Crop Res. **46** (1, 2 & 3) : 169-173 (2013)
With four figures
Printed in India

Effect of nitrogen rate and fungicide or compost tea application on tuber yield and quality of potato cultivars

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(Received : August 2013)

ABSTRACT

The environmental impact of using chemical fungicides to suppress disease in potato production is becoming a concern in recent years. The use of compost tea as a disease suppressant is becoming popular. A study was conducted at Colorado State University, San Luis Valley Research Center, U. S. A. from 2007 to 2009, to evaluate the interactive effect of nitrogen fertilizer rate and compost tea or fungicide application on tuber yield, tuber size distribution and quality of potato cultivars Russet Norkotah and Russet Nugget. Treatment combinations included nitrogen fertilizer (N) applied at 90 and 134 kg/ha with compost tea or fungicide applied. Two control treatments were established where N was applied at 90 and 134 kg/ha with no compost tea or fungicide application. Medium size tuber yield (114-284 g tubers) increased significantly in all three years for Russet Norkotah when compost tea was applied with 90 kg N/ha (2007) or with 134 kg N/ha (2007, 2008 and 2009). Marketable size tuber yield (114-454 g tubers) of Russet Norkotah was significantly increased when compost tea was applied with 134 kg N/ha (2007 and 2009), compared to the control treatment. For Russet Nugget, medium size tuber yield increased significantly in all three years of the study when compost tea was applied with 90 kg nitrogen fertilizer/ha, compared to the control treatment. The yield of large marketable size (170-340 g and 170-454 g tubers) increased when compost tea was applied with 90 kg N/ha in two of the three years study. For Russet Norkotah, the application of fungicide increased tuber specific gravity, compared to the application of compost tea and the control treatments. However, for Russet Nugget tuber specific gravity was similar in the fungicide and compost tea treatments in two of the three years study. Results of these studies suggest that compost tea can be used with reduced or no fungicide application to produce optimum tuber yields in potato production.

Key words : Compost tea, fungicide application, nitrogen rate, potato tuber yield, tuber specific gravity

INTRODUCTION

One of the diseases in potato that often cause yield reduction is early blight, caused by *Alternaria solani.* Early blight is influenced by soil fertility and plant nutrition. Barclay *et al.* (1973) and Davis (1985) stated that high rates of nitrogen (N) fertilizer could suppress early blight. However, the rates of N needed to suppress early blight are higher than the optimum N needed for maximum tuber yield (Barclay *et al.,* 1973). Economic control of early blight has been achieved by applying optimum N rates for maximum tuber production and using fungicides to control early blight (Mackenzie, 1981; Soltanpour and Harrison, 1974).

The use of fungicide programmes in potato production has raised some concerns in recent years due to its negative environmental impact. A non-chemical product that can suppress foliar disease and result in equal yields or yields that are higher than those obtained when fungicides are used will reduce environmental concerns.

Compost tea is a liquid solution from compost that contains plant nutrients. The concept of using compost tea in crop production is relatively new and few research has been conducted to document the effectiveness of

compost tea in potato production. Hibar *et al.* (2006) and Haggag and Saber (2007) in their studies reported that compost tea suppressed disease. Undocumented sources have suggested that compost tea increases the microbial activity in the soil. Hibar *et al.* (2006) in their study showed that compost tea could stimulate root and vegetative growth, while Haggag and Sabar (2007) observed that compost tea increased crop yield and quality.

The objective of this study was to evaluate the interactive effect of nitrogen fertilizer rate (low and optimum) and compost tea or fungicide application, on potato tuber yield, tuber size distribution and quality.

MATERIALS AND METHODS

The field experiments were conducted at the San Luis Valley Research Center, Colorado State University, USA from 2007 to 2009 in a two years' rotation system during the summer growing seasons. The previous crop before the 2007 and 2009 potato crop was barley (*Hordeum vulgare* L.), and the previous crop before the 2008 potato crop was sudan grass (*Sorghum sudanense*). The experiment was established as a factorial arrangement of the treatments in a randomized complete block design. Each treatment was replicated four times. Treatments included compost tea applied at a rate of 75 l/ha with 90 and 134 kg nitrogen fertilizer/ha, and fungicide applied with 90 and 134 kg nitrogen fertilizer/ha. The fungicide programme used was the application of bravo at 1.7 l/ha, quadris at 0.5 l/ha and dithane at the rate of 2.3 kg/ha. The three fungicide chemistries were applied at 10 days interval. Two potato cultivars Russet Norkotah and Russet Nugget were used as test crops.

Seed pieces were planted with an experimental potato planter on May 11, 2007, May 6, 2008 and May 14, 2009. Potato seed was planted in ridges with in-row seed spacing of 30 cm. Individual plots consisted of four rows of potato, each measuring 7.6 m length. Throughout the growing season, plot care and cultural management practices followed recommendations by Colorado State University for the two cultivars studied. On September 4, 2007; August 29, 2008 and September 8, 2009, potato vines were killed using a mechanical vine beater. Tubers from each experimental plot were harvested using an experimental potato harvester from the middle two rows on September 25, 2007; September 25, 2008 and September 23, 2009.

Tubers harvested from each plot were weighed to record total field yield. Tubers were sorted into various size distribution groups based on weight (114-454, 114-284, 170-341 and 170-454 g). Tuber specific gravity was measured using the weight-in-air/weight-in-water method.

Statistical analysis was conducted using analysis of variance [ANOVA (SAS version 9.2; SAS Institute, Cary, NC)]. Where appropriate, differences among treatment means were compared using Fisher's protected least significant difference (LSD) test at the 0.05 level of probability.

RESULTS AND DISCUSSION

Tuber Yield and Tuber Size Distribution Russet Norkotah

The yield of medium size (114-284 g) tubers increased significantly when compost tea or fungicide was applied in the optimum nitrogen rate (134 kg N/ha) plots (Fig. 1a-c). In two of the three years (2007 and 2008), medium size tuber yield was similar for compost tea and fungicide applied treatments at 134 kg N/ha rate (Fig. 1a and b). In 2009, compost tea application in optimum N rate (134 kg N/ha) plots resulted in yields that were significantly higher than the fungicide applied and control treatments (Fig. 1c). At the lower N rate of 90 kg N/ha, compost tea application outyielded the fungicide applied and control treatments in 2007 (Fig. 1a), but not in 2008 or 2009. The yield increase observed when compost tea was applied in the optimum N rate plots was, 12, 7 and 6% in 2007, 2008 and 2009, respectively (Fig. 1a-c). Corresponding yield increase for fungicide application was 14 and 5% in 2007 and 2008, respectively (Fig. 1a and b). In 2009, the yield observed in fungicide applied plots with optimum N fertilizer application was similar to yield from the control plots and was significantly lower than yield from the compost tea treatment.

Marketable tuber yield (114-454 g) was increased with the application of compost tea or fungicide in the optimum N applied plots in two of the three years study (2007 and 2009) (Fig. 2a and c). Compost tea increased

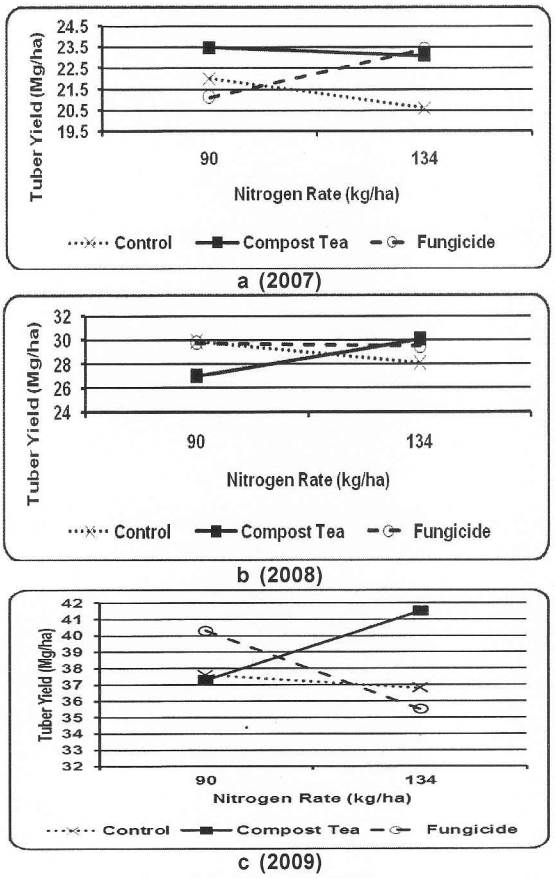

Fig. 1. Interactive effect of nitrogen rate and compost tea or fungicide application on the yield of medium size (114-284 g) tubers of Russet Norkotah (Fig. 1a-c) 2007-09.

marketable tuber yield by 7 and 6%, and the use of fungicide programmes increased marketable tuber yield by 18 and 4% in 2007 and 2009, respectively (Fig. 2a and c). It should be noted that in 2008, marketable tuber yield was similar for all three treatments at 134 kg N/ha application rate (Fig. 2b). Harrison *et al.* (1965) and Harrison and Venette (1970) stated that the infestations of early blight pathogen on foliage did not always result in yield loss, and occasionally chemical control did not improve yield (Easton *et al.,* 1975). The yield increases observed in the application of compost tea or fungicide programmes agree with the findings of Mackenzie (1981) and Soltanpour and Harrison (1974), who concluded that economic control of early blight was achieved by using optimum N rates for maximum tuber production and using fungicides to control early blight.

Results of this study clearly demonstrate that for Russet Norkotah, compost tea can be applied to increase potato

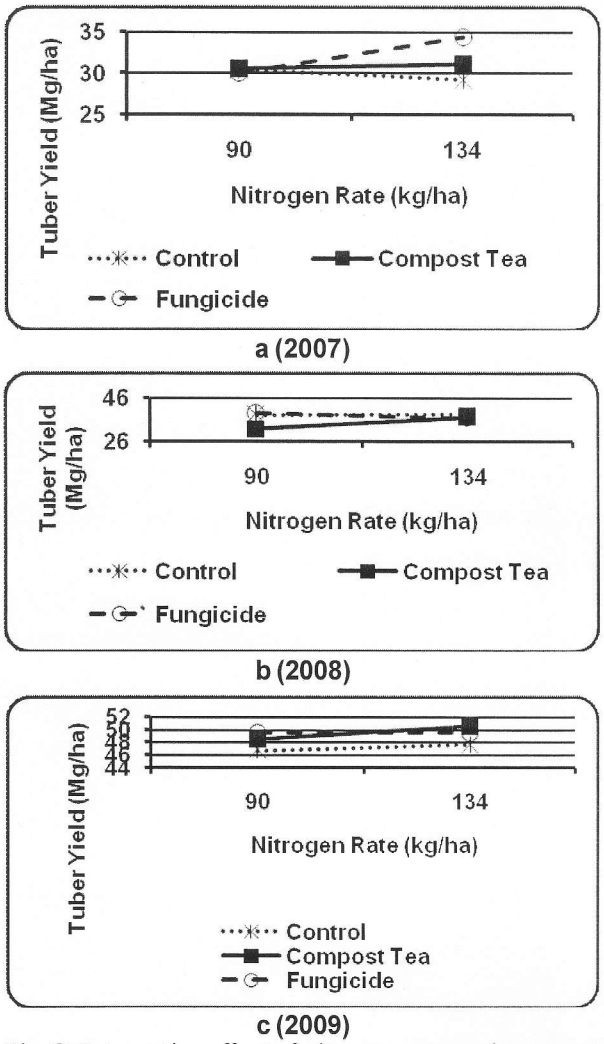

Fig. 2. Interactive effect of nitrogen rate and compost tea or fungicide application on marketable size (114–454 g) tuber yield of Russet Norkotah (Fig. 2a-c) 2007-09.

tuber yield when N is applied at the optimum rate recommended for Russet Norkotah.

Russet Nugget

In two of three years (2008 and 2009), the yield of medium size tubers was higher when compost tea was applied in the low N applied plots (90 kg N/ha) (Fig. 3b and c). Fungicide application produced similar yield to the control treatment at the low N application rate in 2008 and 2009, but these yields were lower than the compost tea yields. The yield increase observed for compost tea at the low N application rate was 13 and 11%, respectively, in 2008 and 2009, when compared to the control treatment (Fig. 3b and c). In 2007, medium size tuber yield was similar for

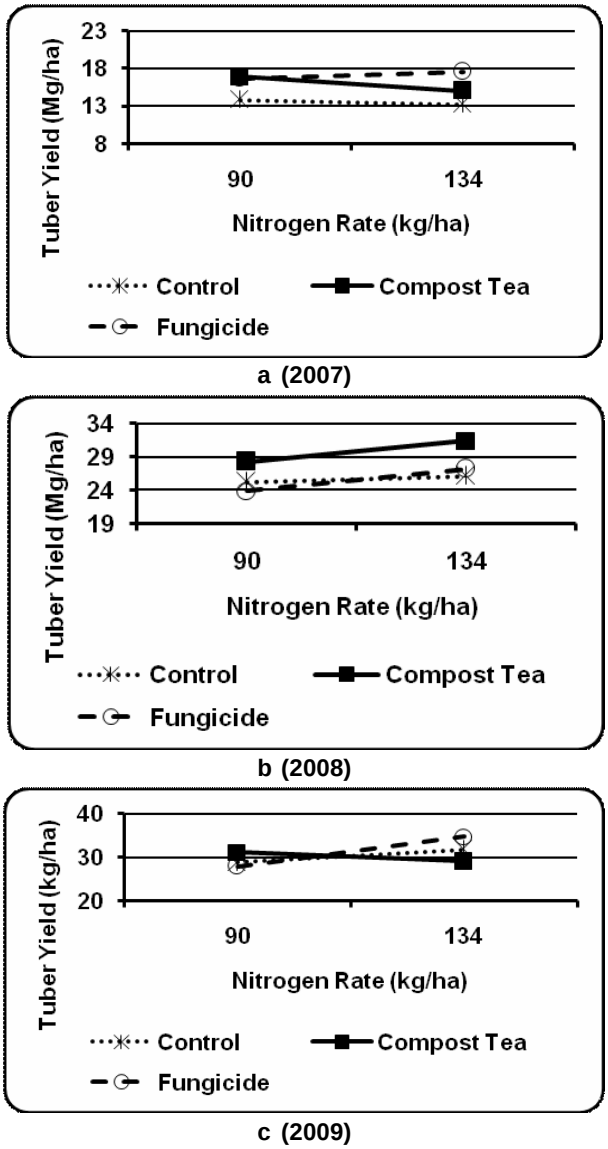

Fig. 3. Interactive effect of nitrogen rate and compost tea or fungicide application on the yield of medium size (114-284 g) tubers of Russet Nugget (Fig. 3a-c) 2007-09.

compost tea and fungicide applied treatments, and these were higher than the control treatment (Fig. 3a).

At the optimum N rate of 134 kg N/ha, compost tea increased medium size tuber yield by 14 and 20% in 2007 and 2008, respectively (Fig. 3a and b). Fungicide application at optimum N rate of 134 kg N/ha increased medium size tuber yield by 33 and 9% in 2007 and 2009, respectively.

The yield of large marketable size tubers (170-340 g) was evaluated for Russet Nugget. Compost tea and fungicide application increased the yield of 170-340 g tubers by 36

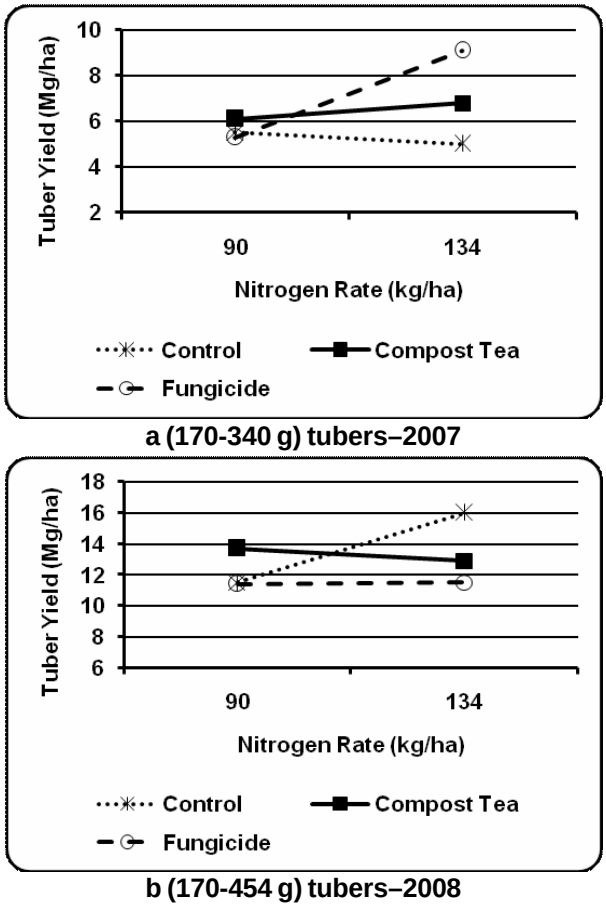

Fig. 4. Interactive effect of nitrogen rate and compost tea or fungicide application on the yield of marketable size tubers of Russet Nugget (a and b)–2007-08.

and 80%, respectively, at the optimum N rate, in 2007 (Fig. 4a). In the 170-340 g tuber size group, yields were lower and similar for all three treatments at the low N rate of 90 kg N/ha.

In 2008, compost tea increased the yield of 170-454 g tuber size by 18% in the low N rate plots (Fig. 4b). No significant yield increase was observed in 2009 (data not shown).

The yield results for Russet Nugget indicate that compost tea can be applied at low N rates (90 kg N/ha) to produce similar or higher yield than when fungicide programmes are used as disease suppressant.

Tuber Specific Gravity

The effect of compost tea and fungicide application on tuber specific gravity of Russet Norkotah and Russet Nugget was evaluated over the average of the two nitrogen application rates used in this study. For Russet Norkotah,

Table 1. Effect of fungicide and compost tea application averaged over nitrogen application rate on potato tuber specific gravity

Treatment	Russet Norkotah			Russet Nugget		
	2007	2008	2009	2007	2008	2009
Control*	1.080c	1.075ab	1.083b	1.089b	1.097b	1.11a
Compost tea	1.082b	1.074b	1.083b	1.088b	1.100a	1.10a
Fungicide	1.084a	1.076a	1.085a	1.091a	1.100a	1.11a

*Control–Nitrogen fertilizer with no compost tea or fungicide application.
Figures in the same column and bearing the same letters are not significantly different from each other at P=0.05 level.

fungicide application increased tuber specific gravity in two of the three years (2007 and 2009) (Table 1). Compost tea application increased tuber specific gravity in 2007, when compared to the control, but tuber specific gravity in the compost tea applied treatments was similar to the control in the other two years (Table 1).

For Russet Nugget, the application of fungicide increased tuber specific gravity, and the gravities were higher than tubers from the control and compost tea treatments in 2007, but higher than the control treatment in 2008 (Table 1). No significant difference was observed in tuber specific gravity among the treatments in 2009. In general, the data suggest that the application of fungicide in potato production increases tuber specific gravity when compared to the application of compost tea, even though in some years, compost tea can produce tubers with similar specific gravities to fungicide applied plots.

CONCLUSION

The main purpose of this study was to evaluate the interactive effect of nitrogen application rate (low and optimum rates) and compost tea or fungicide application in potato production, and to determine whether compost tea could be used as an alternative to fungicide application to obtain optimum potato tuber yield.

Results obtained in the three years study clearly demonstrate that in Russet Norkotah, compost tea can be used as an alternative to fungicide application at optimum nitrogen fertilizer rates to produce higher or similar medium and marketable size tuber yields.

In Russet Nugget, compost tea application can increase tuber yield at low nitrogen fertilizer rates, compared to the use of fungicide as foliar disease suppressant.

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