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Effects of nitrogen and potassium in kikuyu grass on feeding by yellow sugarcane aphid

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Abstract

In Hawaii, infestations of yellow sugarcane aphid (YSA), *Sipha flava* (Forbes) (Homoptera: Aphididae) reduced growth of the forage grass, kikuyu (*Pennisetum clandestinum* Hochst. ex Chiov). To determine the effects of nitrogen (N) and potassium (K) on tolerance of kikuyu grass to YSA, cuttings of eight and five cultivars were grown in the greenhouse using nutrient solutions in two separate trials, respectively. The first trial was conducted during the summer of 1991 and the second during the winter of 1993. In both trials, kikuyu was grown at three N levels (0.05, 0.5 and 3.0 mM) and four K levels (0.05, 0.5 1.0 and 3.0 mM), with one cultivar comprising a block. Prior to exposure to aphids, representative plants were harvested, and shoots were analyzed for foliar nutrients. Then, plants were confined with aphids and rated visually for YSA injury. Dry matter yields and foliar N concentration increased significantly with increasing N fertilization in both trials. In the first trial, there was a significant interaction between N and K levels, in which the greatest increases of shoot and root dry matter with increasing N levels were found at the highest K level. In the second trial, K fertilization had no effect on dry weight of shoots. In both trials, foliar K concentration increased significantly with increasing K levels. Damage due to YSA tended to increase with increasing N levels, although it was unaffected by K fertilization in both trials. Thus, fertilization with increasing N resulted in greater kikuyu dry matter production, but it also tended to increase the damage caused by YSA feeding.

Keywords: *Sipha flava*; *Pennisetum clandestinum*; Insect resistance; Plant nutrition

1. Introduction

Kikuyu (*Pennisetum clandestinum*) grass is one of Hawaii's most important forage grasses (Whitney, 1974). During the 1980s and 1990s, infestations of yellow sugarcane aphid (YSA), *Sipha flava* (Forbes) (Homoptera: Aphididae), resulted in major decreases in kikuyu forage production on the island of Hawaii (Fukumoto and Mau, 1989). This problem continues sporadically through to the present (G.K. Fukumoto, unpublished data).

Fertilization of kikuyu with N increased forage production in Africa, Australia, and Hawaii (Tamimi et al., 1968; Mears, 1970; Campbell et al., 1971; Whitney, 1974; Marais, 2001; Hanna et al., 2004). Kikuyu production in response to K fertilization was variable, depending on K status of the soil, removal of K in crop residues through mechanical harvesting, and amount of N application (Tamimi et al., 1968; Mears, 1970; Hanna et al., 2004).

Three mechanisms of host plant resistance are generally recognized (Painter, 1951; Smith, 1989): antixenosis, or non-preference; antibiosis, which reduces insect survival and reproduction; and tolerance, where the plant compensates for insect feeding. In an earlier study (Miyasaka et al., 2007), we identified cultivars of kikuyu grass that differed in response to YSA feeding, based on either antixenosis or tolerance. Little is known about the effects of N and K

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fertilization on susceptibility of kikuyu grass to YSA damage. If tolerance was a mechanism of resistance to YSA, then we expected that adding N and K could increase plant vigor and further increase resistance. The objectives of these two studies were to determine the effects of N and K fertilization on injury of kikuyu grass by YSA.

2. Materials and methods

2.1. Experimental design and analysis

Several kikuyu cultivars were grown using nutrient solutions in a factorial combination of three N levels as NH_4NO_3 (0.05, 0.5, and 3.0 mM) and four K levels as K_2SO_4 (0.05, 0.5, 1.0, and 3.0 mM). These N and K levels in solution were selected to supply deficient to sufficient amounts of N and K to kikuyu grass. The experiment followed a randomized complete block design with 12 treatments ($3\,N \times 4\,K$), and kikuyu cultivars treated as blocks. In Trial 1, eight cultivars (B-11, D-3, E-15, G-15, F-2, F-9, G-8, and G-15) were selected randomly; in Trial 2, three cultivars were selected as moderately resistant (B-13, C-1, and F-11) and two cultivars were selected as more susceptible (D-17 and F-20) to YSA damage (Miyasaka et al., 2007).

Analysis of variance (ANOVA) was conducted using PROC GLM in SAS© software (SAS Institute Inc., Cary, NC). Main treatment effects of N, K, and block were calculated along with the interaction of $N \times K$ for dry weights of plant parts, foliar concentrations of N and K, and YSA damage ratings. In Trial 2, a single degree of freedom contrasts were estimated for shoot dry weight and YSA damage ratings that compared moderately tolerant cultivars to more susceptible cultivars. A probability level of 0.05 or less was considered to be statistically significant.

2.2. Trial one

Aphid-free, kikuyu cuttings were transplanted into plastic cone-shaped containers ($4\,cm \times 20\,cm$) (SC-10 Super Cell, Stuewe and Sons, Inc., Corvallis, Oregon).[2] The media consisted of 4:1 (v:v) mixture of absorbent to non-absorbent rockwool (Grodan, AgroDynamics, Brooklyn, New York).

The eight kikuyu cultivars were from hybrids developed by the late U. Urata in Hawaii during 1976–1983 (Urata, 1981). They were rated as moderately resistant to YSA in the kikuyu germplasm trials, and they did not differ significantly from each other in YSA damage ratings (Miyasaka et al., 2007).

In addition to the treatment levels of N and K, basal macronutrient concentrations were, in mM: P as Na_2HPO_4, 0.1; calcium (Ca) as $CaCl_2$, 1.0; Mg as $MgSO_4$, 0.4. Basal micronutrient concentrations were, in μM: manganese (Mn) as $MnSO_4$, 2; boron (B) as H_3BO_3, 6; zinc (Zn) as $ZnSO_4$, 1; copper (Cu) as $CuSO_4$, 0.5; molybdenum as H_2MoO_4, 0.1; Fe as FeH-EDTA [*N*-(2-hydroxyethyl)-ethylenediaminetriacetate], 10. Uniformly sized kikuyu cultivars were fertigated five times per week using a flow-through system in which excess solution was allowed to leach from containers.

The trial began in June 1991 in a greenhouse at the University of Hawaii's Waiakea Research Station (19°43′N, 155°4′W) at 90 m elevation near Hilo, Hawaii. Maximum and minimum temperatures ranged from 17 to 41 °C.

After seven weeks, four randomly selected blocks (cvs. B-11, E-15, F-2, and G-8) were harvested, tops separated from roots, and both plant parts were washed in deionized water, weighed, dried to constant weight at 70 °C in a forced-air oven, and reweighed. Shoots from two randomly selected blocks were combined (B-11 plus E-15; F-2 plus G-8) and two samples from each $N \times K$ treatment were sent to the University of Hawaii's Agricultural Diagnostic Service Center for analysis of plant nutrients.

Shoots were analyzed for total N by the micro-Kjeldahl method (Isaac and Johnson, 1976; Nelson and Sommers, 1972). They were ashed in a muffle furnace and analyzed for K in 1 M HCl using an inductively coupled plasma (ICP) emission spectrometer (Model 6500, Perkin-Elmer Inc., Norwalk, Conn.) (Isaac and Jones, 1972). Concentrations were calculated on a dry weight basis. Total contents were calculated by multiplying concentrations in shoots by dry weight of shoots.

Then, five randomly selected blocks (cvs. B-11, D-3, E-15, F-9, and G-15) were transferred to the University of Hawaii's Kona Research Station (19°32′N 155°55′W) at 500 m elevation near Kona, Hawaii, where they were placed in a YSA screening test. Due to an insufficient number of plants available within each cultivar except for cv. B-11, different ones were measured for dry weight and for YSA damage. Maximum and minimum temperatures ranged from 16 to 30 °C.

2.3. Trial two

The same experimental procedures were conducted as in Trial 1, except for the following ones. Cuttings from five kikuyu cultivars were placed in containers in January 1993 and grown as described previously in a greenhouse at the Kona Research Station. Minimum and maximum temperatures ranged from 16 to 25 °C.

Cultivars B-13, C-1, and F-11 were selected as moderately resistant to YSA, and their damage ratings did not differ significantly from the best or most resistant cultivar (Miyasaka et al., 2007). Cultivars D-17 and F-20 were selected as more susceptible to YSA damage, although only cv. F-20 was significantly different from the most resistant cultivar (Miyasaka et al., 2007).

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