2016 Fluid Fertilizer Foundation Report

Benefits of Using Liquid Sources of Potassium Fertilizer in Highbush Blueberry (Year 1)

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Introduction

Consumption of blueberries has increased rapidly in recent years, primarily due to promotion of their health benefits and to greater availability of the fruit year round. Currently, there are more than 250,000 acres of cultivated blueberry (*Vaccinium* sp.) grown worldwide, and projections indicate that usage will nearly triple over the next decade (Brazelton, 2015). Eighty-one percent of the crop is produced in North and South America, but plantings are expanding into less traditional growing regions, including Mexico, Brazil, Peru, southern Europe, northern and southern Africa, Asia, and Australia. By 2019, total global production is predicted to reach 770,000 tons of blueberries per year.

Blueberry is a long-lived perennial crop (30+ years) categorized as a calcifuge, well-adapted to acidic soil conditions (pH 4.5–5.5). Plants acquire primarily the NH_4 form of N over NO_3-N and tolerate relatively low levels of P, K, Ca, and Mg in the soil and high concentrations of plant-available metals such as Mn and Al (Korcak, 1988). Recently, we determined that drip fertigation with various fluid NH_4-N sources, including ammonium sulfate, urea, and urea sulfuric acid, produced more growth and greater yield than conventional granular fertilizers in highbush blueberry (Bryla and Machado, 2011; Ehret et al., 2014; Vargas and Bryla, 2015). We also discovered that humic acids used in combination with liquid N fertilizers during fertigation nearly doubled root production during the first 2 years after planting relative to using the N fertilizers only (Bryla and Strik, 2015). Many blueberry growers throughout the United States are now using fertigation, even in colder growing regions, such as Michigan, where sprinklers are required for frost protection. In this case, growers are investing in dual-irrigation systems to enable them to irrigate and fertigate by drip and use the sprinklers primarily for frost protection and fruit cooling.

Currently, we are interested in evaluating fertigation in blueberry with nutrients other than N, including cations such as K. Despite the relatively low requirements, K deficiency may occur in highbush blueberry in many regions, depending on soil type and production. Factors contributing to deficiency include poor soil drainage, drought, very low soil pH, and heavy crop loads. Plants in sandy soils with low organic matter content are particularly susceptible to K deficiency. Symptoms include leaf cupping and scorched leaf margins and often resemble drought damage in blueberry. Younger leaves near the shoot tip may develop interveinal chlorosis similar to Fe deficiency (Hanson and Hancock, 1996). Despite the potential for K deficiency, very little research has been done with K in blueberry. Application of K fertilizer increased yield of 'Bluecrop' blueberry in Michigan when soil K was low ($0.001-0.03\ g\cdot kg^{-1}$) (Eck, 1983) but had no effect on yield of 'Jersey' blueberry when soil K was higher ($0.03-0.08\ g\cdot kg^{-1}$) (Hancock and Nelson, 1988).

Recently, we examined nutrient uptake in a new planting of 'Bluecrop' blueberry and found that the total K requirements during the first 2 years was 11.2 lb/acre (Bryla et al., 2012).

This was equivalent to approximately 19% of the total K fertilizer applied (i.e., 60 lb/acre of K each spring). Mature plants require much more K due to the high K content in the fruit (>60 mg/berry). The current recommendation for mature blueberry plantings is to apply 75−100 lb/acre of K when soil K is <100 ppm or leaf K is below 0.2%, and to apply 0−75 lb/acre of K when soil K is 100−150 ppm or leaf K is 0.2−0.4% (Hart et al., 2006). This recommendation is derived from anecdotal evidence collected from commercial plantings irrigated by sprinklers and fertilized using granular fertilizers. While this has been the traditional method of managing blueberries, most new fields are now irrigated by drip and, as mentioned, fertigated using liquid fertilizers. Blueberry roots are much more restricted with drip than with sprinklers, and therefore, plants could be easily exposed to nutrient limitations of diffusion-limited ions with slow soil release rates such as K^+. Fertigation using a fluid K fertilizer would ensure continuous supply of the nutrient required for plant growth and fruit production and increase movement of K in the soil profile (Burt et al., 1998).

Potassium is usually applied to blueberry as potassium sulfate. Potassium chloride (muriate of potash) is also used occasionally, but it is not recommended because blueberry is thought to be very sensitive to chloride. Other potential sources of K include mono potassium phosphate, which is largely a source of P, and potassium thiosulfate (KTS). The latter may be particularly useful in high pH soils, such as those in California and eastern Oregon and Washington, because the product is acidifying (thiosulfate is oxidized by *Thiobacillus* bacteria to produce sulfuric acid). Potassium nitrate is also a popular K fertilizer available for fertigation, but it is expensive and a poor N source (i.e., NO_3-N) for blueberry. The goal of proposed project is to develop guidelines for K fertigation in in northern highbush blueberry (*Vaccinium corymbosym* L.). The results of the first year of the project are presented in this report.

Objectives

1. The objective for the first year was to evaluate potassium sulfate and KTS with common sources of N fertilizers used for fertigation in blueberry, including liquid urea and solutions of ammonium sulfate (AS), ammonium thiosulfate (ATS), urea ammonium nitrate (UAN), and a slow-release fluid N source (urea triazone).
2. The objective for the next 2 years will be to evaluate potassium sulfate and KTS in mature plantings of blueberry at two sites, including one with low soil K and the other with adequate K.

Materials and Methods

The first phase was conducted in a climate-controlled greenhouse located at the USDA-ARS Horticultural Crops Research Unit in Corvallis, OR.

Young plants of 'Duke' blueberry (one of the most common cultivars grown worldwide) were transplanted into 1-gallon pots filled with one of two different soil types, a Willamette silt loam that had an optimum pH of 4.9 for blueberry, and Malabon silty clay loam with a high pH of 6.2. After a month of establishment, treatments were arranged in a completely randomized design and included a combination of the two soil types, two liquid K sources [(potassium sulfate and potassium thiosulfate (KTS)], five liquid N sources [urea, ammonium sulfate, ammonium thiosulfate (ATS), urea ammonium nitrate (UAN), and urea-triazone (slow-release N); 0.10 $g \cdot L^{-1}$ N each), and five K rates (0, 0.05, 0.10, 0.15, and 0.20 $g \cdot L^{-1}$). Each treatment was replicated five times for a total of 500 plants. The plants were fertigated three times per week with each combination of K and N fertilizer, plus a modified Johnson's solution to avoid limitations of other nutrients.

Plant growth was monitored weekly by counting leaves and measuring the length of each cane. Soil solution was collected weekly using 10-cm (4-inch) long hydrophilic porous polymer soil moisture samplers (Eijkelkamp Agrisearch Equipment) and analyzed for pH, EC_w, NH_4- and NO_3-N, and K (Bryla et al., 2009). The samplers were installed vertically midway between the plant and the edge of the pot. At 60 days after the treatments were initiated, the plants were harvested destructively and divided into individual plant parts (leaves, stems, crown, and roots). Parts were pooled and oven-dried, weighed, and are currently being analyzed for N and S by combustion analysis and for other nutrients by ICP (Gavlak et al., 2005).

Results and Discussion

The pH of the soil solution was generally greater in the Willamette soil than in the Malabon soil (Fig. 1). In both case, fertigation with ATS and/or KTS reduced pH by at least a unit within 1–3 weeks in both of the soils (Fig. 1). As mention, blueberry prefers a soil pH of 4.5–5.5. Typically, pH is about a unit greater in the soil solution than in soil in these two soil types. Thus, in terms of soil solution, the optimum combination of N and K was urea and KTS in the in the Willamette soil and ammonium sulfate and KTS in the Malabon soil. Each resulted in a relatively stable pH during fertigation with a range considered ideal for blueberry

In no case did electrical conductivity (EC_w) of the soil solution ever exceed 2 dS m^{-1} (Fig. 2). Previously, we determined that blueberry was sensitive to EC_w levels > 2.0 $dS \cdot m^{-1}$ and should be fertigated with solutions containing no more than 0.3 $g \cdot L^{-1}$ of NH_4-N (Bryla et al., 2014).

On average, the concentration of K in the soil solution increased by 25% with potassium sulfate and by 39% with KTS, and was highest when KTS was applied with urea or ammonium sulfate (Fig. 3). The concentration of Ca and Mg also increased with the K fertilizers and was greater with KTS (Figs. 4 and 5).

There were only limited effects of the treatments on plant growth (Table 1). This is not surprising given that the study was conducted for only 2 months on woody perennial. We the complete the nutrient analysis of each tissue (leaves, stems, and roots) this spring.

Conclusion and Future Directions

Overall, KTS appears to be a good source of K for fertigation in blueberry and is recommended for use with urea on soils with optimum pH (4.5–5.5) and with ammonium sulfate on soils with high pH. The second phase (objective 2) will be initiated this April, at the beginning of the blueberry growing season, and will continue for at least 2 years. We will monitor plant and soil nutrition, yield, and berry quality (Brix, firmness, TA) and storage. The results will help growers improve production in the crop and enhance fruit quality for consumers.

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Table 1. Total dry weight of 'Duke' blueberry plants grown in two soil types (Willamette silt loam and Malabon silty clay loam) and fertigated with a combination of three potassium (K) treatments [no K, potassium sulfate (K_2SO_4), potassium thiosulfate (KTS)] and five different sources of nitrogen (N) fertilizer (ammonium sulfate, ammonium thiosulfate, urea, urea ammonium nitrate (UAN), and urea triazone).

			Total dry wt (g/plant)[z]				
Soil type	K treatment	K rate ($g \cdot L^{-1}$)	Ammonium sulfate	Ammonium thiosulfate	Urea	UAN	Urea triazone
Willamette silt loam	No K	0	8.03	5.71	7.05	6.36	7.07
Willamette silt loam	K_2SO_4	0.05	6.41	4.72	7.28	8.74	8.25
Willamette silt loam	K_2SO_4	0.10	6.24	5.71	8.14	6.38	7.43
Willamette silt loam	K_2SO_4	0.15	7.12	6.81	7.28	7.41	6.24
Willamette silt loam	K_2SO_4	0.20	7.30	7.02	7.37	8.13	6.11
		Avg	6.77	6.07	7.52	7.67	7.01
Willamette silt loam	KTS	0.05	6.10	6.83	7.40	6.75	7.41
Willamette silt loam	KTS	0.10	6.32	5.98	7.40	7.58	7.14
Willamette silt loam	KTS	0.15	6.52	6.52	7.75	7.01	6.95
Willamette silt loam	KTS	0.20	5.85	5.69	7.02	6.84	6.95
		Avg	6.20	6.26	7.39	7.05	7.11
Malabon silty clay loam	No K	0	5.85	7.28	6.66	7.31	5.33
Malabon silty clay loam	K_2SO_4	0.05	6.46	7.44	5.79	7.15	7.76
Malabon silty clay loam	K_2SO_4	0.10	6.69	6.91	7.56	6.59	6.56
Malabon silty clay loam	K_2SO_4	0.15	5.40	6.09	5.54	6.24	5.07
Malabon silty clay loam	K_2SO_4	0.20	5.89	6.87	7.45	7.12	6.88
		Avg	6.11	6.83	6.59	6.78	6.57
Malabon silty clay loam	KTS	0.05	7.74	7.34	6.43	5.94	6.97
Malabon silty clay loam	KTS	0.10	5.90	4.59	7.14	6.02	5.52
Malabon silty clay loam	KTS	0.15	5.85	5.76	6.54	6.40	6.81
Malabon silty clay loam	KTS	0.20	7.20	5.88	7.15	6.36	6.43
		Avg	6.67	5.89	6.82	6.18	6.43

[z]Includes leaves, stems, and roots.

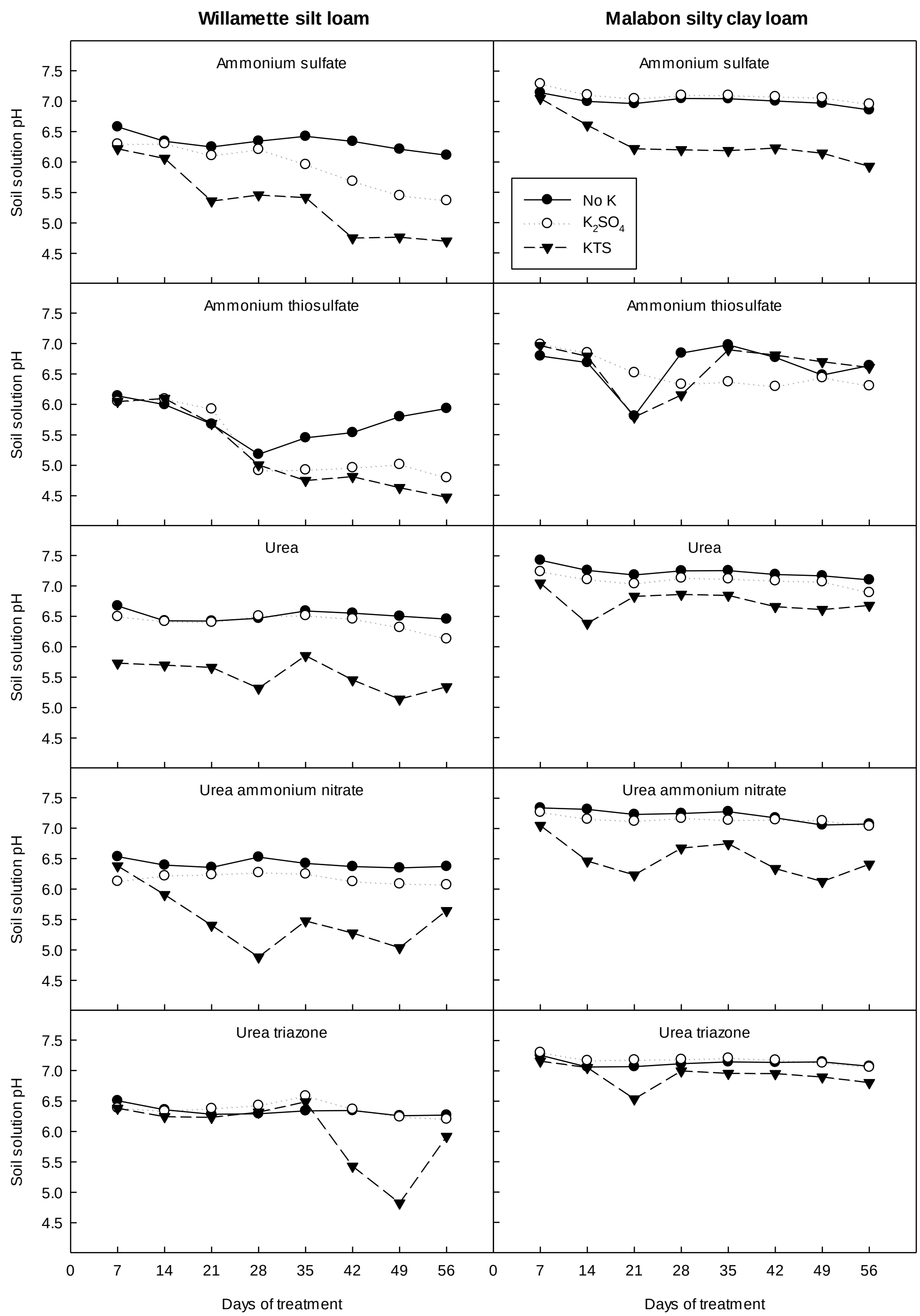

Fig. 1. The pH of the soil solution in pots of 'Duke' blueberry. The plants were grown in two soil types (Willamette silt loam and Malabon silty clay loam) and fertigated with a combination of three potassium (K) treatments4 [no K, potassium sulfate (K_2SO_4), potassium thiosulfate (KTS)] and five different sources of nitrogen (N) fertilizer (ammonium sulfate, ammonium thiosulfate, urea, urea ammonium nitrate, and urea triazone).

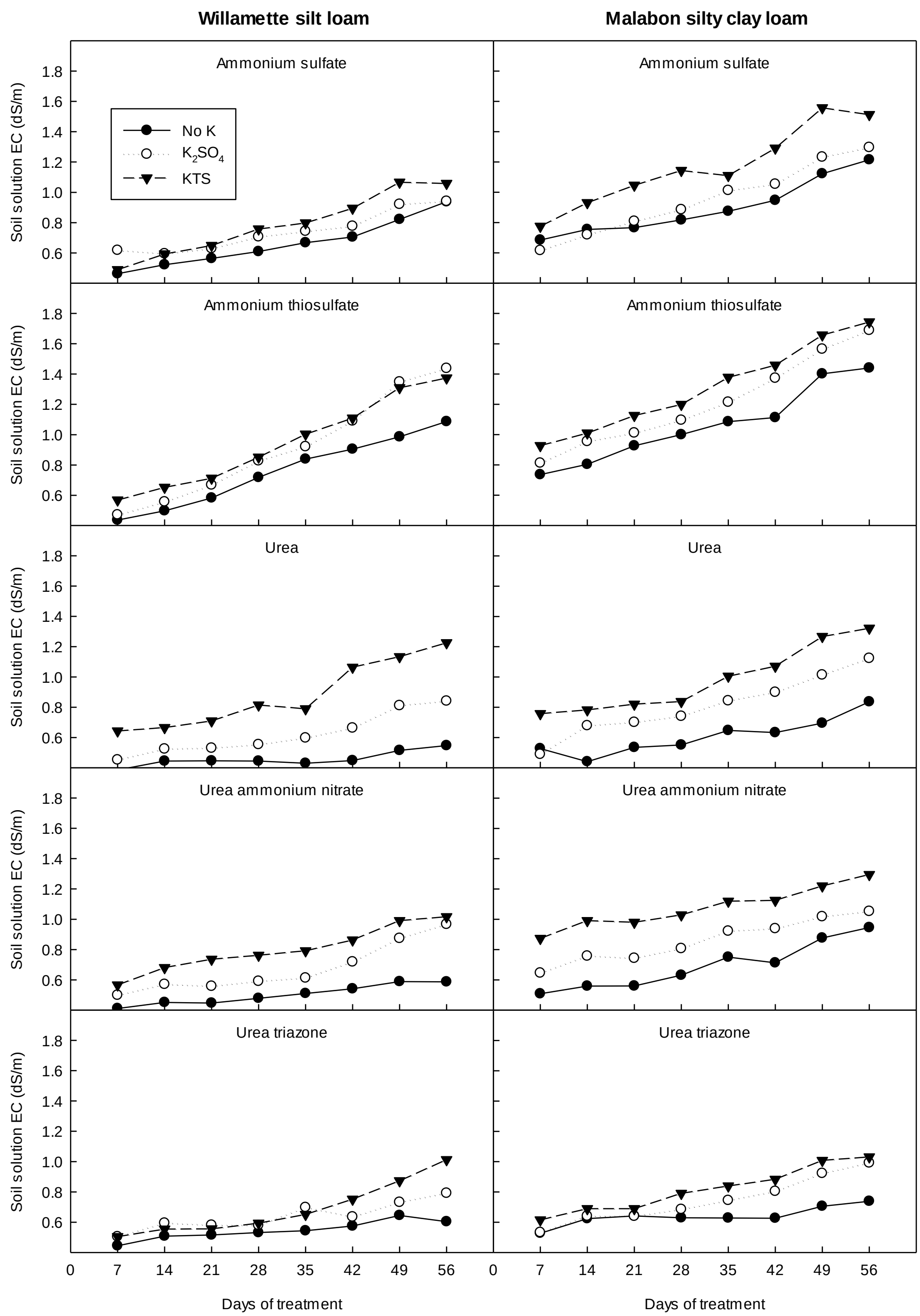

Fig. 2. The electrical conductivity (EC) of the soil solution in pots of ‘Duke’ blueberry. The plants were grown in two soil types (Willamette silt loam and Malabon silty clay loam) and fertigated with a combination of three potassium (K) treatments [no K, potassium sulfate (K_2SO_4), potassium thiosulfate (KTS)] and five different sources of nitrogen (N) fertilizer (ammonium sulfate, ammonium thiosulfate, urea, urea ammonium nitrate, and urea triazone).

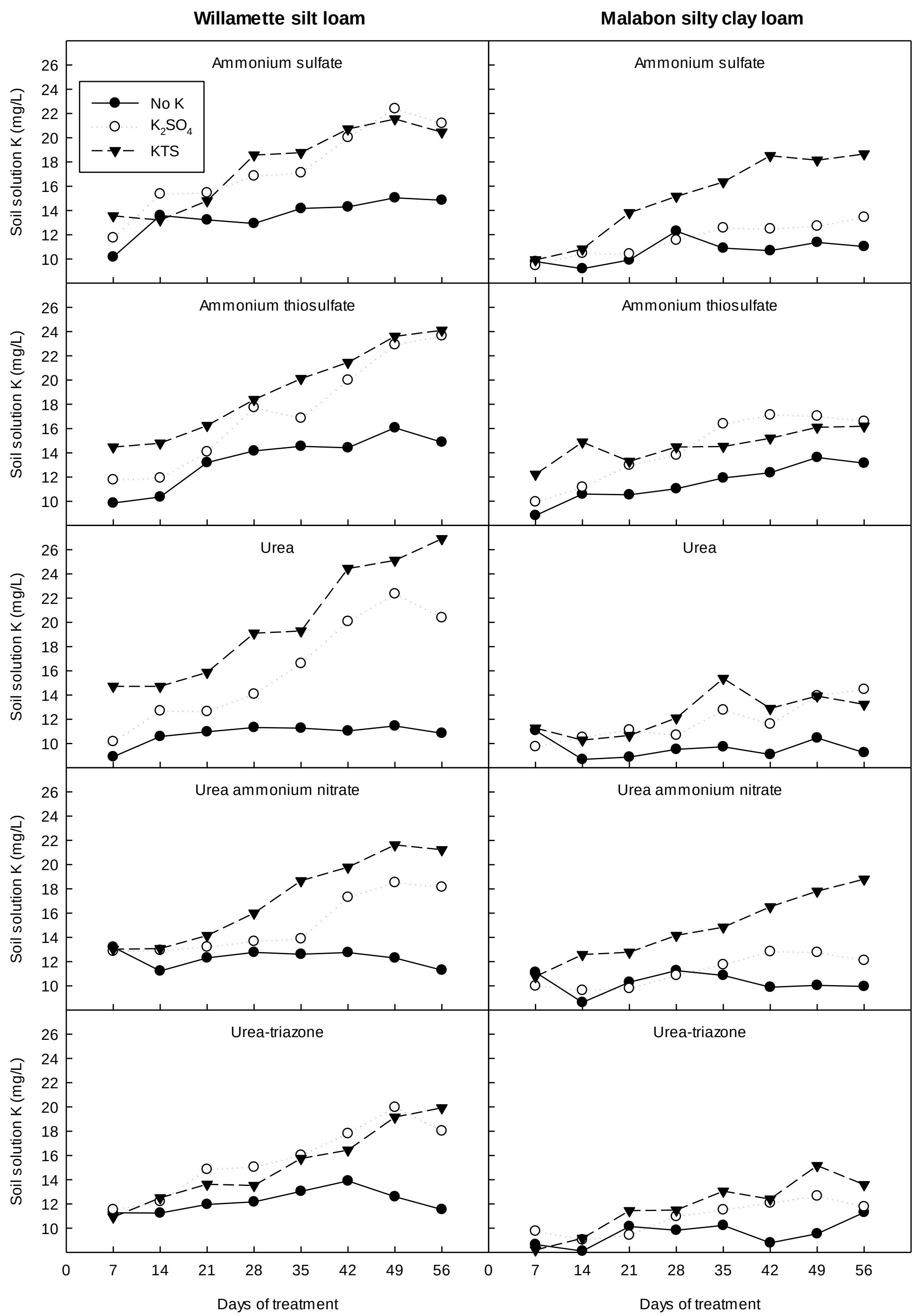

Fig. 3. The concentration of K in the soil solution in pots of 'Duke' blueberry. The plants were grown in two soil types (Willamette silt loam and Malabon silty clay loam) and fertigated with a combination of three potassium (K) treatments [no K, potassium sulfate (K_2SO_4), potassium thiosulfate (KTS)] and five different sources of nitrogen (N) fertilizer (ammonium sulfate, ammonium thiosulfate, urea, urea ammonium nitrate, and urea triazone).

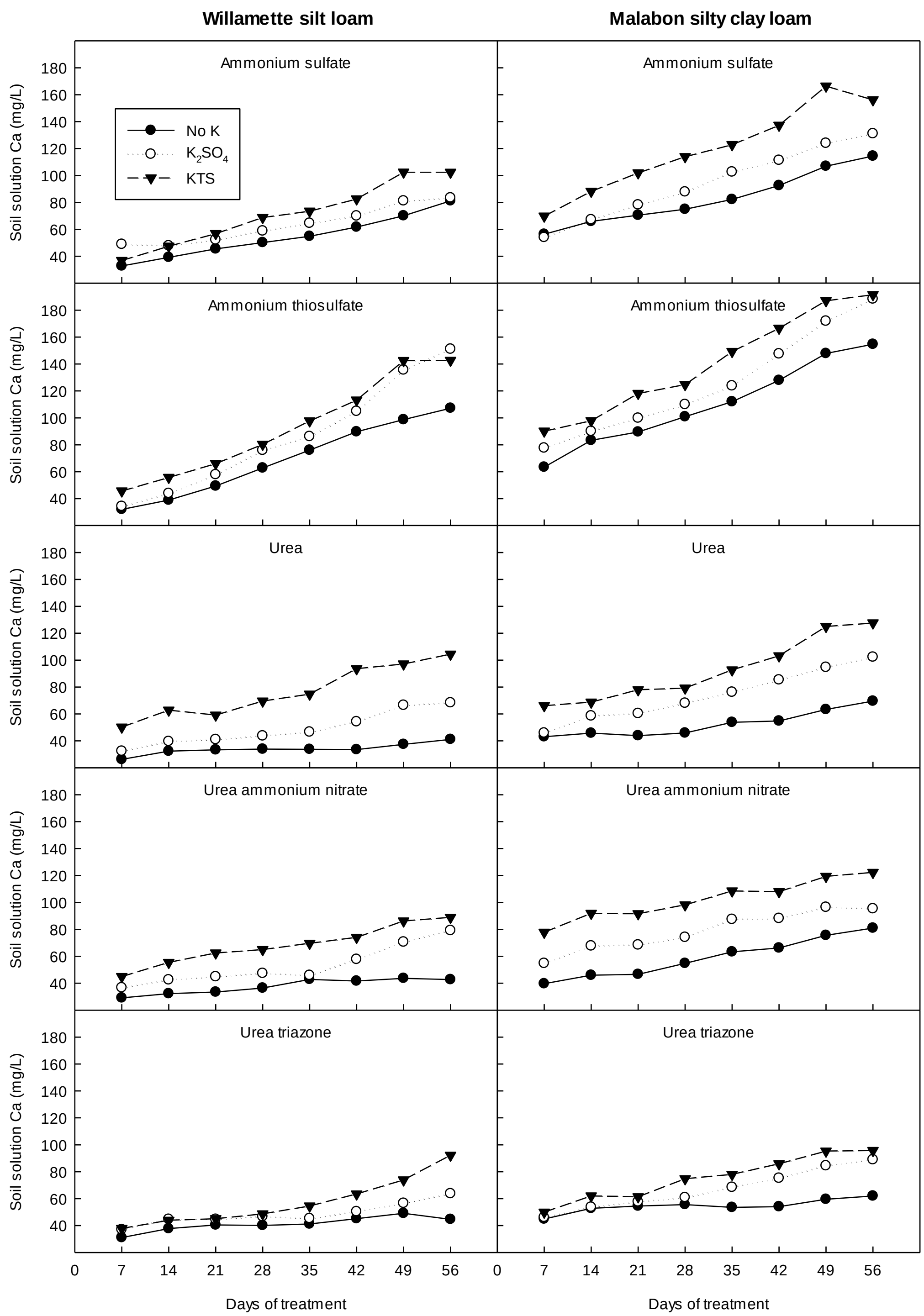

Fig. 4. The concentration of Ca in the soil solution in pots of 'Duke' blueberry. The plants were grown in two soil types (Willamette silt loam and Malabon silty clay loam) and fertigated with a combination of three potassium (K) treatments [no K, potassium sulfate (K_2SO_4), potassium thiosulfate (KTS)] and five different sources of nitrogen (N) fertilizer (ammonium sulfate, ammonium thiosulfate, urea, urea ammonium nitrate, and urea triazone).

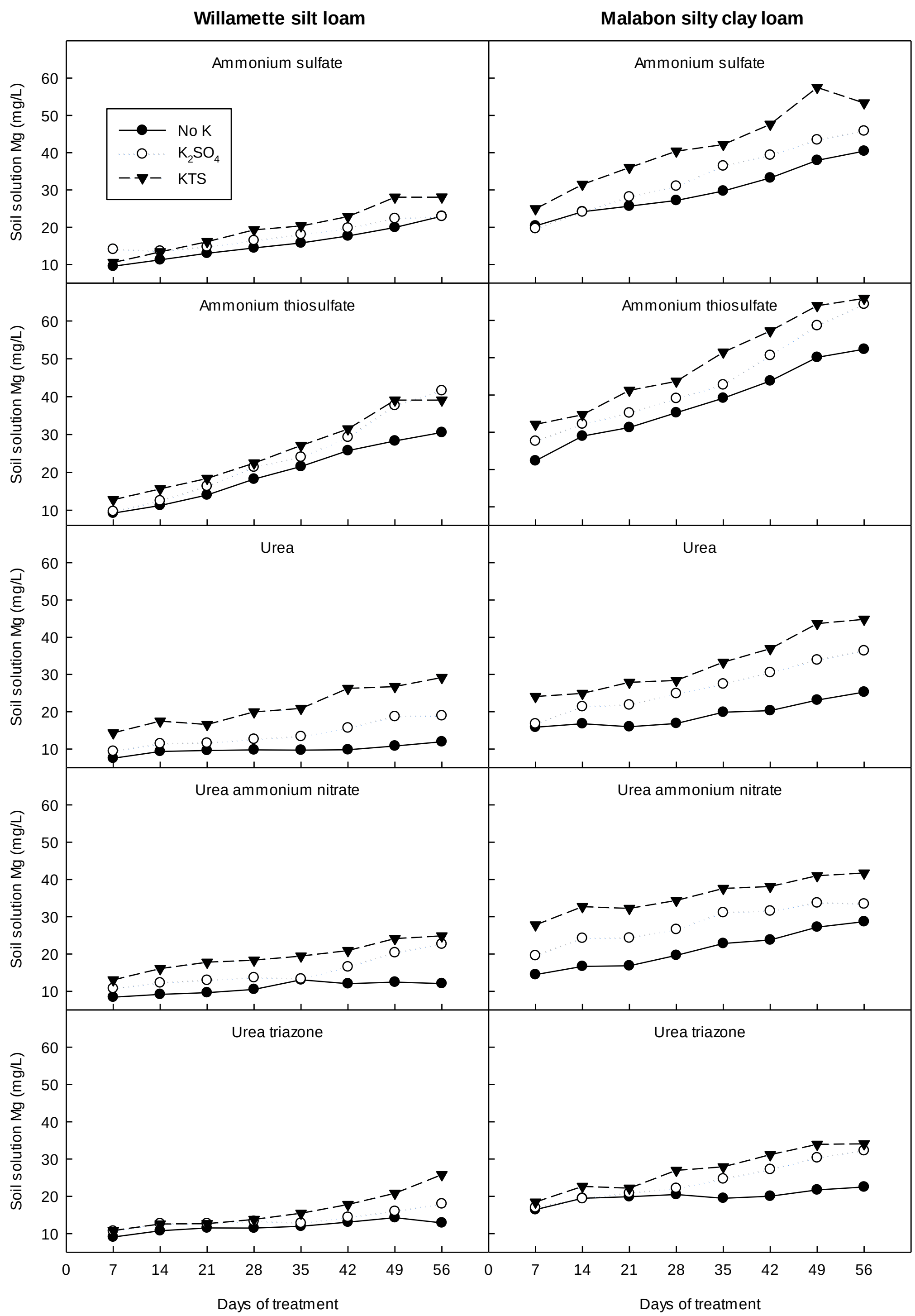

Fig. 5. The concentration of Mg in the soil solution in pots of 'Duke' blueberry. The plants were grown in two soil types (Willamette silt loam and Malabon silty clay loam) and fertigated with a combination of three potassium (K) treatments [no K, potassium sulfate (K_2SO_4), potassium thiosulfate (KTS)] and five different sources of nitrogen (N) fertilizer (ammonium sulfate, ammonium thiosulfate, urea, urea ammonium nitrate, and urea triazone).