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GROWTH AND YIELD RESPONSE OF TOMATO (*Lycopersicon esculentum* Mill.) TO SOIL APPLIED CALCIUM CARBIDE AND L-METHIONINE

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Abstract

A pot experiment was conducted in a wire house to determine the effects of two precursors of ethylene (calcium carbide and L-methionine) on growth and yield of tomato. L-methonine (1 mg kg^{-1}) and encapsulated calcium carbide (15 mg kg^{-1}) was applied (6-cm deep) to soil alone and in combination with recommended dose of N, P and K fertilizers @ 100-90-60 kg ha^{-1}, respectively. Half dose of N and full dose of P and K was applied after one week and the remaining dose after three weeks of nursery transplantation. Encapsulated calcium carbide and L-methionine (dissolved in water) were applied after ten days of transplanting. A completely randomized design was fallowed with six treatments and three treatments. Data regarding number of flowers, number of fruits, shoot dry mass weight, fruit weight, root weight, Nitrogen concentration in shoot/fruit and Nitrogen uptake were recorded. Number of flowers, number of fruits, shoot dry mass weight, fruit weight, root weight, Nitrogen concentration and uptake in shoot and fruit were significantly affected by both precursors in combination with fertilizers compared to control and alone fertilizer. However, maximum number of flower, fruit and weight and uptake was observed with the application of calcium carbide plus NPK fertilizers.

Key words: Tomato, calcium carbide, L-methionine, flowers, fruit weight, N uptake

INTRODUCTION

Tomato (*Lycopersicon enculentum* Mill.) is one of the most important vegetable crops and grown through the world. Ethylene (C_2H_4) is an important gaseous plant hormone involved in almost all phases of growth and development of plants (Abeles et al., 1992; Reid, 1995; Arshad and Frankenberger, 2002). There are certain compounds which are known to release ethylene. Application of these ethylene releasing compounds could be much easier than the gaseous form of ethylene. Similarly calcium carbide releases acetylene, therefore it is considered a powerful nitrification inhibitor because it inhibits the *Nitrosomonas* activity that converts NH_4^+ in to NO_3^- (Banerjee et al., 1990; Freney et al., 1990; Keerthisinghe et al., 1996; Sharma and Yadav, 1996; Randall et al., 2001; Ahmad et al., 2004). Moreover acetylene released from CaC_2 is converted into plant hormone ethylene (C_2H_4) by soil microorganisms (Muromtsev et al., 1988; Lurssen 1991; Arshad and Frankenberger, 2002). C_2H_4 plays major role in growth and development processes of plants by stimulating germination shoot and root growth and early crop maturity (Arshad and Frankenberger, 2002). Muromtsev et al. (1990) conducted a field trail with a CaC_2 – based Retprol. They reported that its addition to soil (120 kg ha^{-1}) in a dry form during growth stage of 3-4 true leaves of tomatoes (Lebyazhinski variety) increased the yield by 3-50% along with accelerated ripening and improved quality.

L-methionine is an established precursor of ethylene and its application to soil has shown positive effect on plant growth (Arshad and Frankenberger, 2002, Akhtar et al., 2005). Addition of L-methionine (L-MET) has shown to increase C_2H_4 accumulation in the soil atmosphere (Frankenberger and Phelan, 1985 a, b; Arshad and Frankenberger, 1990 a, b). Arshad and Frankenberger (1990 a) found that soil application of L-MET (0.0185 to 1.85 mg kg^{-1} soil) affected vegetative growth and resistance to stem lodging of two cultivars of corn. Highest rate of soil of L-MET (1.85 mg kg^{-1}) significantly increased shoot height, stem diameter, shoot fresh and dry weights and resistance to stem breaking in corn (cv. Kandycorn and Miracle). In another experiment, Arshad et al. (1994) observed a significant growth and yield response in soybean when exposed to L-MET applied to soil. They reported that plant height, plant dry weight, root weight and total biomass, pods/plant and grain yield of soybean were significantly increased in response to various levels (2x 10^{-4} to 20 mg kg^{-1} soil) of L-MET application. Zahir and Arshad (1998) investigated the response of sarsoon (*Brassica carinata*) and lentil (*Lens culinaris*) to C_2H_4 precursors added to the rhizosphere and reported that the treatments had significant effects on growth and yield parameters of the tested plants. The soil application of L-MET (0.1 to 6 mg kg^{-1}) caused a significant increase in plant height, pod length, number of seeds per pod, straw and grain yield of sarsoon compared to untreated controls while the 1000-grain weight was maximum with the highest dose of L-MET applied to soil.

MATERIALS AND METHOD

A pot experiment was conducted to test the response of tomato (cv. Money Maker) to substrates dependent biosynthesis of ethylene. The experiment was conducted in a wire house at Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan. The soil used for the experiment was collected from surface soil layer of 15 cm. The soil was sandy clay loam in texture. Some other properties of this soil were as follows: pH 7.7; EC_e 1.16 dS m^{-1}; organic matter contents 0.88%, and total N contents 0.05%. Soil was mixed thoroughly, ground, passed through 2 mm sieve and added in polythene lined earthen pots @ 14 kg per pot. Pots were placed according to completely randomized design in three replicates. The set of treatments were as follow: control; NPK fertilizers @ 100-90-60 kg ha^{-1}; L-methionine @ 1 mg kg^{-1} soil; Calcium carbide @ 15 mg kg^{-1} soil; NPK + L-mathionine and NPK + caicium carbide.

Encapsulation of calcium carbide

Stones of calcium carbide were ground in a mortar with a pestle. The required weight of calcium carbide was filled in protein covering capsules. The objective of encapsulation was just to place calcium carbide safely in soil at required soil depth.

Application of treatments

The one month old seedlings of test crop were transplanted on 13^{th} of December. One plant was maintained in each pot. Nitrogen as urea, phosphorous as SSP and potassium as muriate of potash were applied by dissolving in water. Half N and full P and K were applied after one week of nursery transplantation and other half N was applied after three weeks of nursery transplantation. Calcium carbide was encapsulated @ 15 mg kg^{-1} soil and was applied after 10 days of nursery transplantation. Capsules were placed in the root zone 6 cm deep followed by immediate irrigation. While, L-methionine @ 1.0 mg kg^{-1} soil was dissolved in water and applied after 10 days of transplantation. For irrigation, canal water was used through out the growth period. Data regarding number of flowers, number of fruits and fruit weight were collected during crop growth while shoot and root dry weights, nitrogen concentration and nitrogen uptake were noted after harvesting. The whole earthen boll of each pot was taken out and washed under tap water gently to separate roots.

Plant analysis

Shoot and fruit samples were dried in an oven at 70°C and ground, then 0.5 g material was used to determine total nitrogen in these samples by Hu and Barker (1999) method of sulphuric acid digestion and distillation on micro Kjeldhal's apparatus (Jackson 1962).Nitrogen uptake was calculated by multiplying nitrogen concentration in fruit or shoot with fruit or shoot yield, respectively.

Data analysis

Data collected for various characteristics were analyzed statistically using Fisher's analysis of variance technique (Steel and Torrie 1980). The treatment means were compared by Duncan's Multiple Range test at 5% probability level (Duncan 1955).

RESULTS

Number of flowers was significantly enhanced due to addition of calcium carbide with NPK fertilizers compared to all other treatments. Maximum number of flowers was observed when calcium carbide was applied with NPK fertilizers ten days after transplantation (Table 1). Minimum number of flowers was observed in the control. It was also noted that number of fruits no doubt increased with NPK fertilizers but reached to the maximum in the calcium carbide plus NPK fertilizers treatment. It means that calcium carbide stimulated flower formation and then fruits.

All the treatments affected the shoot and root dry mass compared to control. Shoot dry matter increased with the application of NPK fertilizers however, maximum shoot dry weight was observed where calcium carbide was applied alone or with NPK fertilizers (Table 1). There was not much difference in root weight in treated plants except calcium carbide. It means that tomato roots responded more to calcium carbide plus NPK fertilizers treatment than any other treatment. Minimum root dry weight was observed in the control (without fertilizers).

Effect of precursors of growth regulator on fruit weight is presented in Table 1. All the treatments significantly increased fruit weight over control. Response of tomato for fruit weight to calcium carbide was quite obvious among all the treatments Maximum fruit weight was observed where calcium carbide plus NPK fertilizers was applied (Table 1) and it was about 54% higher than that in alone NPK fertilizers treatment. Comparison of two precursors of ethylene calcium carbide gave better results.

Data regarding the effect of precursors of growth regulator on nitrogen concentration (%) in tomato shoot and fruit is presented in Table 2 Application of fertilizers (100-90-60 kg ha^{-1} NPK) slight increased nitrogen concentration and it further increased L-methionine plus NPK fertilizers treated plants. Calcium carbide plus NPK fertilizers showed the significantly maximum increase in nitrogen concentration than all other treatments.

Nitrogen uptake (g $plant^{-1}$) by shoot and fruit was calculated by multiplying shoot and fruit weights with respective nitrogen concentration in shoot and fruit. Nitrogen uptake by shoot and fruit (Table 2) increased with application of NPK fertilizers, CaC_2 and L-methionine compared to control. However it further increased with application of L-methionine plus NPK fertilizers Calcium carbide had highly significant effect on nitrogen uptake by shoot and tomato fruits. Maximum N uptake was observed where calcium carbide plus NPK fertilizers were applied.

DISCUSSION

Calcium carbide releases nitrification inhibitor gas acetylene that is converted into plant hormone ethylene (Muromtsev et al., 1988; Arshad and Frankenberger, 2002), both gases had pronounced influence on plant growth from germination to maturity and thus influence the yield and yield contributing parameters (Bronson et al., 1992; Freney et al., 1992; Ahmad et al., 2004). Result of this study indicates that application of calcium carbide with recommended doses of NPK fertilizers significantly increased number of flowers, conversion of flowers into fruits and fruit weight of tomato.

Increased yield of tomato with the application of calcium carbide is attributed to enhanced uptake of nutrients by tomato due to production of acetylene on one hand that conserves nitrogen in the soil while ethylene on the other that improves the yield and yield contributing parameters due its hormonal effects. It may be due to increase in root primordiae to explore more volume of soil to acquire nutrients (Ahmad et al., 2004). Enhanced N uptake by fruit due to calcium carbide plus fertilizer application in this study is evident that thistreatment increased the fruit yield than that of fertilizer alone or control. This may be due to nitrification inhibitory effect of acetylene released from calcium carbide that might maintain fertilizer N in plant available form of N as NH_4 over extended periods of time.

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Table 1: Effect of two precursors of ethylene with and without chemical fertilizers and on growth and yield of tomato

Treatments	Number of flowers $plant^{-1}$	Shoot dry weight (g $plant^{-1}$)	Root dry weight (g $plant^{-1}$)	Number of fruits $plant^{-1}$	Average fruit weight (g)
Control	15.33 c	32.56 e	2.45 d	13.00 c	17.93 d
NPK Fertilizer	26.33 b	63.38 b	4.01 c	23.00 b	22.83 c
L-methionine (1 mg kg^{-1} soil)	23.33 b	58.49 c	4.08 c	19.66 b	24.33 c
CaC_2 (15 mg kg^{-1} soil)	24.33 b	65.30 b	4.32 b	21.33 b	30.18 b
L-methionine + Fertilizer	26.66 b	55.39 d	4.23 b	22.66 b	24.73 c
CaC_2 + Fertilizer	33.33 a	72.12 a	5.04 a	29.33 a	35.18 a

Values in the same column with different letter(s) differ significantly ($\alpha = 0.05$) by DMRT
Fertilizer (N-P-K) 100-90-60 kg ha^{-1}

Table 2: Effect of two precursors of ethylene with and without chemical fertilizers and on nitrogen concentration and uptake by shoot and fruit of tomato.

Treatment	N concentration (%)		N uptake (g $plant^{-1}$)	
	Shoot	Fruit	Shoot	Fruit
Control	0.42 e	2.1 f	13.61 d	37.7 c
NPK Fertilizer	1.05 bc	3.92 c	67.54 b	89.4 b
L-methionine (1 mg kg^{-1} soil)	0.98 cd	3.5 d	57.32 c	84.9 b
CaC_2 (15 mg kg^{-1} soil)	0.91 d	3.22 e	59.38 c	97.3 b
L-methionine + Fertilizer	1.12 b	4.06 b	61.93 bc	100.0 b
CaC_2 + Fertilizer	2.1 a	4.99 a	151.39 a	175.0 a

Values in the same column with different letter(s) differ significantly ($\alpha = 0.05$) by DMRT
Fertilizer (N-P-K) 100-90-60 kg ha^{-1}