	**47.35**	**45.04**	**7.61**
		3.309	**3.093**	**0.622**	**7.024**	**47.11**	**44.03**	**7.86**

*Eryuce et al, 2002

As can be seen from Table-5 and Table-6, the highest yield was obtained in the first experimental year in the K_1 dose but in the second year under the stress conditions in the K_2 dose. The treatments were 440 and 1040 g tree K_2O for K_1 and K_2 doses respectively by disregarding the soil K_2O content where K content of the soil upper layer was 255 mg kg^{-1}. The upper limit of the soil K was recognized as 500 mg kg^{-1}. Based on the above results 1000 g K_2O $tree^{-1}$ was taken into consideration to fertilizer recommendation. In order to calculate the K requirement for Hacihaliloglu variety apricot tree for a target yield of 200 kg, the equation "y=2040.2-4.08x" is put forth. In this regard, "x" stands for available K in the soil and "y" for the amount of K_2O that will be given (Figure-1). In the case of expected yield above or below 200 kg $tree^{-1}$, 50 g K_2O must be added or disregarded for each of 10 kg from the calculated amount. Das, (1998) reported that the potassium (K) content of a 100 kg apricot yield is 399 g. However, nutrient elements, their relations and the environmental conditions have to be taken into consideration as do the soil analyses to prepare the fertilizer recommendation. Uslu et. al., (1998) recommended 1600 g $tree^{-1}$ K_2O for the optimum yield, quality and vegetative growth depending upon two years experimental data for the 15- year-old Hacihaliloglu variety.

4. Conclusion

Results revealed that enhanced K applications increased the leaf and fruit nutrient elements, yield and some fruit measurements in apricot trees of which many of them were statistically significant.

Examined parameters like some leaf nutrients, yield and fruit measurements were different in two of the experimental years, which could be explained by the inconvenient climatic conditions. However the effect of K fertilization was clearer under the stress condition compared to the normal conditions, many of which were statistically significant.

The balance of the leaf nutrient elements in N, P, K and K, Ca, Mg came closer to the reference ranges for the region by the enhanced K doses.

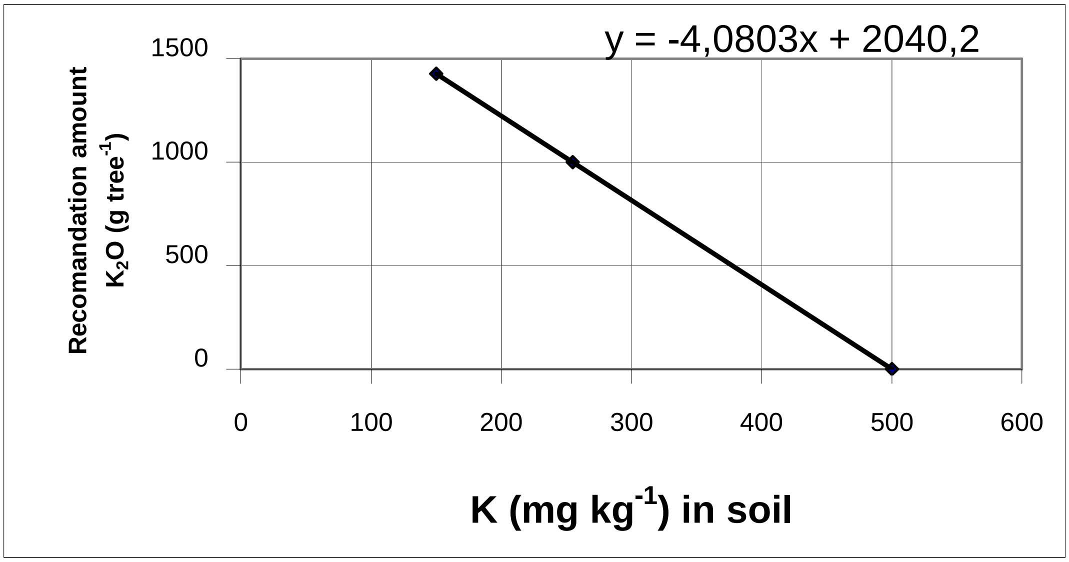

Figure-1. The equation and graphic to determine the amount of the potassium fertilizer

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