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Fulvic and humic acid fertilizers are ineffective in dry bean

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Studies were conducted in Ontario dry bean (*Phaseolus vulgaris* L.) in 2010 and 2011 using fulvic acid (LX7[®], MTS Environmental Inc.) or humic acid (Plant XL[®], Alpha-Agri) fertilizers. Twenty fulvic acid field trials and 15 humic acid field trials indicate that these fertilizers were ineffective as plant vigour, height, 100-seed weight, and yield were similar to a control treatment.

Key words: Dry bean, *Phaseolus vulgaris*, fulvic acid, humic acid

Humic compounds, such as fulvic acid and humic acid, are formed by chemical and microbial degradation of plant and animal material and are a principal component of soil organic matter (Canellas et al. 2015). Because of their growth promoting properties in plants, humic compounds have been studied for decades (Schnitzer and Poapst 1967). In general, the application of fulvic and humic acid fertilizer amendments have been shown to enhance root growth, nutrient uptake, alleviate stress, and increase yield in various crops (Canellas et al. 2015).

Recently, Ontario farmers became interested in using humic compounds as fertilizer. Early seminal research on the effect of humic compounds on bean was conducted at Agriculture and Agri-Food Canada in Ottawa (Schnitzer and Poapst 1967). Unfortunately, information in the literature on fulvic or humic acid amendments used under agricultural field conditions (Hartz and Bottoms 2010) for dry bean in Canada is limited (Akinremi et al. 2000). As a result, studies were conducted to determine if fulvic and humic acid amendments could increase dry bean yield under Ontario field conditions.

MATERIALS AND METHODS

Four separate experiments were conducted over a two-year period (2010 and 2011) across several Ontario locations using various market classes: adzuki [*Vigna angularis* (Willd.) Ohwi and Ohashi], black, cranberry, kidney, navy, and otebo. Experiments 1 and 2 evaluated a fulvic fertilizer (LX7[®], MTS Environmental Inc., Centralia, ON) at 5, 10 (recommended rate), 20, 40, or 80 L ha⁻¹ (i.e., ½×, 1×, 2×, 4× and 8× of the recommended rate) with or without a starter fertilizer (22.5 L ha⁻¹ of 6-24-6). In Experiment 2, the starter fertilizer was eliminated due to equipment limitations. Experiments 3 and 4 evaluated a humic fertilizer (Plant XL[®], Alpha-Agri, Bluevale, ON) at 2.5 L ha⁻¹ (recommended rate) with a starter fertilizer (22.5 L ha⁻¹ of 6-24-6). In Experiment 4, the untreated control treatment was eliminated due to an oversight. In all four experiments, treatments were arranged in a randomized complete block design with at least four replications.

Experiment 1 (eight individual field trials) was conducted in 2010 at University research sites located near Thorndale and repeated in 2011 using four market classes (black cv. Black Velvet, cranberry cv. Etna, kidney cv. Red Hawk, and navy cv. T9905). Experiment 2 (12 individual field trials) was conducted at University research sites and on farmer cooperator sites near Ailsa Craig (adzuki cv. Erimo), Kippen (kidney), and London (kidney) in 2010 and Ailsa Craig (navy), Blyth (black cv. Zorro and navy cv. T9905), Centralia (cranberry cv. Hooter and navy cv. T9905), Ilderton (otebo cv. Hime), and Kippen (kidney cv. Red Hawk, navy cv. T9905 [with 0.75 m row spacing], and navy cv. T9905 [with 0.37 m row spacing]) in 2011. Information on the cultivar used was not collected from the farmer cooperator at the sites near Kippen and London in 2010 and Ailsa Craig in 2011. Regardless, in both experiments, dry bean was seeded at an optimal timing for each location (between May 27 and June 18) with a precision planter 4 cm deep at a rate of 17 and 20 seeds m^{-1} for the large and small seeded market classes, respectively. The experimental units in both experiments were four (0.75 m row spacing) or six (0.37 m row spacing) rows wide by 6 m long. The fulvic fertilizer treatments were applied preemergence using a sprayer calibrated to deliver 200 L ha^{-1} of water at 275 kPa.

Similar to Experiment 1, Experiment 3 (eight individual field trials) was conducted in 2010 and 2011 at University research sites located near Thorndale with four market classes (black cv. Black Velvet, cranberry cv. Etna, kidney cv. Red Hawk, and navy cv. T9905). Experiment 4 (seven individual field trials) was conducted at University research sites located near Blyth (black cv. Zorro and navy cv. T9905), Centralia (kidney cv. Red Hawk and navy cv. T9905), and Kippen (cranberry cv. Etna, kidney cv. Red Hawk, and navy cv. T9905) in 2011. In both experiments, dry bean was seeded between May 27 and June 15 with the previously described

equipment at similar seeded rates and the experimental units were established similar to Experiments 1 and 2. The humic fertilizer treatments were applied in the seed furrow at planting, using a liquid fertilizer applicator on the planter.

The soil types at each field trial location ranged from a silt loam to a clay loam, soil organic matter levels were $> 3\%$, and good to excellent soil nutrient levels were present for dry bean production. In all experiments, weeds, insects, and diseases were managed according to Ontario Ministry of Agriculture, Food and Rural Affairs guidelines to minimize potential confounding effects on the dry bean data collected (i.e., vigour, height, 100-seed weight, and yield). Dry bean plant vigour was rated at first flower, early pod fill, and at maturity as a visual estimate of plant canopy fullness (i.e., fresh weight) on a scale of 0 (complete plant death) to 10 (perfect plant health), with the best plot in each replication given a rating of 10. Dry bean plant height was measured at maturity for 10 randomly selected plants per plot. At harvest, potential edge effects were minimized by harvesting plants from the interior two or four rows of each experimental unit (discarding 0.5 m at both ends) using a small plot combine. Seed weight was adjusted to the standard of 18% moisture and then converted to t ha^{-1} .

Data for vigour, height, 100-seed weight, and yield were analyzed using PROC MIXED (SAS Ver. 9.2, SAS Institute Inc., Cary, NC). For the initial analysis of the data, each field trial was considered as a separate environment. Variances were divided into fixed (fertilizer treatment) and random effects (block, environment, block nested within environment, and fertilizer $\times$ environment interaction). Significance of the fixed effect was tested using an F-test and random effects were tested using a Z-test of the variance estimate. Environments were combined for

analysis if the fertilizer $\times$ environment interaction was not significant ($P > 0.05$). PROC UNIVARIATE was used to test data for normality and homogeneity of variance based on the Shapiro-Wilk statistic.

RESULTS AND DISCUSSION

Dry bean plant vigour, plant height, and 100-seed weight were similar regardless of fertilizer type or rate (data not shown). The absence of a plant vigour response in the current experiments was consistent with Canadian research on humic acid by Akinremi et al. (2000). However, Middle Eastern research showed that humic acid amendments increased fresh weights (El-Bassiony et al. 2010; Ibrahim and Ramadan 2015; Meganid et al. 2015). For plant height, Meganid et al. (2015) similarly found that humic acid had no effect; but, these results were contrary to other studies (Kaya et al. 2005; El-Bassiony et al. 2010; Hanafy et al. 2010). Lastly, the lack of a 100-seed weight response in the current experiments was similar to some studies with humic acid (Kaya et al. 2005; Ibrahim and Ramadan 2015), but not with a study by Barakat et al. (2015).

For all four experiments, yield data were combined across multiple field trials and/or market classes (Tables 1 and 2). This suggests that other factors, such as environmental conditions, had a greater influence on yield than the fulvic acid or humic acid fertilizer treatments. For example, across 20 field trials for Experiments 1 and 2, dry bean yields were no different than the untreated control regardless of the rate of fulvic acid fertilizer applied, up to 8 $\times$ of the recommended rate (Table 1). Similarly for Experiments 3 and 4, the results from 15 field trials

indicated that there was no yield response to the addition of the humic acid fertilizer (Table 2). However, other studies have demonstrated increased seed yield (Kaya et al. 2005; Barakat et al. 2015; Ibrahim and Ramadan 2015) or pod yield (Ece et al. 2007; El-Bassiony et al. 2010; Hanafy et al. 2010) with humic acid treatments.

Comparing results of the current experiments with previous research can be challenging as the composition of fulvic and humic acid amendments can vary considerably across commercially available formulations (Hartz and Bottoms 2010). However, it should be noted that the studies which reported stimulatory responses to humic acid amendments can be characterized as being conducted on sandy, low organic matter, or nutrient-deficient soils (Kaya et al. 2005; Ece et al. 2007; El-Bassiony et al. 2010; Hanafy et al. 2010; Barakat et al. 2015; Ibrahim and Ramadan 2015; Meganid et al. 2015). Hartz and Bottoms (2010) concluded that humic acid amendments may be beneficial under those conditions; but, for Ontario dry bean producers, the results from 20 fulvic acid field trials and 15 humic acid field trials indicate that the commercially available fertilizers used in these experiments would provide very little benefit.

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Table 1. Mean dry bean yield from 20 individual field trials treated with a fulvic fertilizer with or without starter fertilizer at various locations in Ontario in 2010 and 2011.

Treatment ^a	Experiment 1 ^b	Experiment 2 ^c		
		Grouping 1	Grouping 2	Grouping 3
		(t ha ⁻¹)		
Untreated control	2.9	2.9	3.4	1.9
Starter fertilizer (SF)	2.8	---	---	---
SF + Fulvic fertilizer ½×	2.8	2.8	3.4	1.7
SF + Fulvic fertilizer 1×	2.8	2.9	3.4	1.9
SF + Fulvic fertilizer 2×	2.9	2.8	3.5	1.9
SF + Fulvic fertilizer 4×	3.0	2.8	3.4	1.9
SF + Fulvic fertilizer 8×	---	2.9	3.5	1.9
Standard error	0.37	0.60	0.20	0.23

^aStarter fertilizer, 22.5 L ha⁻¹ of 6-24-6, used only in Experiment 1 due to equipment limitations; Fulvic fertilizer, 1× = 10 L ha⁻¹ of LX7® (MTS Environmental Inc., Centralia, ON).

^bConducted in 2010 at Thorndale and repeated in 2011 using four market classes (black cv. Black Velvet, cranberry cv. Etna, kidney cv. Red Hawk, and navy cv. T9905).

^cGrouping 1, three field trials which were conducted in 2010 at Ailsa Craig (adzuki cv. Erimo), Kippen (kidney), and London (kidney); Grouping 2, seven field trials which were conducted in 2011 at Ailsa Craig (navy), Blyth (black cv. Zorro and navy cv. T9905), Centralia (cranberry cv. Hooter and navy cv. T9905), Ilderton (otebo cv. Hime), and Kippen (navy cv. T9905 [with 0.37 m row spacing]); Grouping 3, two field trials which were conducted in 2011 at Kippen using two market classes (kidney cv. Red Hawk and navy cv. T9905 [with 0.75 m row spacing]).

Table 2. Mean dry bean yield from 15 individual field trials with a humic fertilizer and a starter fertilizer at various locations in Ontario in 2010 and 2011.

Treatment ^a	Experiment 3 ^b		Experiment 4 ^c
	Grouping 1	Grouping 2	
	----- (t ha ⁻¹) -----		
Untreated control	3.1	2.7	---
Starter fertilizer (SF)	3.2	2.8	3.7
SF + Humic fertilizer	3.0	2.8	3.7
Standard error	0.40	0.33	0.36

^aUntreated control was eliminated in Experiment 4 due to an oversight; Starter fertilizer, 22.5 L ha⁻¹ of 6-24-6; Humic fertilizer, 2.5 L ha⁻¹ of Plant XL® (Aphla-Agri, Bluevale, ON).

^bGrouping 1, conducted at Thorndale in 2010 using four market classes (black cv. Black Velvet, cranberry cv. Etna, kidney cv. Red Hawk, and navy cv. T9905); Grouping 2, conducted at Thorndale in 2011 using four market classes (black cv. Black Velvet, cranberry cv. Etna, kidney cv. Red Hawk, and navy cv. T9905).

^cExperiment 4, seven field trials which were conducted in 2011 at Blyth (black cv. Zorro and navy cv. T9905), Centralia (kidney cv. Red Hawk and navy cv. T9905), and Kippen (cranberry cv. Etna, kidney cv. Red Hawk, and navy cv. T9905).