Optimizing Crop Nutrition

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Editorial

Dear readers,

Some may say it is a little premature to reflect on the achievements of the first decade of the 21st century. But it is, we believe, timely to stop and ask what has been happening during this time and to look to the challenges that we face in the next ten years and beyond.

In 1990, the world's population was approx. 5.3 billion, growing to 6.7 billion in 2009; an increase of more than 25 per cent. Within a period of less than 20 years, global agricultural production must feed an additional 1.4 billion people... equivalent to feeding another India. An enormous challenge indeed.

Average yields of maize, wheat and rice, the major staple foods of the world have increased by 30, 17 and 13 per cent respectively (if the averages are calculated for the years 1990-92 and 2005-07). Bearing in mind that much of the maize is utilized for feed and biofuels, it seems that agricultural productivity is lagging behind population growth, and indeed, additional food is - and probably will have to be - produced on more land previously used for other purposes, or by cultivating virgin terrain.

To do so has a cost. In the past, we only looked at agricultural productivity per se. But now it is necessary to take into account other issues including the ecosystem services that land, water and biodiversity provide, and the carbon cycle which has increasingly attracted much attention.

How to balance the production of food and yet at the same time preserve nature and our atmosphere in a sustainable way will undoubtedly be a major challenge for the years ahead. This approach was not so widely accepted only 10-15 years ago and, in this respect, poses huge challenges for those dedicated to increasing agricultural productivity.

In this edition of *e-ifc,* we highlight research findings on potassium fertilization of turmeric *(Curcuma longa)* in India, and alfalfa (*Medicago sativa* cv. Crioula) in Brazil, and a short paper on the link between mineral nutrition and plant disease. New publications and events are included as usual.

I wish you all an enjoyable read.

Hillel Magen

Director

Growing carbon. Participants from the IPI-Corvinus University symposium on "Nutrient management and nutrient demand of energy plants" visiting Sándor Bényei's farm in Fadd village, near Szekszárd, Hungary. The farm has the largest collection of Populus nigra clones (Poplar) in Europe, Photo by IPI.

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Research Findings

The Effect of Potassium on the Yield and Quality of Turmeric *(Curcuma longa)*

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The experiment signboard, Arachalur, Tamil Nadu. Photo by P.K. Karthikeyan.

Introduction

Turmeric (*Curcuma longa)* is a tropical rhizomatous crop cultivated most extensively in India, followed by Bangladesh, China, Thailand, Cambodia, Malaysia, Indonesia, and the Philippines. In India, the main turmeric-growing states are Tamil Nadu, Andhra Pradesh, Maharashtra, Orissa, Karnataka and Kerala. In Tamil Nadu, as much as 25,000 hectares of turmeric are cultivated, with a production of more than 125,000 mt of cured rhizome yield. Turmeric is prized for its ability to impart a brilliant yellow-gold color to food and is an essential ingredient in curry and curry powders, giving culinary dish a characteristic peppery taste (Ravindran *et al*., 2007). The active components in turmeric possess a broad spectrum of biological activities with various beneficial properties e.g. anti-bacterial, anti-fungal, anti-parasitic, anti-mutagen, anti-inflammatory, hypolipidemic, hepatoprotective; lipoxygenase, cyclooxygenase, and protease-inhibitory effects, besides being effective in reactive oxygen species scavengers and lipid peroxidase inhibitors (Khanna, 1999).

As a crop, turmeric has a high demand for plant mineral nutrients and yield production generally responds to increased soil fertility; the quantity of fertilizers (inorganic or organic) required by the crop depend on the variety selected, as well as soil and prevailing weather conditions during crop growth. The average cured rhizome yield of turmeric ranges from 3-5 mt ha^{-1} in the Erode district, of Tamil Nadu (Selvarajan and Chezhiyan, 2001). However, inadequate nutrient management and nutrient mining has led to low productivity of fresh rhizome yield in the major turmeric growing regions in South India. In order to study the effect of potassium and magnesium on turmeric production, and on its quality attributes of the crop under conditions of adequate supply of nitrogen and phosphorus, a field experiment was carried out on the Irugur soil series (Inceptisols) in the western zone of Tamil Nadu.

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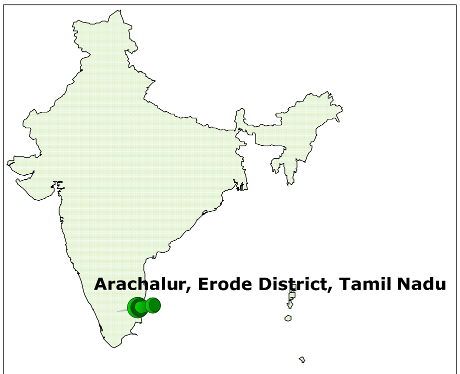

Map of India showing the experimental site.

Materials and Methods

The field experiment was carried out on an Inceptisol (a soil with little horizon development) in farmers' holdings at Arachalur, in the Erode District of Tamil Nadu, under the supervision of the Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University. Soil samples taken from the field experiment prior to treatment application, were analyzed for all important soil parameters adopting standard procedures (Table 1).

Table 1. Soil properties.

Physical Properties	unit	
Clay	g kg^{-1}	155
Silt	g kg^{-1}	230
Fine sand	g kg^{-1}	240
Coarse sand	g kg^{-1}	350
Texture		Sandy loam
Chemical Properties		
Soil pH (1:2)		6.5
EC	dSm^{-1}	0.05
CEC	cmole kg^{-1}	12.1
Organic carbon	g kg^{-1}	4.8
$KMnO_4$–N	mg kg^{-1}	105
Olsen –P	mg kg^{-1}	8.2
NH_4OAC–K	mg kg^{-1}	60
Exchangeable Ca	cmole kg^{-1}	7.0
Exchangeable Mg	cmole kg^{-1}	1.8

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The experimental design was a randomized block design with seven treatments replicated threefold. The details of the treatments are given in Table 2.

Table 2. Experimental treatments.

Treatment	Potassium application (kg ha^{-1})
K1	Control (no potash)
K2	40
K3	120
K4	200
K5	260
K6	260+60*
K7	320

*60 kg $MgSO_4$ ha^{-1}

120 kg of N ha^{-1} (urea), 50 kg P_2O_5 ha^{-1} (superphosphate), 5 kg $ZnSO_4$ ha^{-1}, and 5 kg Fe SO_4 ha^{-1} were applied to all treatments.

A plot size of 10 x 6 m was used, with the experimental site being previously prepared in broad ridge and furrow for the cultivation of the rhizomes. Farmyard manure - at a rate of 25 mt ha^{-1}, as well as 50 kg of P_2O_5 ha^{-1} and 5 kg of $ZnSO_4$ ha^{-1} and 5 kg of $FeSO_4$ ha^{-1} - were applied as a basal treatment on all plots. The fertilizers, potassium (as muriate of potash KCl), nitrogen (as urea) and magnesium (as $MgSO_4$) were applied in four equal splits. The first split was applied basally and the rest at 30, 60, and 90 days after planting. Various cultivation procedures, including irrigation and plant protection measures, were carried out as per the recommended practice for the region. During crop growth, growth parameters viz., tiller count per plant and secondary rhizomes per plant were recorded. The crop was harvested 290 days after planting and the yield of fresh rhizomes was documented. Rhizome samples were collected, dried and analyzed for the content of nitrogen (Alkaline permanganate method, (Subbiah and Asija, 1956), phosphorus (0.5 M $NaHCO_3$ (pH 8.5), (Olsen *et. al.*, 1954)) and potassium (Neutral normal ammonium acetate method–flame photometry, (Stanford and English, 1949)). The curcumin (yellow pigment of tumeric) content of rhizome samples was estimated by the method suggested by ASTA (1968). Uptake of nutrients by rhizomes was calculated at harvest by making use of the data on nutrient contents and yields of the cured rhizomes.

Potash fertilized turmeric crop (Curcurma longa) cv. Erode local. Photo by P.K. Karthikeyan.

Results and Discussion

Yield and quality

The positive response of turmeric to increased potassium fertilization expressed itself by way of enhanced tillering coupled with increased yields (Table 3).

The treatment (K6) which received 260 kg of K_2O ha^{-1} and 60 kg $MgSO_4$ ha^{-1} recorded the highest tiller count (14.7 $plant^{-1}$) but the difference between that and treatment K5 (260 kg of K_2O ha^{-1}), which recorded 14.3 tillers $plant^{-1}$ was not statistically significant. A similar trend, with slightly higher but non significant values between treatment K6 (with addition of Mg) and treatment K5, was recorded for both secondary rhizome and fresh rhizome yield. Singh *et al.*, (1998) also showed that increasing rates of potassium application had a positive and significant effect on fresh rhizome yield. Yield declined significantly at the highest rate of potassium application

Table 3. Influence of potassium on the yield and quality of turmeric cv. Erode local.

Treatments	Potash application	No. of tillers	No. of secondary rhizomes	Fresh turmeric yield	Curcumin content
	kg ha^{-1}	*No./plant*	*No./plant*	*mt ha^{-1}*	*%*
K1	0 (control)	3.70	8.70	18.0	2.90
K2	40	5.70	13.3	24.3	3.30
K3	120	8.00	17.7	28.3	3.63
K4	200	10.7	20.3	31.4	3.93
K5	260	14.3	23.3	34.4	4.47
K6	260 + 60*	14.7	24.0	34.9	4.53
K7	320	11.0	20.7	32.4	4.07
CD (P=0.05)		0.80	2.09	1.68	0.15

*60 kg $MgSO_4$ ha^{-1}

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(treatment K7) in accordance with the other growth and yield parameters.

Rhizome quality is judged on how much curcumin it contains. This important quality parameter of the rhizome has been shown to increase significantly in response to K application (Singh *et al.*, 1992). Our results confirmed this finding with significantly increased concentrations as a consequence of K application.

The control recorded a value of 2.9 per cent which was significantly lower than the other treatments (3.30-4.53 per cent). The highest curcumin content of 4.53 per cent was recorded in treatment K6 (K and Mg), followed by treatment K5 which recorded 4.47 per cent, but again the difference between these two treatments was not statistically significant.

Large rhizomes due to potash application (K6, 260 kg of K_2O ha^{-1};left) and no K applied (K1, right). Photo by P.K. Karthikeyan.

Nutrient content and uptake

Nutrient content of N, P and K of the rhizome at harvest (Table 4) - particularly those of K - show an increasing trend similar to yield and yield attributes, with significantly increased values recorded after application of K. The highest K contents of 2.2 per cent K (in treatments K5 and K6 with 260 kg K_2O ha^{-1}) contrasted markedly against the control of 1.6 per cent (treatment K1). This beneficial effect of K application on rhizome K content is in agreement with the findings of Subramanian *et al.*, (2001). With the exception of treatment K4, both N and P contents were also somewhat increased by K application.

Since both dry weight yields of the rhizomes and their respective nutrient contents were considerably increased by K application, the effect of K fertilization in increasing uptake of N, P and K as the products of dry matter and nutrient content was even greater. Highest dry matter yields were recorded in treatment K6 with uptakes of nitrogen, phosphorus and potassium of 86, 14, and 151 kg ha^{-1}, respectively. This beneficial effect of K fertilization in increasing the uptake and utilization of other nutrients is an important aspect of K fertilization. In this experiment (as calculated from the data shown in Tables 3 & 4) K application at 260 kg ha^{-1} resulted in a more than 2.5 fold increase in yield of cured rhizomes with markedly raised quality, increasing curcumin production fourfold from 75 to 305 kg ha^{-1}.

The application of magnesium had no significant effect on any of the parameters recorded in this experiment. In all cases, however, the benefits of applying 260 kg K_2O ha^{-1} appeared to be slightly improved by the magnesium treatment. In view of possible competitive effects between K and Mg in uptake and utilization (see Mengel and Kirkby, 2001), this observation needs to be borne in mind in future work with this crop, particularly on soils where magnesium supply might be limiting.

Conclusions

The influence of potassium on growth, yield, nutrient uptake and quality

Table 4. Influence of potassium on nutrient uptake of cured rhizome for turmeric cv. Erode local.

Treatments	Potash application	Cured rhizome yield	Nutrient content			Nutrient uptake		
			N	P	K	N	P	K
	kg ha^{-1}	*mt ha^{-1}*	---------%---------			-------*kg ha^{-1}*--------		
K1	0 (control)	2.57	1.20	0.16	1.60	31	4	41
K2	40	3.75	1.23	0.16	1.80	46	6	68
K3	120	4.71	1.24	0.16	1.93	59	8	91
K4	200	5.77	1.20	0.15	2.10	69	9	121
K5	260	6.83	1.25	0.20	2.20	86	14	150
K6	260 + 60(1)	6.87	1.25	0.20	2.20	86	14	151
K7	320	5.82	1.24	0.16	2.10	72	10	122
CD (P=0.05)		0.35	0.02	0.01	0.03	4.60	0.807	7.97

*60 kg $MgSO_4$ ha^{-1}

Research Findings

parameters of turmeric *cv. Erode local* was assessed from a field experiment on an Inceptisol low in available K in Tamil Nadu, the major turmeric growing region of south India. Increasing the application rate of potassium in the form of KCl enhanced growth, nutrient uptake and utilization, increasing yield and quality of turmeric. From our findings, the application of 260 kg K_2O ha^{-1} should be recommended. This more than doubled cured rhizome yield and increased curcumin content by over 50 per cent. These results suggest that the turmeric crop requires large amounts of potassium for both yield and quality. No statistical evidence of a beneficial effect on yield or quality parameters was found by supplying magnesium at the highest rate of K application. In view of the competitive effects of these two nutrients in uptake and utilization, however, the possible beneficial effect of magnesium application does need to be borne in mind in cultivating turmeric on soils low in magnesium.

Turmeric (Curcurma longa) cv. Erode local. Photo by P.K. Karthikeyan.

Acknowledgment

Funding from International Potash Institute, Switzerland for this research program is sincerely acknowledged.

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The paper "The Effect of Potassium on the Yield and Quality of Turmeric *(Curcuma longa)*" is also available in:

Regional Activities/India and

K Center/Potassium and Food Quality

Research Findings

Mineral Nutrient Management and Plant Disease

Katan, J.[(1)].

Introduction and background

A major goal in crop production is to produce healthy plants and healthy crops in a sustainable manner. The concept of plant health involves more than pest control and protecting the plants from pests; it also involves other disciplines, which include crop management, ecology, and climatology. The final goal is to grow the crop under optimal production conditions and to produce high, sustainable and economic yields with minimal disturbance of the environment. Mineral nutrition is an important component in this system. Its management can affect not only the yield, but also plant health and the environment.

Properly balanced nutrition is a critical factor in allowing crops to realize their full yield potential. The application of fertilizer to accomplish this balance is a universal practice in commercial crop production. Macro- and microelements have long been recognized as being associated with size, quality, and yield of crops, and also with changes in levels of the incidence of disease (Rush *et al.*, 1997). Pathogens, as well as crops, have nutritional requirements of their own. Two major objectives of nutrient applications to crops for protection from pathogens are to avoid plant stress, which may allow crops to better withstand pathogen attack, and to manipulate nutrients to the advantage of the plant and disadvantage of the pathogen (Palti, 1981). Not only is the supply of an individual nutrient important, but also balanced, crop-specific nutrient ratios are crucial for improving plant health by adequately supplying the plant during its development under varying environmental conditions. Through an understanding of disease interactions with each specific nutrient, the effects on the plant, pathogen and environment can be effectively modified to improve disease control, enhance production efficiency and increase crop quality (Walters and Bingham, 2007).

A plant disease is the result of the interactions between three major components: the host plant (its resistance to the pathogen), the pathogen (its capacity to develop and induce a disease) and the biotic (e.g. microbial antagonists) and abiotic (e.g. mineral nutrients, temperature) environment (Fig. 1).

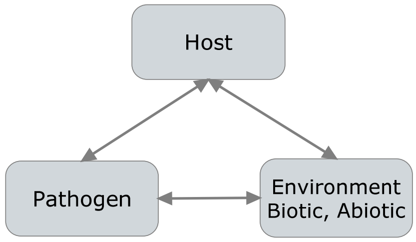

Fig 1. The interactions involved in plant disease.

Any external factor introduced into this system, e.g. a pesticide or a mineral nutrient can positively or negatively affect any one or all of the above components, leading to a decrease, increase or no effect on disease incidence and severity. However, as will also be shown below, generalizations should not be made: a particular mineral nutrient may be associated with an increase in severity of a certain disease in one crop but with suppression of another disease in a different crop or have no effect. Also, an environmental stress does not always suppress plant resistance. Each interaction is specific for the particular mineral nutrient, the specific plant and the specific pathogen. In this article we concentrate on interactions between mineral nutrients and plant diseases, with emphasis on the major elements, NPK.

From the viewpoint of plant health, two aspects of mineral nutrients may be considered: their role in achieving optimal yields and their effect on plant diseases.

The effect of mineral nutrition on plant diseases has long been recognized. As early as the 1940s and 50s, intensive studies were carried out on the interactions between mineral nutrients and plant diseases, especially in Wisconsin, USA. For example, it was found that potassium deficiency increased the severity of Fusarium wilt in cotton, whereas applying high levels of this fertilizer reduced incidence of the disease. Similar results were obtained with Fusarium wilt of tomato and cabbage, but the opposite was found with clubroot disease in cabbage. It was also found that a balanced NPK nutrition, especially at high concentrations, reduced Fusarium wilt in tomato. It should be emphasized that most of these experiments were carried out under controlled conditions in the greenhouse. Whether these findings were of relevance to field conditions was not always clear, and only in a few cases were results obtained on a large-scale under realistic field conditions. Nevertheless, the above early studies indicate the potential of this approach, which may be utilized as a tool for reducing the incidence of plant diseases.

There have been attempts since then to harness mineral nutrition as a tool for disease reduction. However, in many cases these have resulted in failure, apparently because the methods of application have been inadequate and knowledge of the nature of the interactions between the mineral nutrients and plant disease has been limited. It is now recognized that there is a need to explore ways in which to use mineral nutrition to bring about a reduction in the incidence of disease without affecting yield and quality. This approach is now possible because better and more sophisticated tools for controlled fertilizer application, and its

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monitoring, are now available especially in soilless cultures.

Interactions of three major minerals with plant diseases are briefly reviewed below.

Nitrogen

Nitrogen is the most commonly used fertilizer and is essential for the production of many cellular components (Huber and Thompson, 2007). It may be absorbed by plants in either a reduced or an oxidized form. The rapid rate of nitrification in many cultivated soils provides nitrate (NO_3) for plant uptake which is internally reduced to amino acids prior to utilization by cells. The two forms of nitrogen absorbed by the plant are assimilated differently and can have a profound effect on diseases. The uptake and assimilation of nitrate leads to an increase in pH at the root/soil interface, the rhizosphere, whereas with ammonium (NH_4) nutrition the rhizosphere is acidified. This basic difference between forms of N supply can have a major impact on the activity of root-borne diseases which can be sensitive to pH. Most of the contradictions in reports of the effects of N on diseases may result from a failure to recognize the different effects of the various forms of nitrogen (Huber and Thompson, 2007). Interactions between nitrogen and other nutrients are well known. For example NO_3 nutrition stimulates K uptake and *vice versa* promoting the synthesis of organic N compounds, whereas NH_4 uptake competes with K uptake which can be restricted. On the other hand, uptake of phosphate is relatively favoured by NH_4 nutrition in comparison with NO_3 as the N source.

The effect of nitrogen on plant diseases is extensively reported. A general concept is that nitrogen frequently tends to increase disease incidence. However, there are also cases of a decrease in incidence of diseases induced by nitrogen fertilizers. This apparent contradiction appears to result from differences in rate of application, time of application, form of nitrogen, and soil conditions. Interactions with other nutrient elements have also to be considered. Nitrogen can affect disease incidence in various ways including effects on cellulose formation in the plant, on root and leaf exudates and consequently on pathogen growth and virulence, as well as on plant response. Damping-off disease in beans caused by *Rhizoctonia solani* is more severe with plants receiving NH_4 than in plants receiving NO_3. Again, this demonstrates that the type of interaction is specific to the nutrient type, the host and the pathogen.

Control; K, P=0 4 kg K_2O & 6 kg P_2O_5 ha^{-1} Control; K, P=0

Effect of foliar spray of K and P (KH_2PO_4; MKP) on Nova mandarin (Duncan grapefruit X Dancy tangerine) resistance to pests and disease after six weeks in cold storage. Left and right: 0 K & P (non-treated control); middle: 4 and 6 kg K_2O and P_2O_5 ha^{-1} respectively. The damage on the infected fruit is caused by Phytophthora citrophthora and Penicillium spp. Photo by A. Ovadia and M. Assaraf, Yavne, Israel, 2005.

For strategies to reduce disease with nitrogen nutrition, it is recommended to maintain a balanced fertilizer program with a full sufficiency of nitrogen for optimum plant growth and yield. Also, nitrogen has to be applied appropriately in order to avoid periods of excessive nitrogen supply or nitrogen deficiency. Nitrogen nutrient management has to take into account the potential response of the major crop pathogens to nitrogen in order to adjust it to minimize potential adverse effects.

Phosphorus

Phosphorus is an essential plant nutrient and its deficiency in soils significantly reduces yields of crop plants. Phosphorus is an essential element of the building blocks of life, the ribonucleic acids (RNA), as well as being required for many additional biochemical and physiological processes including energy transfer, protein metabolism and other functions (Prabhu *et al.*, 2007a).

There are reports indicating a reduction in disease incidence by phosphorus with the opposite also being found, although it appears that phosphorus has a predominantly beneficial effect. For example, phosphorus reduces the progress of some rusts and other foliar diseases and is especially beneficial in counteracting high levels of nitrogen. However, high levels of phosphorus alone in sugarcane have been associated with a high severity of rust. Phosphorus alone, or in combination with potassium, increased resistance of wheat to powdery mildew. Application of phosphorus increased Fusarium wilt in tomato at pH 6.0 but suppressed it at pH 7.0 and 7.5. The severity of Rhizoctonia disease in soybean increased as a result of phosphorus deficiency in the soil, emphasizing the importance of balanced and adequate nutrition. There are also cases in which phosphorus reduced incidence of certain nematode and bacterial diseases. There are many other examples of the interaction between phosphorus and plant diseases. It is especially interesting to note that in certain cases foliar application of phosphate salts has been shown to induce resistance to various diseases in cucumber, beans and other crop plants. As with other mineral nutrients, phosphorus management for disease control should aim to both improve crop productivity and disease control. In other words, phosphorus has to be supplied in

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adequate amounts and in the appropriate form and methods of application. These have to be adjusted according to crop requirements and edaphic conditions. Foliar sprays of phosphorus can confer local and systemic protection against some foliar pathogens, e.g. powdery mildews in grape, mango, apple, wheat, and peppers, rust on maize and others. This means of application offers another potential benefit which deserves further consideration.

Potassium

Potassium is a basic nutrient for plant life and plays many essential roles in plant nutrition. Leaves of potassium deficient plants are chlorotic and often show necrosis at the margins with plant growth and root development depressed. It has been argued that potassium-deficient plants might be pre-disposed to diseases (Prabhu *et al.*, 2007b) and indeed in many cases, potassium application has been shown to reduce the incidence of both foliar and soil-borne diseases, while in a few cases the opposite has been found to be true. For example, out of 165 cases of effects of potassium on fungal, bacterial and nematode diseases (compiled by Prabbu *et al.*, 2007b), 117 cases (71 per cent) resulted in a decrease in diseases whilst 29 per cent showed an increase. The beneficial effect of potassium application in reducing diseases, e.g. Verticillium wilt is especially evident in potassium-deficient soils. Potassium deficiency also predisposes cotton to Fusarium wilt, thus adequate potassium fertilization contributes to plant health. The effect of potassium on diseases is also influenced by interaction with other nutrients. For example, blast severity in rice is low when there is a high K:N ratio in leaf tissue, whereas a low K:N ratio increases the disease. The accompanying anions in K salts applied as fertilizers may also affect the disease. In some cases, the increased resistance to disease by potassium has been attributed to various mechanisms, e.g. decreased cell permeability and decreased susceptibility of tissue to maceration and penetration by the pathogen. Moreover, potassium in combination with phosphorus induces the development of thicker cuticles and cell walls which function as mechanical barriers to invasion and infection by pathogens.

As with other mineral nutrients, appropriate management practices of potassium relating to application can improve the uptake of potassium by plants and consequently increase crop production, while reducing disease incidence. Again, this involves adequate application rates, appropriate timing and methods of application, and other practices which increase potassium availability in the soil. Potassium has significant potential as a tool for reducing diseases, which needs further investigation.

Concluding remarks

Mineral nutrients may reduce the incidence of diseases in certain cases or increase them in others, depending on the particular mineral nutrient, the host plant, the pathogen and other factors. Appropriate management which takes into account fertilizer form and rates, and time and mode of application, has the potential to achieve high crop productivity while reducing the incidence of diseases, or at least avoiding their increase. A key factor is the supply of plants with a well balanced form of nutrition and avoidance of stress e.g. soil salinity. There is currently a big gap between promising results obtained under controlled conditions and the implication, as well as the application of these findings to farming practice. It is hoped that the introduction of sophisticated methods of application and better understanding of the mechanisms underlying the beneficial effects of mineral nutrients in reducing disease incidence will enable the realization of this approach on a large scale. Appropriate management of mineral nutrition which leads to a reduction in the incidence of disease is also an additional tool for minimizing the use of pesticides. This is a significant benefit to the environment. To achieve this important multidisciplinary goal, there is a need for joint research between plant pathologists and soil scientists.

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The paper "Mineral Nutrient Management and Plant Disease" is also available at:

K Center/Potassium and Stress and Plant Disease

Research Findings

Potassium Doses and Frequency of Application to Alfalfa Growing on a Brazilian Tropical Soil: Influence on Dry Matter Yield and K Content of the Harvested Crop and Exchangeable Soil K

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General view of the experimental plot at Embrapa Cattle Southeast, Sao Carlos, Brazil. Photo by A. Bernardi.

Introduction

Providing an adequate supply of nutrients is an important requirement for alfalfa production for maintaining high quality and profitable yields. On highly weathered, low-fertile and acids soils of tropical regions, potassium fertilization is essential (Rassini and Freitas, 1998) and is the most common nutrient input for this crop. High-yielding alfalfa removes large amounts of potassium from the field at each cutting (Smith, 1975; Lanyon and Smith, 1985), extractions range from 1,500 to 1,700 kg ha^{-1} associated with a productivity of 21.5 mt ha^{-1} DM being reported by Lloveras *et al*. (2001) on a soil of high fertility.

Potassium (K) is taken up by plant roots in ionic form. Diffusion to the roots accounts for the major form of K acquisition, with mass flow contributing only a small fraction of total plant K (Mengel and Kirkby, 2001). K salts in general are highly soluble and, when applied to soils low in K-fixing capacity, relatively high K concentrations may occur in soil solution, which in turn may lead to leaching of potassium from the soil and excessive absorption by plants (Havlin *et al*., 1999).

Experimental Studies

A two-year field study made over two growing seasons was carried out at Embrapa Cattle Southeast, in Sao Carlos (22^{o}01'S and 47^{o}54'W; 856m above sea level), Brazil. The climate is a Cwa (Köeppen), with yearly average of low and high temperatures of 16.3 and 23.0°C respectively, and a total precipitation of 1,502 mm falling mostly in summer. Soil type is a Typic Hapludox with chemical properties as presented in Table 1.

Table 1. Soil analysis of a Typic Hapludox at 0-0.2, 0.2-0.4 and 0.4-0.6m layers.

Chemical property	Depth (m)		
	0-0.2	0.2-0.4	0.4-0.6
pH_{CaCl2}	5.9	5.3	5.1
Organic matter (g dm^{-3})	21	11	10
P_{resin} (mg.dm^{-3})	42	10	3
K (mmol$_c$ dm^{-3})	1.3	0.9	0.5
Ca (mmol$_c$ dm^{-3})	29	14	11
Mg (mmol$_c$ dm^{-3})	13	5	2
CEC (mmol$_c$ dm^{-3})	69	50	48
Base saturation (%)	63	39	28
Clay (g kg^{-1})	253	273	302
Sand (g kg^{-1})	730	710	689
Silt (g kg^{-1})	17	17	9

Potassium is involved in essential physiological and metabolic roles within the alfalfa plant including photosynthesis, ATP production, sugar translocation, starch production, nitrogen fixation, and protein synthesis. A deficiency of K in plants has a major impact in disrupting plant water status, as well as decreasing photosynthetic activity, increasing respiration, slowing growth, and suppressing yields which, in agricultural practice, is expressed as a loss in income for the farmer (Lanyon and Smith, 1985).

Map of Brazil showing the experimental site.

The objective of this study was to evaluate the effect of doses and frequency of application of potassium fertilizer on alfalfa dry matter yield and plant-soil interaction of potassium as measured by alfalfa shoot content and exchangeable soil K.

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Irrigated alfalfa (*Medicago sativa* cv. Crioula) was sown with a planting density of 20 kg ha^{-1} of seed inoculated with *Sinorhizobium meliloti*. Before planting, dolomite lime was applied to increase the base saturation of the soil to 80 per cent. Plots were uniformly fertilized at planting with 120 kg ha^{-1} P_2O_5 (single superphosphate; SSP) and 30 kg ha^{-1} of FTE BR-12 (a micronutrient source; 1.8% of B, 0.8% Cu, 3% Fe, 2% Mn, 0.1% Mo, 9% Zn). Soil liming, phosphorus and micronutrient fertilization were repeated when soil testing indicated any decrease in fertility. The experiment was carried out in 3.2 m^2 plots, formed by eight sowing 2 m-length rows, with a 0.2 m-interlinear space.

The experimental design was in 4X4-factorial randomized blocks with three replications. Treatments comprised four levels of potassium: a control without any potassium treatment; 600, 1,200 and 1,800 kg ha^{-1} of K_2O as KCl; and four frequencies of application: after each cutting (12 applications), after every two cuttings (6 applications), after every three cuttings (4 applications); and after six cuttings (2 applications per year). K doses were split equally by the number of application.

Results and Discussion

Yield

Dry matter yield of alfalfa for the first and second growing seasons, expressed as a function of K fertilizer level and frequency of application, is illustrated in Fig. 1. The highest DM yields in both years (36,890 and 24,131 kg ha^{-1}) were obtained with 1,411 and 1,432 kg ha^{-1} of K_2O respectively applied after every two cuttings (6 applications). These values are approximately 57 and 59 per cent higher than those obtained without potassium fertilizer. The results are consistent with those observed by both Smith (1975) and Rassini and Freitas (1998), who found an increase in alfalfa DM yield as potassium fertilization increased. The yield increases in this study were higher than the increases reported by Kafkafi *et al.* (1977) and Lloveras *et al.* (2001).

The results also indicate that adequate potassium supply increases the stand longevity, as already shown by Smith (1975) and Berg *et al.* (2005). The yield reduction in our experiment from first year to second was greater at the lower levels of potassium fertilization. The smallest yield reduction (-33.5%) was obtained with 1,346 kg ha^{-1} of K_2O applied approximately after two cuttings.

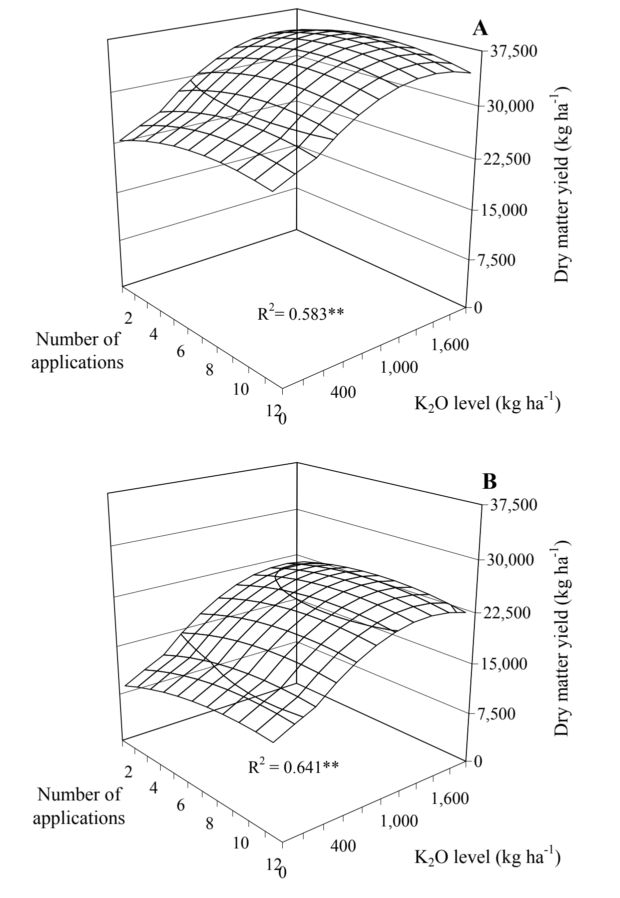

Fig. 1. Alfalfa dry matter yield for 1st (A, top) and 2nd (B, bottom) cropping season.

Equation A: $y=-0.0053K^2+15.895K-73.474T^2+1258.5T-0.134KT+21{,}101$

Equation B: $y=-0.0054K^2+16.985K-60.094T^2+1207.3T-0.182KT+7{,}211$

The large difference in yield between the years is the result of a natural decline induced by repeated cutting of the crop. Stand longevity of alfalfa is of major importance for ranchers with irrigated stands. Alfalfa longevity is limited by a decline in plant population, which results from harvesting or inappropriate grazing management. Additionally, the decline is brought about by diseases, the presence of weeds, insect damage, a fall in soil fertility, and deterioration occurring more rapidly with irrigation (Rice *et al.*, 1989). Longevity is limited and reaches no more than four-to-six years (Humphries *et al.*, 2004).

Maximum K concentrations in alfalfa shoots were 35.2 g kg^{-1} DM, achieved with 1,610 kg K_2O ha^{-1} (Fig. 2). The increase in K concentration (from 20.4 to 35.2 g kg^{-1}) with increasing K fertilization is similar to the results reported by Smith (1975) and Sheaffer *et al.* (1986) on soils responsive to K fertilization. Werner *et al.* (1997), in experiments in Brazil investigating the cationic nutrient composition of alfalfa shoots at the early flowering stage, reported adequate ranges for these nutrients in terms of g kg^{-1} DM as follows: K (20-35), Ca (10-25), and Mg (3-8). Compared with these findings, all our values for K are within an adequate range. However, at higher levels of K fertilization, there is evidence that both Ca and Mg concentrations are lower than the respective adequate ranges for these two nutrients as shown below (Fig. 2). Even at a low rate of K fertilization (100 kg K_2O ha^{-1}), the concentration of Ca in the shoot dry matter was below 10 g kg^{-1} DM. The

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same was true for Mg at less than 3 g Mg kg^{-1} DM but this was at a much higher potassium fertilization level (1,800 kg K_2O ha^{-1}).

Cation competition between K, Ca and Mg uptake by plants is a very well established phenomenon (Mengel and Kirkby 2001) and has been reported in alfalfa by Smith (1975), Lanyon and Smith (1985) and Lloveras *et al.* (2001). Potassium, in contrast to the other two nutrients (in particular Ca), is taken up very rapidly by highly efficient transport systems in the roots. Even though K is usually present in the soil solution in much lower concentrations than Ca or Mg, it is preferentially absorbed by root cells. This preferential K absorption can result, as observed above, in lower concentrations of Ca and Mg in shoots especially in response to increasing K application. Only on soils which are exceptionally high in Mg is there a possibility of any restriction in K uptake by Mg competition.

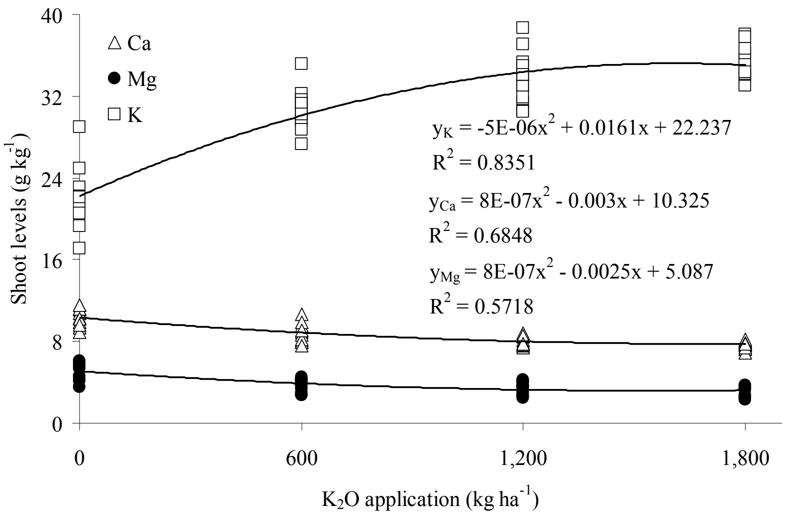

Fig. 2. Concentrations of K, Ca and Mg in alfalfa shoot in relation to potassium fertilizer application. Results from the first cropping season.

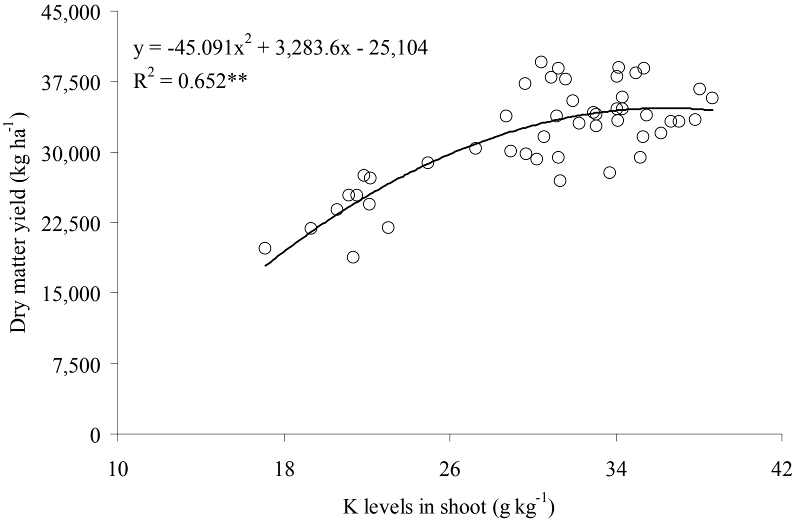

Fig. 3. K concentration in alfalfa shoots in relation to dry matter yield. Results from the first cropping season.

Potassium uptake in relation to exchangeable soil K

The relationship between nutrient concentration and crop yield forms the basis for using plant analysis to assess plant nutrient status. Dry matter production and K levels in the shoot showed a positive correlation (Fig. 3), where yield increased with increasing shoot K concentration. Furthermore, alfalfa plants continue to absorb K even when available K exceeds plant needs. This unique property of K plant uptake called "luxury consumption" (Havlin *et al.*, 1999) was observed in which the alfalfa plants continued to absorb K in excess of needs for dry matter production so that large amounts of K were accumulated without any increase in crop yield. The reasons for this high uptake are not clear but it should be remembered that K fulfills many physiological and biochemical functions, which are not necessarily directed towards dry matter yield production.

The total amount of K removed with the aboveground herbage increased with applied K and frequency of application (Fig. 4), as was observed for dry matter yield. Removal of K_2O reached 704 kg ha^{-1} per year with the application of 1,623 kg K_2O ha^{-1}, as compared with 205 kg K_2O ha^{-1} for the control treatment. Lloveras *et al.* (2001) found linear increases in potassium removal with increased K fertilization.

Potassium fertilization increased the exchangeable K of the soil in all three soil layers measured; the higher the application rate, the higher the exchangeable K value observed (Fig. 5). No difference in soil K_{ex} was found in relation to the number of K applications. Alfalfa has a lower root density than most grasses and generally a deeper rooting zone where soil moisture is available. Despite this deep root system, Peterson *et al.* (1983) reported that alfalfa absorbed K to the

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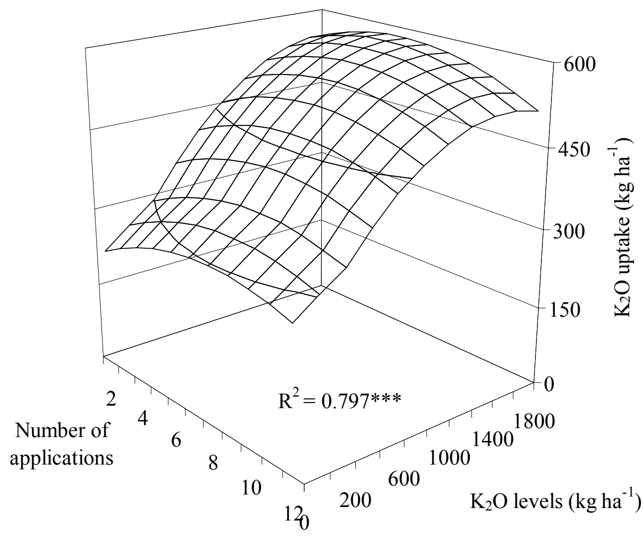

Fig. 4. Alfalfa total K uptake (K_2O units) in aboveground biomass in response to level of K and number of applications. Results from the first cropping season.

$y = -0.0001K^2+0.395K-1.877T^2+30.818T-0.005KT+170.9$

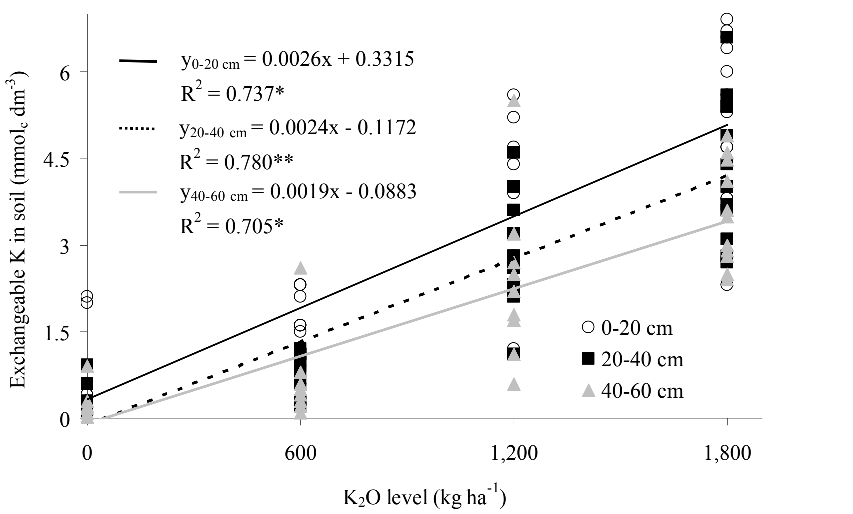

Fig. 5. Exchangeable potassium of the soil measured at three depths in relation to potassium fertilizer application.

greatest extent from the surface soil as compared with the Ap (cultivated soil) and deeper horizons. This finding supports the efficacy of topdressing K fertilizer onto existing stands of alfalfa when needed, as is commonly practiced.

Potassium leaching depends on the concentration of K in the soil solution, the amount of water moving through the soil, and the ability of the soil to bind K (Havlin *et al.*, 1999; Wilcke and Lilienfein, 2005). Considering the high levels of potassium fertilizer used in this experiment and the low ability of tropical soil to adsorb and hold K (due to low cation exchange capacity CEC) it is not surprising that K movement was observed in the soil profile leading to values which are considered high by Raij *et al.* (1997) (>3,1 mmol$_c$.dm^{-3} at 0.2-0.4 and 0.4-0.6m-depths). In our experiment, values of exchangeable K in the soil for achieving the maximum two years-average yield (30.5 mt ha^{-1}) as calculated from equations in Fig. 6 were 3.4; 1.9 and 1.6 mmol$_c$.dm^{-3} K at 0-20, 20-40 and 40-60 cm, respectively.

Conclusions

For both crop seasons, the use of 1,420 kg ha^{-1} per year of K_2O applied after every two cuttings (6 applications per year) markedly increased alfalfa dry matter yield.

Soil exchangeable K increased with increasing K rates to 0.6m depth. The number of applications had no effect on this and at all K rates, the 0-20 cm layer was enriched to a greater extent than the 20-40 cm, which in turn was enriched to a greater extent than the 40-60 cm layer.

Results from the first cropping season indicate that total alfalfa shoot K removal reached 704 kg ha^{-1} of K_2O with the application of 1,623 kg ha^{-1} of K_2O per year. Potassium fertilizer recommendations should take into account the high removal rates at harvest, as well as potential leaching.

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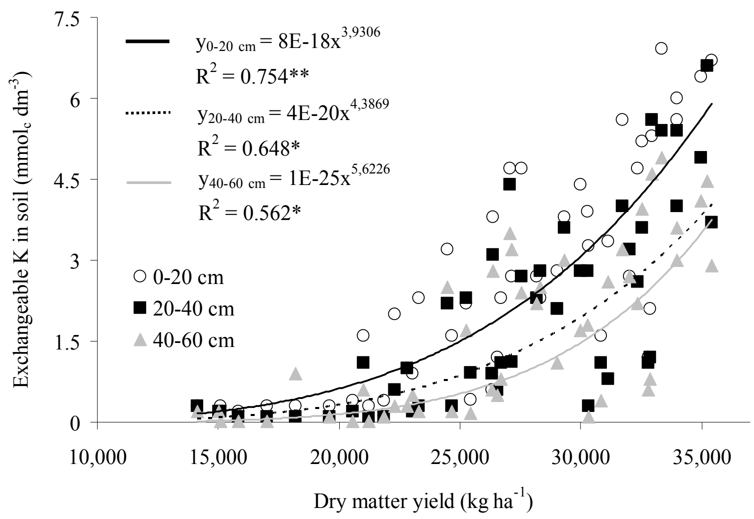

Fig. 6. Alfalfa dry matter yield as a function of exchangeable K of the soil at three soil depths.

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The paper "Potassium Doses and Frequency of Application to Alfalfa Growing on a Brazilian Tropical Soil: Influence on Dry Matter Yield and K Content of the Harvested Crop and Exchangeable soil K" appears also at:

Regional Activities/Latin America

Cattle feeding on fertile alfalfa fields. Photo by A. Bernardi.

IPI Events

November 2009

IPI-OUAT-IPNI International Symposium on "Potassium Role and Benefits in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damages", 5-7 November 2009, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, India.

See the 2nd circular on the IPI website.

The symposium will be organized by the International Potash Institute (IPI), International Plant Nutrition Institute (IPNI), and the Orissa University of Agriculture & Technology (OUAT). It is co-sponsored by the Indian Council of Agricultural Research (ICAR), Fertilizer Association of India (FAI), Bangladesh Fertilizer Association (BFA) and the Pakistan Agricultural Research Council (PARC). The scientific committee, chaired by Dr. J.S. Samra, has selected the following sessions: 1) Nutrient management to meet challenges of food security; 2) Potassium and nutrient use efficiency; 3) Role of potassium and mineral nutrition in alleviation of stress; 4) The effect of quality and nutritional value of agricultural products on human health: the role of potassium; 5) Spatial variability of soil properties and Site Specific Nutrient Management (SSNM); 6) The role of extension in increasing agricultural productivity; 7) Potassium and the environment; and 8) Nutrient mining and input-output balances.

The draft program is available on IPI website.

More details will appear regularly on IPI and IPNI websites. ■

March 2010

IPI, together with the Soil Science Association of El Salvador, is organizing a regional symposium titled "Importance of Soil Management and Potash Fertilization for Sustainable Agricultural Development of Central America and the Caribbean". For more details see IPI website or contact IPI Coordinator Dr. A. Naumov. ■

Other Events

August 2010

19th World Congress of Soil Science, 1-6 August 2010, Brisbane Convention and Exhibition Centre, Queensland, Australia. For more details see congress website.

New Publications

Kálium - Minőség és termésbiztonság a burgonyatermesztésben - Potassium Quality and Harvest Assurance in Potato Cropping. Terbe István, 4 pages. In Hungarian. 2008. Download from IPI website■

A kálium garancia a zöldségtermesztésben a termésminőségre és a termésbiztonságra - Potassium - a Guarantee for Yield Quality and Yield Security in Vegetable Cropping. István Terbe, 6 pages. In Hungarian. 2009. Download from IPI website ■

Potassium Deficiency Symptoms in Crops. Abdallah Hammam Abdel Hadi, Mohamed Saleh Khedr and Attiat Abou Bakr Abdel Aty. Edited by Abdallah Hammam Abdel Hadi. In Arabic. This booklet contains a brief summary of plant nutrition (optimum concentration levels of nutrients for various crops), the role of nutrients in plants and its deficiency symptoms (with photos), the relationship between certain nutrients and infection with diseases and insects, and finally, fertilizer requirements for most important field, vegetable, and horticultural crops. To receive a copy, contact the Soil Water and Environment Research Institute (SWERI), 9 El Gamma Street, Giza, Egypt, Postal code: 12619; Fax: 02-5720607; e-mail: Sweriswerі@hotmail.com ■

Publications by the PDA

The Potash Development Association (PDA) is an independent organisation formed in 1984 to provide technical information and advice in the UK on soil fertility, plant nutrition and fertilizer use with particular emphasis on potash. See also www.pda.org.uk/.

Note: Hardcopies of PDA's publications are available only in the UK and Ireland.

- **Some frequently asked questions about P and K.** See www.pda.org.uk/news/nf70.asp
- **Nutrient management risks for major crops.** See www.pda.org.uk/news/nf69.asp
- **Cereal straw - nutrient contents.** See www.pda.org.uk/news/nf65.asp ■

K in the Literature

Doses e formas de aplicação da adubação potássica na rotação soja, milheto e algodão em sistema plantío direto; Potassium Fertilization of Soybean, Pearl Millet, and Cotton in a No-Till Rotation System in the *Cerrado* Region.

Alberto Carlos de Campos Bernardi, Juarez Patrício de Oliveira Júnior, Wilson Mozena Leandro, Tiago Gomes da Silva Mesquita, Pedro Luiz de Freitas, Maria da Conceição Santana Carvalho. *Pesquisa Agropecuária Tropical* v. 39, n. 2, p. 158-167, abr./jun. 2009. In Portuguese, abstract in English. ISSN 1517-6398 / e-ISSN 1983-4063. This paper is based on a project supported by IPI.

www.revistas.ufg.br/index.php/pat/article/view/3519/4782

Abstract:

The main objective of this study was to evaluate the efficiency of potassium fertilizer application, as related to rate, placement (in-row, broadcast, and split topdress) and time (before sowing, at sowing, and topdressing), in a soybean, pearl millet, and cotton no-till rotation system, in a typic dystrophic Red Latosol (Hapludox), in Turvelândia, Goiás State, Brazil (17°51'S, 50°18'W). The experimental design was a factorial randomized block, with 4 replications. Potassium source was KCl. Potassium was applied to soybean (0 kg ha^{-1}, 30 kg ha^{-1}, 60 kg ha^{-1}, and 180 kg ha^{-1} of K_2O) in the planting row or broadcasted before sowing, at sowing, or topdressed. For cotton, the K rates were 0 kg ha^{-1}, 60 kg ha^{-1}, 120 kg ha^{-1}, and 240 kg ha^{-1} of K_2O, applied before sowing and placed in the planting row, with none or one topdressing, or split in two applications. The pre-planting cotton K was applied in the pearl millet. There was no effect of potassium fertilization on soybean yield. As a cover crop, pearl millet used, more efficiently, the 60 kg ha^{-1} of K_2O rate. Results showed that the best cotton agronomic efficiency was obtained with 146 kg ha^{-1} of K_2O, supplied before sowing. Results also showed positive effects of potassium fertilization on cotton fiber quality. ■

Correlation and Calibration of Soil Potassium Availability with Rice Yield and Nutritional Status. Slaton, N.A., B.R. Golden, R.J. Norman, C.E. Wilson Jr., and R.E. DeLong. Soil Sci. Soc. Am. J. 73(4):1192-1201. 2009. English.

dx.doi.org/10.2136/sssaj2008.0200

Abstract:

Soil testing is an important tool for estimating soil K availability and determining how much fertilizer must be applied to realize crop yield potential and minimize fertilizer costs. Our primary objectives were to correlate relative rice (*Oryza sativa* L.) yield with Mehlich-3 and 1 mol L^{-1} HNO_3 extractable K, define sufficient whole-plant K concentrations at panicle differentiation (PD) and early heading (HDG), and calibrate K-fertilizer rates with Mehlich-3 soil K in the direct-seeded, delayed-flood rice production system. Potassium rate experiments were established at 32 site-years on silt loams in eastern Arkansas. Relationships between selected parameters were evaluated with linear, curvilinear, and linear-plateau models. The relationships between relative yield regressed against Mehlich-3 and HNO_3 extractable K were significant and curvilinear. The final curvilinear models for Mehlich-3 and HNO_3 K explained 63 and 43% of yield variability among site-years, with predicted critical soil concentrations to produce 95% relative yield of 99 and 390 mg K kg^{-1}, respectively. Linear-plateau models provided comparable critical soil K concentrations. Rice having whole-plant K concentrations of 23.1 g kg^{-1} at PD and 13.0 g kg^{-1} at HDG were predicted to produce 95% relative yield. The predicted K-fertilizer rates required to optimize rice grain yield depended on the model and ranged from 51 to 90, 41 to 70, 30 to 55, and 20 to 35 kg K ha^{-1} for soil having Mehlich-3 soil K concentrations of 60, 70, 80, and 90 mg K kg^{-1}, respectively. The suggested Mehlich-3 soil and plant K critical concentrations should be appropriate for other U.S. mid-South rice-producing areas using similar cultural production practices. ■

Effects of N, P and K Application on Merchandise Properties and Yields of Welsh-Onion (*Allium fistulosukm*). Lin, C.H., Y.L. Bai, G.A. Luo, and Z.J Xie. Plant Nutrition and Fertilizer Science 15(3):649-655. 2009. Chinese.

www.plantnutrifert.org/en/search_gkll.asp?sel_niandu=2009&sel_qihao=3&sel_kanchurq=2009-5-25

Abstract:

The effects of N, P and K application on stem length, stalk width, yield of welsh onion (*Allium fistulosukm*) and benefit of the fertilization were studied in the field by using the 311-A optimum regression design of supposed saturation. The results show that the optimum N, P and K application amounts for the maximum stem length of welsh-onion (92.88 cm) are N 371.30, P_2O_5 157.50, and K_2O 309.58 kg/ha; the optimum application amounts for the maximum stalk width of the crop (1.769 cm) are N 350.63, P_2O_5 157.50, and K_2O 225.00 kg/ha; and those for the maximum yield (55805.06 kg/ha) are N 394.08, P_2O_5 193.62, and K_2O 225.00 kg/ha. The optimum N, P and K application amounts for the best fertilization benefit are N 391.35, P_2O_5 192.97 and K_2O 225.00 kg/ha. The best fertilization benefit is about 136865.6 Yuan/ha with a yield of 55802.74 kg/ha. ■

Effect of Combined K and N Application on Yield, Qualities and K Absorption of Ginger. Li, L.J., J.Y. Jin, F. Chen, R.L. Liu, N. Ding, and X.S. Guo. Plant Nutrition and Fertilizer Science 15(3):643-648. 2009. Chinese.

K in the Literature

www.plantnutrifert.org/en/search_gkll.asp?sel_niandu=2009&sel_qihao=3&sel_kanchurq=2009-5-25

Abstract:

Field experiment was carried out to study the effect of combined potassium (K) and nitrogen (N) application on yield, qualities and K uptake in ginger (*Zingiber officinale*) rhizome. The results showed that there was an obvious response of ginger growth and qualities to the combined N and K application. A suitable rate and ratio of K and N combined application could obviously promote ginger growth, increase rhizome yield, improve nutrition qualities and enhance K recovery efficiency. The rhizomatous yield and its components increased with the increase of K application rates as it applied with less than K_2O 450 kg/ha. The largest values of plant height, branches number, stem diameter, dry weight of shoot and weight of single rhizome were found in K_{450} (medium K application rate). The maximum rhizomatous yield was attained by the treatment $N_{450}K_{450}$. The results of quality analyses indicated that a suitable K and N application ratio could improve the nutrition qualities by increasing the content of vitamin C and sugar and dropping the concentration of nitrate in ginger rhizome. Combined application of N and K increased the content of vitamin C in rhizome compared single K application, and the highest content was obtained by the treatment of K_{450}. But there were no significant effects of raising N application rate to vitamin C. K application increased the concentration of soluble sugar and sucrose, but it differed with the combined N and K application rate. The concentration of nitrate increased significantly with the increase of N application rate at low K application, but it showed an opposite trend with high K application rate. The lowest content of nitrate was attained in $N_{375}K_{375}$ and $N_{450}K_{450}$. K application significantly improved the concentration of K in ginger shoot, rhizome and total plant, and enhanced K absorption compared to control. The concentration and uptake of K in ginger shoot, rhizome and total plant also increased obviously as increased N application rate at the same K application rate. The agricultural efficiency of K was highest in K_{450} and it declined with the increase of K application rate at low rate of N application. The highest K recovery efficiency was obtained in K_{450} with two N application rates. ■

Effect of Free Air Carbon-Dioxide Enrichment on Soil Available K in Rice-Wheat Rotation System. Ma, H.L., J.G. Zhu, Z.B. Xie, G. Liu, and Q. Zeng. Plant Nutrition and Fertilizer Science 15(3):607-612. 2009. Chinese.

www.plantnutrifert.org/en/search_gkll.asp?sel_niandu=2009&sel_qihao=3&sel_kanchurq=2009-5-25

Abstract:

The effect of elevated athmospheric CO_2 on soil available K in paddy soil through FACE (Free air carbon dioxide enrichment) system was studied by comparing the contents of soil available K at different growth stages of the rice-wheat rotation system. The results show that compared to the ambient air treatment, K uptakes of the crops are increased by elevated CO_2 due to significant increase of their biomass, while the contents of soil available K of both upper soil layer (0-5 cm) and lower soil layer (5-15 cm) are not decreased. The increase magnitudes of soil available K due to elevated CO_2 are 6.3%-22.3% in root rhizosphere and 3.7%-11.2% between crops lines. The increment of soil available K around wheat roots is higher than that of rice. These results indicate that root increased by elevated CO_2 is beneficial to soil available K for crops, and K is not a limited factor for response of crops to elevated CO_2 in a short time. However, this phenomenon may have negative effects for soils with poor fertility. ■

Effects of Different Magnesium Nutrition on Root Growth and Physiological Characteristics of Rice. Ding, Y.C, W. Luo, X.L. Ren, and G.H. Xu. Plant Nutrition and Fertilizer Science 15(3):537-543. 2009. Chinese.

www.plantnutrifert.org/en/search_gkll.asp?sel_niandu=2009&sel_qihao=3&sel_kanchurq=2009-5-25

Abstract:

Magnesium (Mg) is one of the essential nutrients for higher plants. It plays an essential role in photosynthesis and many other metabolic processes. Rice (*Oryza sativa* L.) plants were grown in hydroponics culture at three Mg^{2+} levels under a greenhouse conditions to investigate the effects of different Mg concentrations on root growth, Mg uptake and some related physiological characteristics of rice. The results showed that root dry matter weight, root to shoot ratio, total root length, root activity, bleeding sap flow rate, the concentrations of total free amino acids and Mg in bleeding sap, Mg influx rate and Mg uptake rate of rice were significantly related to Mg supply levels. At low Mg^{2+} supply (0.05 mmol/L), rice plants partitioned larger proportion of dry matter to the roots causing to an increase of total root length and root to shoot dry weight ratio before Mg deficiency in rice leaves, which might be one of adaptive low-Mg-stress mechanisms of rice at early growth stage. Moderate Mg^{2+} supply (1.0 mmol/L) was able to promote plant growth and development, increase dry matter yield, and enhance root activity and bleeding sap rate as well as the total free amino acids contents. Root activity and amino-synthesized power might be restained to a certain extend by low or high levels of Mg^{2+} (5.0 mmol/L). The results also showed that Mg uptake, Mg concentrations in the bleeding saps,

K in the Literature

average Mg influx rate and the Mg uptake rate were significantly increased with an increase of Mg^{2+} concentrations in the nutrient solution. ■

Productivity Enhancement of Jute through Balanced Application of N, P and K. Mahapatra, B.S., S. Mitra, M. Saha, A.R. Saha, and M.K. Sinha. Indian J. of Fertilisers 5(7):31-34&37-40&51. 2009. English.

Abstract:

The impact of balanced application of N, P and K on productivity of jute and jute based cropping systems had been evaluated. The contribution of fertiliser application to fibre yield of jute was found highest and was closely followed by weed management in farmer's field at North 24 Paragana district of West Bengal. The yield response of tossa jute was found to be 13.8, 10.2 and 7.5 kg of fibre to per kg of fertiliser N, P and K applied respectively. The slow release N fertilisers were found more effective in increasing jute yield than urea. The critical limit of soil P for jute had been estimated as 24 kg P_2O_5 ha^{-1}. The requirement of N, P_2O_5, and K_2O to produce one kg dry fibre was found to be 2.06, 1.66 and 5.18, in olitorius and 3.14, 1.50 and 7.97 kg in capsularis, respectively. The soil test based fertiliser application increased crop yield, improved the availability of nutrients in soil and also increased the net return of jute and jute based cropping systems. A declining trend in jute yield over a period of 34 years was observed even at 150% level of chemical fertiliser application while the Sustainable Yield Index (SYI) was maintained with addition of organic matter. Integrated nutrient management was found to increase the Fluoroscene Diacetate Hydrolyzing Activity (FDHA), Dehydrogenase Hydrolyzing Activity (DHA), urease and acid phosphatase activity in jute soil. ■

Potassium Dynamics in Root-Zone and Non Root-Zone in Yellow Cinnamon Soil with Paddy-Upland Rotation. Li, X.K., J.W. Lu, L.S. Wu, F. Chen, R.H. Cong, Z.W. Liao, and C.C. Jiang. Plant Nutrition and Fertilizer Science 15(4):850-856. 2009. Chinese.

www.plantnutrifert.org/en/search_gk11.asp?sel_niandu=2009&sel_qihao=4&sel_kanchurq=2009-7-25

Abstract:

Potassium dynamics in the root-zone and the non root-zone in yellow cinnamon soil with a rapeseed-rice rotation system was studied through a rhizobox device to provide evidence for research on soil K supplying mechanism and reasonable control of rhizosphere nutrition. The results show that soil water soluble K and exchangeable K in the root-zone are reduced at early stage of rapeseed growth under the rapeseed-rice rotation. Along with rapeseed growth and K uptake, soil non-exchangeable K in the root-zone are also decreased significantly. Soil water soluble K in the inner (0-20 mm), middle (20-40 mm) and outer (40-60 mm) parts of the non root-zone are moved forward to the root-zone. Soil exchangeable K and non-exchangeable K are transformed to water soluble K and decreased gradually. In the early stage of rice growth, water-log cultivating practice promotes the diffusion of soil water soluble K from the non root-zone to the root-zone and transition of exchangeable K to water soluble K. Along with the growth of rice and more K uptake, soil non-exchangeable K in each part is decreased significantly, while soil water soluble K and exchangeable K are not decreased. These results indicate that K uptake by crops is mainly contributed by the root-zone, and K in the non root-zone can be moved to the root zone gradually depending on the distance. Within the rotation system, soil non-exchangeable K is the main potassium source, followed by soil exchangeable K and water soluble K. ■

Effects of Long-Term Potassium Application on Q/I Relationship of Potassium in Soil Under Wheat-Corn Cropping System. Zhang, H.M., M.G. Xu, B.R. Wang, S.M. Huang, and X.Y. Yang. Plant Nutrition and Fertilizer Science 15(4):843-849. 2009. Chinese.

www.plantnutrifert.org/en/search_gk11.asp?sel_niandu=2009&sel_qihao=4&sel_kanchurq=2009-7-25

Abstract:

Quantity/intensity (Q/I) relationship of potassium (K) in soil was evaluated under a long-term K fertilization experiment. Soil samples collected from the NP and NPK treatments in the three soils (manural loess soil, fluvo-aquic soil and red soil) were analyzed for revealing the Q/I relationship of K, and the relationships between Q/I parameters and soil properties using Q/I approach under a 15 year wheat-corn cropping system. The values of K^+ equilibrium activity ratio (AR_0), soil labile K (K_L), non-specific K ($-\Delta K_0$), and specific K (K_X) in the NPK treatments are larger than those in the NP treatments. The AR_0 and $-\Delta K_0$ values in the NPK treatments are 13.78 and 12.17 times larger than those in the NP treatments in red soil. The potential buffering capacity (PBC) is decreased (ranging from 17% to 20%) in the NPK treatments in manural loess soil and fluvo-aquic soil, and is not changed in red soil compared with those in the NP treatments. Free energies of K^+ exchange for Ca^{2+} and Mg^{2+} ($-\Delta G$) in the treatments with K fertilization are lower than those in the treatments without K application (12.15~12.81 vs 13.69~19.33 kJ/mol). There are significant correlations between the Q/I parameters and the 1 mol/L HNO_3 extractable K, K^+ saturation and soil organic matter. The Q/I parameters provide useful

K in the Literature

information for understanding the soil K status. Soil K supplying power is increased due to the long-term K fertilization, while, continuous cropping without K inputs could cause the remarkable depletion of available K especially in the fluvo-aquic soil and red soil. ■

Potassium Fertilisation Recommendations for Crops Need Rethinking. Prasad, R. Indian J. of Fertilisers 5(8):31-33. 2009. English.

Abstract:

Potassium is an essential plant nutrient and adequate K fertilisation is must for successful crop production. Current recommendations for K fertilisation are based on exchangeable-K in surface 0-15 cm soil. However, available reports suggest that non-exchangeable-K and sub-soil K contributes significantly towards K uptake by crops. These factors therefore need to be taken into account along with exchangeable-K for making fertiliser recommendations for crops. Red and lateritic soils, which occur in east, northeast and southern India, are the poorest in K and need K fertilisation beyond the standard N:P:K ration 4:2:1. Black soils, which have a high exchangeable-K content are poor in non-exchangeable-K and total K and therefore need adequate K fertilisation to prevent K mining of soils. ■

Typical maize OPV grown in Mozambique. First priority is to fill the grains. Organic food may come later. Photo by IPI.

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Clipboard

Soil Friends Club of Rio Verde, IPI and the National Soils Research Center of EMBRAPA award on "Sustainability in No-Till Systems"

Ms. Graciely Vilela Gomes (right) receives the award from Mr. Charles Peeters, President of the 9th Meeting of No-Till at Rio Verde, who is also currently President of the Soil Friends Club (left). Photo by V.M. Benites.

An award for "Sustainability in No-Till Systems" was recently presented to Ms. Graciely Vilela Gomes, MSc during the 9th Meeting of the Brazilian No-Till Association. The meeting was held on the 10-12th August 2009 at Rio Verde in Goias state, Brazil. The award, established by the Soil Friends Club of Rio Verde, IPI, and the National Soils Research Center of EMBRAPA (Brazilian Corporation for Agricultural Research), invites papers focusing on innovations in no-till practices based on academic research and on-farm experiments. No-till veterans and advanced farmers from the region evaluated almost 30 papers (28 manuscripts) presented by candidates from Rio Verde and other municipalities in Goias and Sao Paulo states. The paper submitted by Graciely Vilela Gomes, who recently graduated from the Federal University of Rio Verde (FESURV) on the "*Importance of Brachiaria for soil fertility in no-till system*", was selected as the best paper. The research conducted by Ms. Gomes during the 2008/2009 agricultural season, was supported by the AGRISUS Foundation, and the soil and plant analyses were conducted as part of the joint IPI-EMBRAPA project "Fertilize Brazil". The results of this research show that in fields under an integrated cropping-pasture system, where *Brachiaria* was planted as a cover crop before soybean and maize, concentration of potassium and organic matter are higher in the upper layers of soil horizon, which enables higher yields of grains. ■

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