Agronomic and Environmental Consequences of Applying Fertilizer Nitrogen and Phosphorus to Processing Tomatoes and Green Peppers under Drip Fertigation

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Executive Summary

Processing tomatoes and green peppers are high nutrient-demand crops, and the requirements can be further increased with increased yield potential resulted from improved water supply. Irrigation, especially drip irrigation/fertigation, has been largely adopted in southwestern Ontario for processing tomatoes and green peppers to overcome the frequent incidences of drought stress. However, excessive nutrient supply can have adverse impacts on water quality through surface runoff and leaching (nitrogen and phosphorus) and to air quality through gaseous emissions. New fertilization techniques must be developed for irrigated crops to maximize farmers' profits and to sustain or improve the environmental quality.

The long-term objectives of this study are 1) to develop optimum rates of fertilizer nitrogen and phosphorus for processing tomatoes and green peppers under drip fertigation, which are both economically and environmentally sound, 2) to determine the amounts of nitrogen and phosphorus required for each ton production of processing tomatoes and green peppers, and 3) to determine the threshold values of petiole NO_3-N for processing tomatoes for Ontario conditions. The short-term objectives for 2004 were 1) to determine the relationships between fertilizer nitrogen and phosphorus rates and yield and quality of processing tomatoes and green peppers under; 2) to determine crop nitrogen and phosphorus removals; and 3) to evaluate the potential leaching losses of soil NO_3-N.

The experiment was conducted in a Granby sandy loam soil in Harrow, ON. Treatments for processing tomatoes included 4 fertilizer nitrogen rates ranging from 0 to 360 kg N ha^{-1} and 3 fertilizer P rates ranging from 0 to 200 kg P_2O_5 ha^{-1}). For green peppers, treatments included 4 fertilizer N rates ranging from 0 to 240 kg N ha^{-1} and 3 fertilizer phosphorus rates ranging from 0 to 200 kg P_2O_5 ha^{-1}. Both trials were arranged in a factorial randomized completely block design, with 4 replicates.

Green peppers: The marketable yield was maximized at 44.8 ton ha^{-1} with added fertilizer nitrogen at 277 kg N ha^{-1}, which was about 4 times as much as the rate recommended by the OMAF publication 363. Green peppers require an increased nitrogen supply under drip fertigation.

Fruit nitrogen removal ranged from 17 to 71 kg N ha^{-1}. Total above-ground nitrogen uptake ranged from 24 to 103 kg N ha^{-1}. Both nitrogen removal and total uptake were linearly related to fertilizer nitrogen rate.

Amount of nitrogen required to produce each ton of marketable yield varied from 0.3 to 6.2 kg N ton^{-1}, depending on the level of target yield. The values are comparable with those (0.4 to 6.7 kg N ton^{-1}) obtained in 2003, but are higher than what obtained in 2002 (0.2 to 3.1 kg N ton^{-1}).

Total above-ground phosphorus uptake ranged from 6.4 to 20 kg P ha^{-1} (14.7 to 45.8 kg P_2O_5 ha^{-1}), with fruit phosphorus removal ranged from 4.1 to 13.6 kg P ha^{-1}. Phosphorus removal was linearly related to fertilizer nitrogen rate, while total phosphorus uptake was linearly related to fertilizer rates of nitrogen and phosphorus, respectively.

Total potassium uptake increased linearly with fertilizer nitrogen rate, and ranged from 50 to 160 kg K ha^{-1}.

Soil profile NO_3-N after harvest increased with increases in fertilizer nitrogen rate, with the majority of residual fertilizer nitrogen found in the top (0-20 cm) and non-root zone (40-100cm) soil layers. The results reflect significantly the effects of continuous fertigation and crop uptake.

Processing tomatoes: Both total and marketable yields responded quadratically to nitrogen application. A maximum marketable yield of 140 ton ha^{-1} was produced with 292 kg N ha^{-1} fertilizer nitrogen applied. Processing tomatoes under fertigation requires much more nitrogen supply (140-224% more in 2004) than the current recommendation to develop the maximum yield potential and to obtain the maximum profits.

Fruit nitrogen removal was related quadratically to fertilizer nitrogen rate, and ranged from 67 to 234 kg N ha^{-1}. The above-ground total nitrogen uptake reacted quadratically to added fertilizer nitrogen, and ranged from 82 to 293 kg N ha^{-1}.

The amount of fertilizer nitrogen required for each tonne of marketable yield production varied depending on the level of target yield. Calculated values of fertilizer nitrogen required for each tonne of marketable yield production ranged from 0.1 to 2.1 kg N ton^{-1}. The values are higher than those obtained in 2003 that ranged from 0.07 to 1.7 kg N ton^{-1}, presumably due to the variation in weather conditions.

Fruit phosphorus removal ranged from 19 to 36 kg P ha^{-1} (43.5 to 82.4 kg P_2O_5 ha^{-1}), and was affected interactively by the application of fertilizer nitrogen and phosphorus. Responses of fruit phosphorus removals to nitrogen were similar when phosphorus was added at rates below 100 kg P_2O_5 ha^{-1}. Increased phosphorus rate up to 200 kg P_2O_5 ha^{-1} increased phosphorous removals, especially when nitrogen was applied at rates above 100 kg N ha^{-1}.

Total phosphorus uptake ranged from 26 to 41 kg P ha^{-1} (60 to 94 kg P_2O_5 ha^{-1}), and responded quadratically to nitrogen rate. The maximum phosphorus uptake occurred with nitrogen applied at 245 kg N ha^{-1}. Increased phosphorus application enhanced total phosphorus uptake.

Total potassium uptake ranging from 218 to 459 kg K ha^{-1} (262 to 551 kg K_2O ha^{-1}) was also interactively related to nitrogen and phosphorus addition. Optimum combination of nitrogen and phosphorus maximized the total potassium uptake.

Relationships between petiole NO_3-N concentration and marketable yield were the highest at the full blooming stage, and declined substantially afterwards. Levels of petiole NO_3-N at the full blooming stage accounted for over 80% of the variation in yield. High levels of petiole NO_3-N at later stages reduced marketable yield. Nitrogen fertilization should be performed right before full blooming, and later application should be restricted. However, the threshold vale of petiole NO_3-N at the full blooming stage was not obtainable in 2004, because of the linear relationship between petiole NO_3-N content and the marketable yield. The threshold vale of petiole NO_3-N at the full blooming stage was 1934 mg N kg^{-1} in 2003.

Post-harvest soil profile NO_3-N contents increased with fertilizer nitrogen rate. While majority of the soil residual nitrogen remained in the depth of 0-20 cm, NO_3-N leaching was noticed with fertilizer nitrogen added at high rates. However, low contents of soil residual NO_3-N indicate that the potential impact on water quality during the non-growing season can be neglectable.