Solutions for human progress

Specialty Plant Nutrition **experts**

GET TO KNO_3W

POTASSIUM NITRATE IN BANANA

+Rendimiento

- Mayor rentabilidad
- Más cajas por ha

+Calidad

- Racimos de mayor peso
- Más manos por racimo
- Más frutas por racimo
- Pseudotallo más grueso

SQM

Specialty Plant Nutrition **experts**

GET TO KNO$_3$W

POTASSIUM NITRATE IN BANANA

Introduction

SPECIALTY PLANT NUTRITION EXPERTS **BANANO**

KNO_3 ensures efficient uptake of plant nutrients

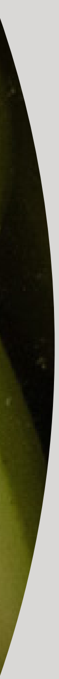
SQM agronomists are problem solvers who deliver results in terms of higher crop yield, better product quality, and lower crop losses. They design fertilization programs that follow the nutrient uptake curve of the crop throughout its entire growth cycle. The programs can be applied with granulated or prilled fertilizers, or with well-balanced recipes of nutrient solutions for fertigation. The result is a greater efficiency in nutrient absorption, less risk of nutrient leaching, and a N to K ratio that will meet the plants' need in each phenological phase of the crop.

SQM agronomists understand the importance of correct nutrient source selection. For example, nitrogen is applied primarily as fast acting nitric nitrogen to ensure N uptake and energy efficient metabolism in the leaf, particularly under cooler growing conditions. Additionally nitric nitrogen facilitates uptake of cations like potassium, calcium and magnesium. Nitric nitrogen is also a preferred source of N in crops grown under saline conditions, since nitrate counteracts chloride uptake by the plant.

When choosing the K source, SQM agronomists develop fertilization programs that limit the amount of potassium sulfate application to the sulfate demand of the crop, to prevent an excess of sulfate accumulating in the soils. This prevents the accumulation of salinity in the root zone, particularly in dry conditions. Of course, fertilizers that contain chloride are avoided, particularly for chloride sensitive crops like banana. The trials presented in this folder show clearly that SQM's science-based fertilization programmes are an investment with excellent profitability, not a cost!

SQM invests in research programmes looking into the crop nutrition management to improve banana production, developing scientific knowledge with independent research organizations and universities. Here we present five summaries of a number of scientifically designed trials performed in Ecuador, Mexico and South Africa:


SQM
Soluciones
para el
desarrollo
humano



1. Qrop® K (prilled potassium nitrate): a superior source of N and K that improved plant growth and yield of banana in Ecuador

Choosing the preferred K source - potassium nitrate (KNO_3) - instead of potassium sulfate (SOP; K_2SO_4) or potassium chloride (KCl), increases the yield, plant growth and the uptake of cations in bananas.

This was demonstrated in two field trials by W.A. Huarquila (trial A) and C.V. Gonzales (trial B) at the Technical University of Machala, Ecuador. The replacement of SOP or KCl respectively by KNO_3 increased bunch weight by 21% and 11%, and the ratio of boxes / bunch increased by 21% and 15%.

Both trials were carried out in commercial banana plantations, in the province of El Oro, Ecuador, with a dry tropical forest climate (annual rainfall of 699 mm and annual temperatures between 25 and 30 ° C). The type of soil was clay silt, with pH 6.7-7.1 (KCl) and organic matter 4-6%, which contained 50.5-62.5 ppm K (extraction in H_2O 1: 2).

Both trials were designed in completely randomized blocks, with five replicates of 20 plants each.

The growth and yield parameters of the plants were determined in marked suckers, at least 1.5 m tall at the beginning of the trial. The fertilizers were administered to the soil at three week intervals from the beginning of the fertilization. The nutrients applied in the farmer's usual practice were: 400 kg N / ha, 100 kg P_2O_5 / ha, 700 kg K_2O / ha, with N and P applied with urea and DAP, and K with SOP (trial A) and KCl (trial B). In SQM programs the nitrogen supplied with KNO_3 was compensated by reducing the amount of urea (Table 1).

Table 1. The amount of nutrients applied (in kg/ha) with granular fertilizers in the two trials.

Treatment	N-total	N-NO_3	N-NH_4	N-NH_2	P_2O_5	K_2O	S	Cl
		KNO_3	DAP	Urea	DAP	KNO_3/SOP/ KCl	SOP	KCl
Qrop® K (KNO_3)	400	202	39	159	100	700	0	0
SOP (A)	400	0	39	361	100	700	252	0
KCl (B)	400	0	39	361	100	700	0	548

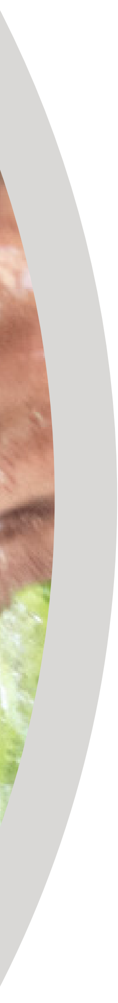
In **trial A**, the replacement of SOP by Qrop® K increased bunch yield parameters by + 21% and pseudostem circumference by 8% (Table 2).

In **trial B**, the replacement of KCl by Qrop® K increased the yield parameters by + 11-15% and the circumference of the pseudostem by 6% (Table 2).

Table 2. *The effect of the K source applied on banana yield parameters and pseudostem circumference in two trials.*

Parameter	Unit	Trial A				Trial B			
		SOP	KNO_3	Difference		KCl	KNO_3	Difference	
				abs.	%			abs.	%
Weight/bunch	kg	30.4	36.9	6.5	21	32.3	35.7	3.4	11
Boxes/bunch	Nº	1.3	1.6	0.3	21	1.3	1.5	0.2	15
Pseudostem circumference	cm	55.5	60.2	4.7	8	77.0	82.0	5.0	6


SQM
Soluciones
para el
desarrollo
humano



2. The use of Qrop® K (prilled potassium nitrate) in Ecuador prevented leaf fall caused by Black Sigatoka, and increased banana yield by 33%

Replacing KCl by Qrop® K (prilled potassium nitrate) as the main source of potassium, in agricultural practice in Ecuador, resulted in 33% more banana yield and income. The higher crop productivity was attributed to a significantly higher retention of leaves with Qrop® K in the presence of Black Sigatoka in the plantation.

Black Sigatoka (Mycosphaerella fijiensis) is a fungal disease that represents a serious threat to banana production worldwide. The fast growing banana crop has a great need for potassium, an important nutrient to support the resistance of plants to fungal attack. Banana plants that receive optimal potassium nutrition can overcome the damage caused by Black Sigatoka. Unfortunately, producers continue to choose to use potassium chloride as the primary, but not optimal, source of potassium.

Dr. Carmen Suárez and Dr. Ignacio Sotomayor, from the Technical University of Quevedo, Ecuador, supervised a study initiated by SQM managers, whose objective was to show the benefits of the preferred source of potassium - potassium nitrate in Qrop® K - to increase the resistance of plants to Black Sigatoka. The trial was carried out between January and August in the province of Los Ríos, Ecuador in collaboration with the State Technical University of Quevedo.

The treatments and observations were made in three replications of 7 plants each, in a completely randomized design, in new suckers measuring between 1.3 and 1.5 m at the beginning of the trial. Routine farmer practice included potassium chloride as the sole source of K, whereas in the Qrop® K-based programs all K was supplied with potassium nitrate. All fertilizers were administered in 11 split applications during the test period.

Table 1. *The amount of nutrients applied (kg/ha) with granular fertilizers.*

Treatment	N-total	N-NO_3	N-NH_4	K_2O	MgO	S	CaO	Cl
		AN, KNO_3, 21-0-0-11CaO-7.5MgO	AN		21-0-0-11CaO-7.5MgO, $MgSO_4$	$MgSO_4$	21-0-0-11CaO-7.5MgO	KCl
KCl	351	177	174	576	112	51	70	432
	100%	50%	50%					
KNO_3	350	258	92	574	85	68	0	0
	100%	74%	26%					

Banana plants fertilized with Qrop® K, as the sole K source, retained 23% more leaves at the moment of harvest compared to normal farmer practice.

This was mainly attributed to the increased resistance of the plants to infestation by Black Sigatoka. By retaining a higher level of photosynthetic potential, the plants were able to produce larger and heavier bunches, with up to 20% more weight per bunch and filling 33% more boxes per bunch (Table 2). Financial analyses of the treatments were performed for the Qrop® K and the KCl programs (Table 3). The 33% higher income obtained with 840 additional boxes / ha, more than offset the higher price of the Qrop® K program: the breakeven point is reached with an additional 3% yield (81 boxes / ha).

Table 2. The effect of the K source on banana plant development and yield parameters.

Parameter	Unit	K source		Difference	
		KCl	KNO_3	abs.	%
Weight/bunch	kg	27.3	32.8	5.5	20
Boxes/bunch	Nº	1.2	1.6	0.4	33
Total developed leaves/crop cycle	Nº	27.1	30.3	3.2	12
Remaining leaves at harvest time	Nº	6.1	7.5	1.4	23
Pseudostem circumference	cm	25.1	26.7	1.6	6

Table 3. The effect of the K source applied to the gross profit of the banana producer.

Parameter	Unit	K source		Difference	
		KCl	KNO_3	abs.	%
Yield	Boxes/ha	2520	3360	840	33
Price	USD/box	6.2	6.2	0	0
Revenue	1000 USD/ha	15.6	20.8	5.2	33
Cost of fertilizers	1000 USD/ha	0.9	1.4	0.5	56
Gross profit	1000 USD/ha	14.7	19.4	4.7	32
Break-even point: Yield increase required to return the investment in Qrop® K	Boxes/ha	-	-	81	3


SQM
Soluciones para el desarrollo humano

3. Greater use of Qrop® KS (prilled potassium nitrate) increased the yield and quality of banana fruits in Mexico

A scientific trial was performed in the Mexican municipality of Tapachula (15 ° N latitude), Chiapas state, to position Qrop® KS (prilled potassium nitrate) as a source of N and K in fertilizer blends. Five increasing doses of potassium were included in the trial (Table 1). In all doses, 50% of the total K_2O was provided as Qrop® KS (prilled potassium nitrate) and 50% as KCl (potassium chloride). The potassium doses were compared with the control where no potassium fertilizer was added (T1), and to the current farmer's practice (T2). The statistical design consisted of a completely randomized design of four replications with plots of 10 m^2, 20 plants / plot.

The local fertilizer practice uses granular fertilizers; urea, DAP and KCl as predominant sources of N, P and K. There are two reasons for farmers to search for alternatives to their traditional fertilizer practices.

The first reason to change to a programme higher in nitric nitrogen is due to climate. In a period of five months, between November and March, the crop is affected by decreasing temperatures and low rainfall. Formulas that work well in summer do not show the same performance in winter. Under low temperature and in dry weather the following guidelines are recommended:

- Apply fast-acting nitric nitrogen ($N\text{-}NO_3$), readily available to the plant, to maintain active growth.
- Reduce the plant's energy expenditure, by application of $N\text{-}NO_3$ instead of only urea ($N\text{-}NH_2$) or ammonium ($N\text{-}NH_4$) sources. This will leave the plant with more energy to spare for growth and fruit production.
- Apply $N\text{-}NO_3$ instead of $N\text{-}NH_4$ to promote cytokinin synthesis, in order to enhance crop development.
- Apply KNO_3 instead of KCl or SOP to avoid the accumulation of chloride or sulphate, leading to salinity in the root zone of the plant, particularly in dry conditions.

Table 1. *The amount of nutrients applied (kg / ha) with granular fertilizers.*

Treatments (kg K_2O/ha)	N-total	$N\text{-}NO_3$	$N\text{-}NH_4$	$N\text{-}NH_2$	P_2O_5	K_2O	Cl
		Qrop® KS (KNO_3)	DAP	Urea	DAP	KCl + Qrop® KS (KNO_3)	KCl
T1 (0)	400	0	39	361	100	0	0
T2 (350)	400	91	39	270	100	350	274
T3 (450)	400	117	39	243	100	450	353
T4 (550)	400	143	39	217	100	550	431
T5 (650)	400	170	39	191	100	650	509
T6 (750)	400	196	39	165	100	750	588

The second reason for farmers to change their fertilizer practice, is to improve fruit quality to service the demanding export market. Mexican fruits are exported to the USA, which sets high standards for quality and fruit condition. Increase of the application of the total K to 750 kg K_2O/ha/year with 50% as Qrop® KS (T6) gave the best results both in yield and quality of fruits in the trial in Mexico.

Not only did this treatment (T6) show higher total yield per ha (an increase of 39% compared to the no-K control (T1) and 27% compared to the farmers' practice (T2). Additionally, the bunch quality was improved with an increased bunch-to-box conversion factor with 15% in comparison to the farmers' practice, and more hands and fingers per bunch (Tables 2 and 3).

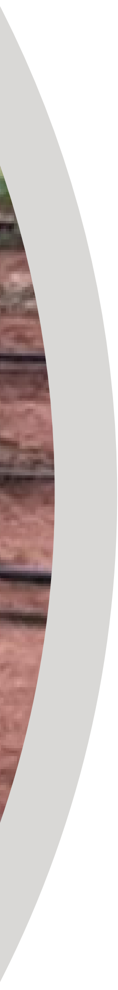
Table 2. *Average length of fingers, number of hands and fingers per bunch. Averages followed by the same letter are not significantly different (Duncan, 95%).*

Treatments (kg K_2O/ha)	Max. finger length (cm)	Hands per bunch (Nº)	Fingers per bunch (Nº)	Bunch weight (kg)
T1 (0)	9.4	5.6 ab	95 ab	21 ab
T2 (350)	9.2	5.8 ab	98 ab	23 ab
T3 (450)	9.5	5.8 ab	101 ab	23 ab
T4 (550)	9.4	6.0 ab	105 ab	25 ab
T5 (650)	9.3	6.2 ab	105 ab	25 ab
T6 (750)	9.8	7.2 a	113 a	30 a

Table 3. *Yield per hectare and conversion rate to boxes (C.R.). The percentage increase is calculated relative to the control without the addition of potassium (T1).*

Treatments (kg K_2O/ha)	Yield (MT/ha)	Relative yield (%)	Boxes/bunch (C.R.)	Relative C.R. (%)
T1 (0)	47	100	0.91	100
T2 (350)	51	110	0.93	102
T3 (450)	51	110	0.96	105
T4 (550)	55	119	1.00	110
T5 (650)	56	120	1.00	110
T6 (750)	65	139	1.07	118


SQM
Soluciones para el desarrollo humano



4. Net benefit increased with up to 19%, by application of KNO_3 compared to other granular K-sources containing KCl or K_2SO_4 in a scientifically designed trial investigating yield of Williams banana in South Africa

This trial was carried out to show the beneficial effects of potassium nitrate over the other two potassium sources in a scientifically designed trial in a commercial plantation, in a newly planted field in virgin soil in Mpumalanga (Lowveld region), South Africa. The trial was conducted in collaboration with AgNova (Pty) Ltd, Lowveld. The soil was of the Hutton series, with pH_{KCl} 5.6 and CEC 4.2 cmol kg^{-1} soil with 71.2% Ca^{2+}, 23.6% Mg^{2+}, 2.7% K^{+} and 2.1% Na^{+}. P content was 3 mg/kg (Bray1). Williams banana plants (tissue cultured) were planted at a spacing of 3m x 2m (1 667 plants/ha).

Phosphate was applied at the time of planting. 31.5 kg of P/ha (72 kg P_2O_5/ha) with single super phosphate (15% P). Nitrogen was applied as CAN (28% N) in treatments with K_2SO_4 and KCl. For the Qrop® KS treatments, the amount of nitrogen supplied as CAN was reduced with the amount of $N\text{-}NO_3$ applied with potassium nitrate (Table 1). All treatment plots received one foliar spray application of a micronutrients cocktail during spring.

SQM Solutions for human progress

Large differences in Williams banana plant performance were found in the response to fertilization with prilled potassium nitrate (KNO_3: as Qrop® KS), potassium sulphate (K_2SO_4) or potassium chloride (KCl). Fruit weight and quality parameters were reduced where KCl was applied: a statistically significant difference (Table 2) . The application of Qrop® KS turned out to be a profitable investment for the grower. Using Qrop® KS as K-source, resulted in the greatest plant productiveness in marketable total hand weight, with increased return on investment for the grower (Table 3).

The highest yield of 40 MT/ha was recorded for Qrop® KS, at the higher rates of N (300 kg/ha) and K (700 kg/ha).

The banana yield (total hand weight) averaged across two varied N and K rates was best for Qrop® KS with 35.4 MT/ha, and substantially lower for K_2SO_4 (32.8 MT/ha, -7%) and KCl (28.5 MT/ha, -20%).

Table 1. *The amount of nutrients/ha for treatments varying in the different K sources is given as an example of how the K -source affects the ratio of N-NO_3:N-NH_4, S and Cl in this table only for the high N (300 kg N/ha) and K (700 kg K (840 kg K_2O)/ha) treatments.*

Factor		K-source	CAN	SSP	K	N-total	N-NO_3	N-NH_4	S	Cl
		kg fertilizer/ha			kg nutrient/ha					
K-source	Qrop® KS (KNO_3)	1845	215	210	700	300	270	30	8	0
	K_2SO_4	1710	1070	210	700	300	150	150	316	0
	KCl	1400	1070	210	700	300	150	150	8	672

Table 2. *Yield parameter, means of the main effects per factor. The data was analysed with a suitable statistical method: ANOVA for main effects and interactions, followed by 95% LSD mean separation for factor means. Means followed by the same letters in the same factor are not statistically different at $p<0.05$.*

Factor		Bunch weight	Hands per bunch	Hand weight	Total hand weight	Fingers per hand	Finger length	Finger girth
		kg/bunch	number	kg/hand	kg/plant	number	cm	cm
K-source	Qrop® KS (KNO_3)	22 a	9.2 a	2.2 a	21 a	17.9 a	15.1 a	15.0 a
	K_2SO_4	21 a	9.0 ab	2.1 ab	20 ab	17.4 ab	14.9 ab	14.4 ab
	KCl	20 a	8.6 b	1.9 b	17 b	16.8 b	14.6 b	14.1 b
N rate Kg N/ha	200	19 a	8.5 a	1.9 a	17 a	16.7 a	14.6 a	14.2 a
	300	23 b	9.4 b	2.2 b	21 b	18.1 b	15.1 b	14.8 b
K rate Kg K/ha	450	19 a	8.5 a	2.0 a	18 a	16.8 a	14.6 a	13.9 a
	700	23 b	9.4 b	2.2 b	21 b	18.0 b	15.2 b	15.1 b

Table 3. *Financial analysis of revenue in this trial. The calculation departs from the mean effect in yield of the different K-sources over the varied rates of N and K.*

K-Source	Total hand weight	Bunches per ha	Yield per ha	Boxes of 18 kg per ha	Price per box	Total income per ha	Cost of NPK fertilizers	Net benefit
	kg/plant	number	MT/ha	number	USD/box	USD/box	USD/ha	USD/ha
Qrop® KS (KNO_3)	21.3	1 667	35.4	1 969	8.82	17 366	1 449	15 897
K_2SO_4	19.7	1 667	32.8	1 823	8.82	16 075	1 064	15 008
KCl	17.1	1 667	28.5	1 581	8.82	13 943	6 54	13 311

Soluciones para el desarrollo humano

5. The effect of nitrate to ammonium ratio in nutrient solutions on growth and resilience to saline conditions of young Williams banana plants in sandy soil

A high ratio of NO_3^-: NH_4^+ in fertigation solutions is known to markedly reduce the inhibiting effect of salinity on crop growth. Choice of K_2SO_4 or KCl as the main K source in fertigation solutions, as opposed to KNO_3, negatively impacts on the quantity of NO_3^- that can be applied, because the alternative N-sources usually contain a high proportion of NH_4^+. This principle was confirmed in a nursery trial on young Williams banana plants in plastic pots filled with natural river sand (pH 6) or sand with addition of $CaCO_3$ (pH 7) as a proxy for a sandy alkaline desert soil.

In all treatments salinity stress was imposed by addition of NaCl in the nutrient solution. The plants were drenched with 150 ml/plant of nutrient solutions composed with different K-sources, three times/week for the 3-months trial period (Table 1). The K source was either KCl, K_2SO_4 or KNO_3. As a consequence the NO_3^- to NH_4^+ ratio differed between solutions as well as the Cl^- or SO_4^{2-} content. Concentration of all other nutrients, except for that of SO_4^{2-} and Cl^-, was equal in the K-containing nutrient solutions. All micronutrients were applied in their recommended dose, with fully chelated Fe (EDDHA) and Cu, Mn and Zn (EDTA).

The experiments each comprised 20 single-plant replicates of six treatments (factorial combinations of addition of $CaCO_3$ or K-source) in a randomized complete block design. Every week, the plant height was measured from the point of soil-emergence to the tip of the longest upper leaf, and at the end of the trial the total plant fresh weight and number of primary roots was recorded. For banana, the effect of soil pH by addition of $CaCO_3$ was not statistically significant, so only the mean effects over the three different K sources are considered here.

The study showed clearly that plant growth in sandy soils and with a high concentration of sodium in the water, is better assured when using KNO_3 as opposed to K_2SO_4 or KCl as the K source in fertilizer programmes for a banana crop (Table 1). At a high concentration of sodium in the irrigation water, banana plants fertigated with KNO_3 as main K-source grew fastest, attained greatest fresh weight and developed a higher number of primary roots. Fertigation with K_2SO_4 as the main K-source decreased plant biomass by 17%, and root development by 23%. Using KCl as main K-source decreased both plant weight and number of roots with 45%.

Table 1. *Effect of potassium source in fertilization of banana plants on plant and root growth in saline conditions. The data was analysed with a suitable statistical method: ANOVA for main effects and interactions, followed by 95% LSD mean separation for factor means. Means followed by the same letters in the same factor are not statistically different at $p<0.05$.*

K-source	Ratio NO_3:NH_4	SO_4	Cl	NaCl	Plant fresh weight (g)	Number of primary roots	Plant height (cm)
KNO_3	67%:33%	100%	100%	2 g/L	48.5 c	16.7 c	29.3 c
K_2SO_4	33%:67%	380%	100%	2 g/L	40.3 b	12.9 b	24.9 b
KCl	33%:67%	230%	115%	2 g/L	26.5 a	9.3 a	23.1 a

Reference: Oosthuyse, S.A. and Holwerda, H.T. (2016). Nutrient salt balance differences on the growth of potted banana, orange or tomato plants growing in sand or sand/$CaCO_3$ and fertigated with highly saline solutions. Acta Hortic. 1112, 127-134.
DOI: 10.17660/ActaHortic.2016.1112.18
https://doi.org/10.17660/ActaHortic.2016.1112.18

Solutions for human progress

POTASSIUM NITRATE FROM NATURAL RESOURCES

Efficient plant nutrition
Stronger and healthier crops

Element Q stands for quality
KNO_3 improves the quality of harvested products

Increased crop yield
KNO_3 improves return on farmer investment in optimal plant nutrition

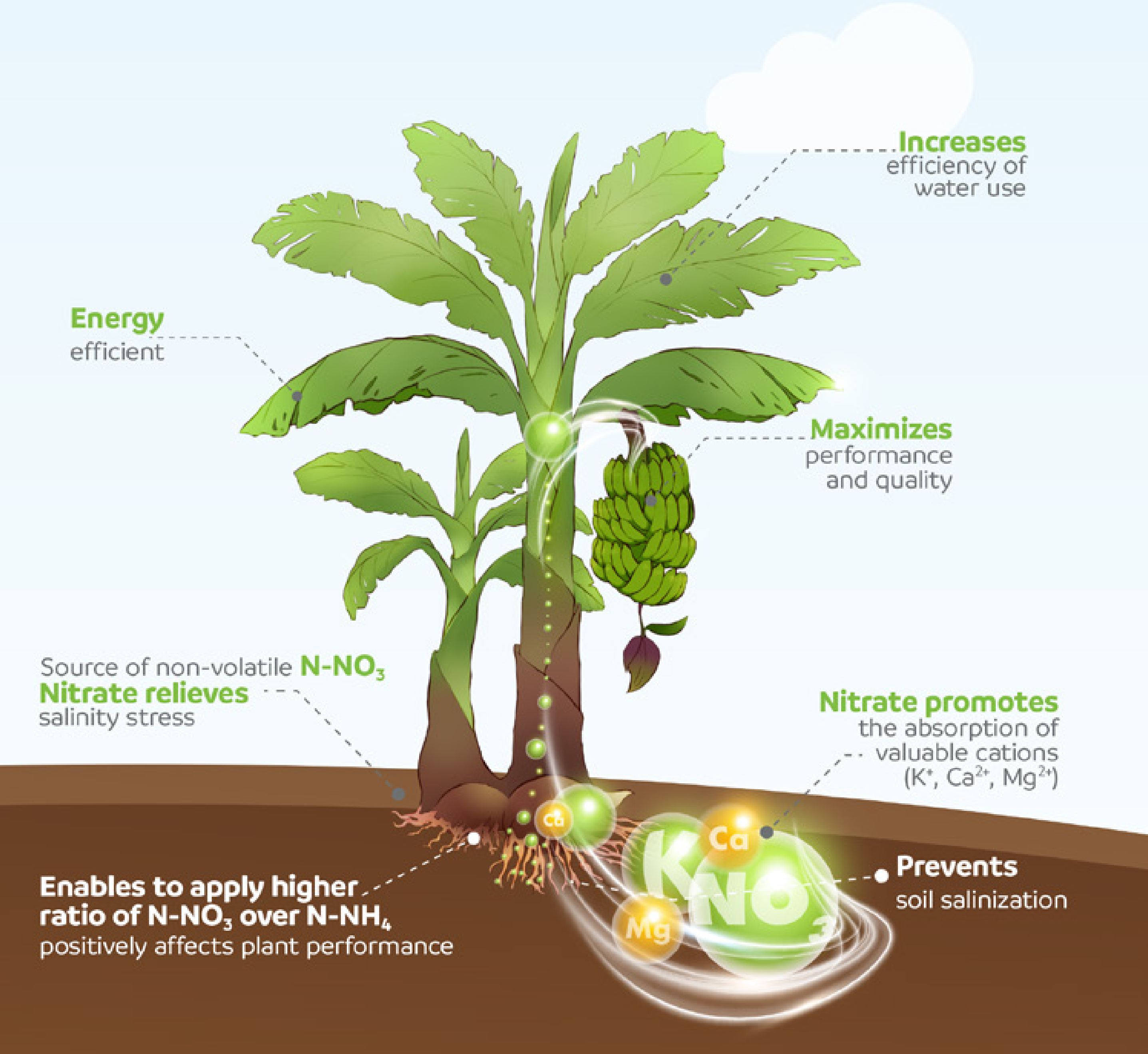
Saves water
Improved water use efficiency

Prevents soil salinization
K^+ and NO_3^- are completely absorbed by the plant, according to the need of the crop

Sustainable production processes
SQM has a strong commitment to sustainable development

Why POTASSIUM NITRATE

Is the preferred source of K and N



Solutions for human progress

Specialty Plant Nutrition experts

GET TO KNO_3W

POTASSIUM NITRATE IN BANANA

SQM

Solutions
for human
progress

Specialty Plant Nutrition **experts**

GET TO KNO$_3$W

POTASSIUM NITRATE IN BANANA