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Effect of triazole compounds on induced changes in growth biomass and biochemical content of white radish (*Raphanus sativus* L.)

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ABSTRACT

Radish (*Raphanus sativus* L.), belongs to the family Brassicaceae is an important vegetable crop and cultivated all over the India. The tuber of radish is used to prepare the salad and for the preparation of various health dishes. It is rich in vitamin 'C' and minerals. It is also used as medicinal properties such as currying liver disorders, jaundice, and various physiological disorders. In the present investigation, the effect of triazole compounds such as triadimefon (TDM) and hexaconazole (HEX) on radish. The plants were given separate treatment with 1 L of water solution containing 20/mg TDM and 1 L of water solution containing 20/mg HEX on 23, 35, and 53 days after sowing (DAS) by soil drenching method. The plants were harvested randomly on 30, 45, and 60 DAS for the determination of growth of tuber, shoot, and biochemical contents viz., starch, protein, and amino acid both in the control and triazole treated plants. From the results it is observed that the triazole treated plants showed pronounced effect in increasing the tuber fresh and dry biomass, protein, amino acid, and starch content in both shoot and tuber tissues of radish, whereas the shoot fresh and dry biomass were decreased when compared to control plants of radish.

KEY WORDS: Amino acid, growth, protein, *raphanus sativus*, starch, triazole

INTRODUCTION

White radish (*Raphanus sativus* L.), belongs to the family Brassicaceae is an important vegetable crop and cultivated in tropical and subtropical regions of India. It is available at a cheaper price for the poor people (Sankari *et al.,* 2006). Ascorbic acid (vitamin 'C') consists of a 6-carbon lactone ring with 2,3-enediol moiety and shows antioxidant activity due to enediol group. It is a leading natural antioxidant that can scavenge reactive oxygen species and has anti-carcinogenic effects (Kim and Lee, 2004; Lee *et al.,* 2002). Plant growth regulators have been successfully used to increase the yield in many vegetable crops and particularly in tuber crops. Triazole compounds like triadimefon (TDM), hexaconazole (HEX), paclobutrazol, and uniconazole are mainly used as systematic fungicides and also have growth regulating properties (Fletcher and Hofstra, 1990; Fletcher *et al.,* 2000). Over the past few years, several triazole derivatives, collectively described as sterol biosynthesis inhibitors, have been developed and used as fungicides. They also have plant growth regulating properties. TDM (bayleton) propiconazole (banner), paclobutrazole (bonzi), and uniconazole (sumagic) are used as growth regulators or retardants. However, all of these products can exhibit both fungicidal and growth regulating properties to varying degrees (Fletcher *et al.*, 2000). Plant growth retardants, i.e. uniconazole, paclobutrazol, triapenthenol, TDM and HEX have been reported as effective agents in reducing the size of plants, but retaining dark-green leaves and thick roots, which define them as healthy plantlets, and aiding anti-wilting, leading to better survival, growth root yield (Hazarika, 2006; Kozak, 2006; Thakur *et al.,* 2006). Triazoles affect the isoprenoid pathway and alter the levels of certain plant hormones by inhibiting gibberellin synthesis, reducing ethylene evolution, and increasing cytokinin levels (Rademacher, 2000; Jaleel *et al.,* 2007). TDM treated plants accumulate zeatin and have cytokinin like activity with anti-senescence properties and darker green leaves in cucumber (Fletcher and Arnold, 1986). Increased level of cytokinin, particularly transaction and its riboside has been reported in sunflower, rice, soybean, and rape after uniconazole treatment (Grossmann *et al.*, 1994). The increased cytokinin levels with triazole

treatments resulted in the inhibition of ethylene formation (Grossmann *et al*., 1993). The objective of the present research work is to estimate the effect of TDM and HEX on the improvement of growth biomass and biochemical content of radish.

MATERIALS AND METHODS

Seed Material and Plant Treatments

The seed of *R. sativus* L. var. Pusa Chetki was obtained from Mahyco Hybrid Seeds Co. Ltd, Maharashtra, India. The field work was carried out in Botanical Garden, and analyses were done in Plant Growth Regulation Lab, Department of Botany, Annamalai University, Tamil Nadu. The field experiment was conducted in Completely Randomized Block Design (CRBD) with three replicates during 2013-2014. Each plant was treated with 20/mg of TDM and 20/mg of HEX on 23, 38 and 53 days after sowing (DAS). The treatments were given by soil drenching. The fully expanded mature leaves of plants which emerged after the treatments were collected randomly on 30, 45 and 60 DAS to determine by growth and biochemical content of *R. sativus*.

Determinations of Fresh and Dry Weight

After washing the plants in tap water, fresh weight was determined by using an electronic balance (Model-XK3190A7M) and the values were expressed in gram. After taking the fresh weight, the plants were dried at 60°C in an hot air oven for 24 h. After drying, the weight was measured and the values were expressed in gram.

Biochemical Analysis

Starch content was extracted and estimated by the method of Clegg (1956), protein content by the method of Bradford (1976), amino acid content by the method of Moore and Stein (1948).

Statistical Analysis

The experiments were conducted by CRBD. Statistical analyses were performed using SPSS software the one-way analysis of variance. The expressed values are mean ± standard deviation for 3 replications in each group.

RESULTS AND DISCUSSION

Effect of TDM and HEX on the Shoot and Tuber Fresh and Dry Biomass of Radish

Triazole compounds significantly reduced the shoot fresh and dry weight. But vegetable part of the fresh and dry weight of tuber increased in radish. Among the triazole treatments, HEX treatment reduced to a larger extent when compared to TDM (Figures 1-3). Triazole compounds have promoted tuber growth in various tuber crops such as carrot, coleus, and Chinese potato (Gopi *et al.,* 2007; Lakshmanan *et al.,* 2007; Kishorekumar *et al.,* 2007). Triazole treatments reduced the stem elongation, plant height and decreased the fresh weight in citrus (Mehouachi *et al.,* 1996). Paclobutrazol suppressed shoot height and dry weight in tomato (Pasian and Bennett, 2001; Still and Pill, 2003), wheat (Berova *et al.,* 2002), barley (Sarkar *et al.,* 2004). Triazole compounds such as TDM, paclobutrazol, and uniconazole have promoted rooting in various plants such as chrysanthemum, bean (Davis *et al.,* 1988) and apple (Wang and Faust, 1986). Triazole treated plants have exhibited thickened fleshy roots with increased root diameter and weight in apple and soybean (Sankhla *et al.,* 1985; Wang and Faust, 1986; Bausher and Yelenosky, 1987). Paclobutrazol and TDM treatments affected the fresh and dry weight of the shoot, while increasing it in the roots as in *Brassica carinata* (Setia *et al.,* 1995). The growth retarding effect of triazole is caused by the inhibition of gibberellic acid biosynthesis and increased abscisic acid content in *Cucurbita maxima* (Buchenauer and Grossmann, 1977). Triazole induced marked reduced in the shoot and this be attributed to the reduced gibberellic acid level by triazole treatment. Inhibition of shoot growth induced by increased abscisic acid and lowered gibberellin may be the cause for reduced fresh and dry weight of shoot reduced by triazole treatments.

Effect of TDM and HEX on the Starch, Protein and Amino Acid Content of Radish

Triazole treatments increased the starch content in the tuber and shoot parts of the radish plant. Among the triazole treatments, TDM treated plants exhibited a higher starch content than HEX treated plants (Figure 4). Triazole compounds are known to alter the carbohydrate

Figure 1: Effect of triadimefon and hexaconazole treatments on the growth variation of 45 days after sowing old radish

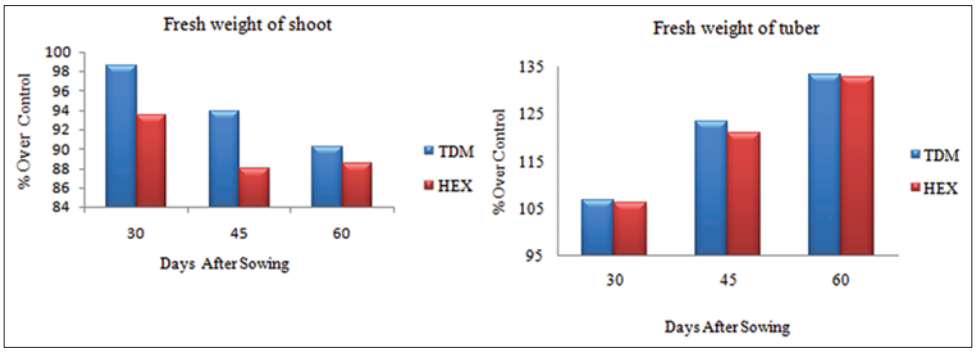

Figure 2: Effect of hexaconazole and triadimefon on the dry weight of radish

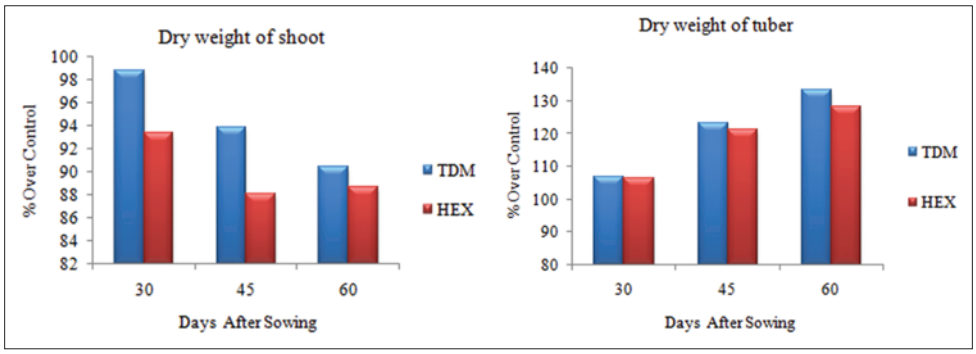

Figure 3: Effect of hexaconazole and triadimefon on the dry weight of radish

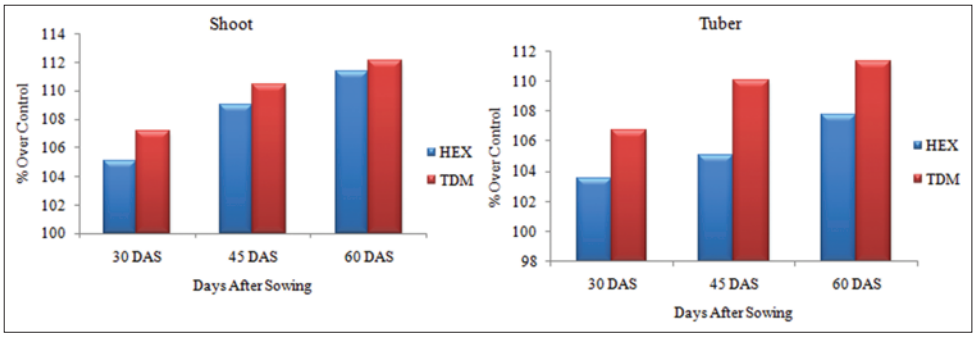

Figure 4: Effect of hexaconazole and triadimefon on the starch content of radish

status in various plants such as sweet orange (Vu and Yelenosky, 1992) and potato (Kapur *et al.,* 1993). The increased starch content in triazole treated plants may be due to decrease in starch hydrolysis as reported in treated bean (Steffens *et al.,* 1983; Upadhyaya *et al.,* 1986). TDM and uniconazole treatments increased the total starch content in potato (Kapur *et al.,* 1993). TDM, paclobutrazol, Uniconazole, and etaconazole increased the nonstructural carbohydrates in mature leaves of *Poa paratensis*, *B. carinata* and apple (Setia *et al.,* 1995; Wang and Steffens, 1985; Wang and Faust, 1986). Paclobutrazol increased the started and sorbitol concentration in apple (Wieland and Wample, 1985). In both triazoles treated *R. sativus* the protein content was increased in all the stages of growth when compared to control. Among the treatments, TDM had pronounced effect in increased higher amount of protein accumulation than HEX (Figure 5). Propiconazole caused a higher level of protein accumulation in *Basella alba* (Shanmugam *et al.,* 2012). Similar results were observed in cucumber seedling (Feng *et al.,* 2003) and TDM treated cow pea, white yam (Gopi *et al.,* 1999; Jaleel *et al.,* 2007). The increased cytokinin content induced by TDM and HEX treatments might have increased the protein content in the shoot and tuber of *R. sativus*. The amino acid content increased with the age in control and treated plants in all growth stages of the radish plant. HEX and TDM treatments had pronounced effect to increase the amino acid content to a higher level when compared to control plants (Figure 6). TDM treatment increased the amino acid content in

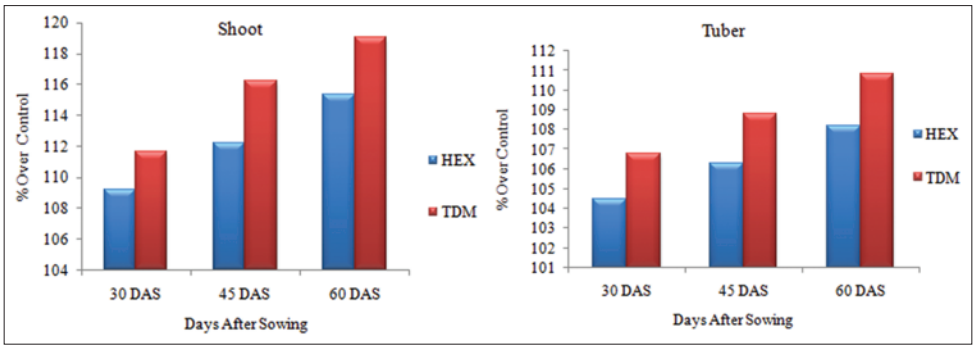

Figure 5: Effect of hexaconazole and triadimefon on the protein content of radish

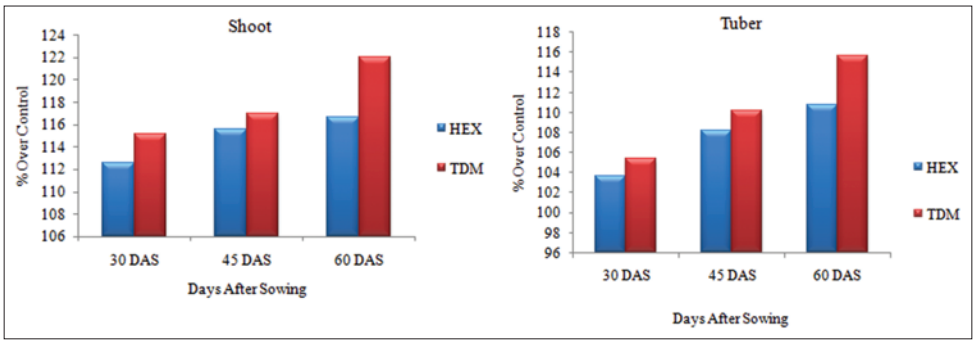

Figure 6: Effect of hexaconazole and triadimefon on the amino acid content of radish

Phaseolus vulgaris (Mackay *et al.,* 1990), paclobutrazol treatment also induced a moderate increase in amino acid content of *Catharanthus roseus* (Jaleel *et al.,* 2006). HEX and paclobutrazol treatments increased the amino acid content in carrot (Gopi *et al.,* 2007). Among the organs, leaf tissue accumulated the higher level of amino acids than stem and root tissue. Accumulated amino acid may be occurring in response to the change in osmotic adjustment of their cellular contents (Shao *et al,* 2007). Amino acids accumulation plays a very important role in drought tolerance, probably through osmotic adjustment in different plant species, such as *Radix astragali* (Tan *et al.,* 2006). The increased cytokinin content induced by triazole treatments might have increased the protein and amino acid contents in the shoot and root of radish.

CONCLUSION

From these results, it is cleared that triazole applications at low concentrations are highly increased the fresh and dry biomass and also biochemical content in economically important tuber of *R. sativus.* Triazole compounds such as TDM and HEX enhanced the tuber productivity. The relative growth rate of the radish was elevated by the triazole compounds and they increased the relative root growth net assimilation rate, root/shoot ratio but decreased the shoot biomass and storage part tuber increased in all the stages of growth of radish.

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REFERENCES

Bausher MG, Yelenosky G. Morphological changes in citrus associated with relatively high concentrations of paclobutrazol. J Plant Growth Regul 1987;5:139-47.

Berova M, Zlatev Z, Stoeva N. Effect of paclobutrazol on wheat seedlings under low temperature stress. Bulg J Plant Physiol 2002;28:5-84.

Bradford MM. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Anal Biochem 1976;72:248-54.

Buchenauer H, Grossmann F. Triadimefon: Mode of action in plants and fungi. Neth J Plant Pathol 1977;83:93-103.

Clegg KM. The application of the anthrone reagent to the estimation of starch in cereals. J Sci Food Agric 1956;7:40-4.

Davis TD, Steffens GL, Sankhla N. Triazole plant growth regulators. In: Kamocl J, editor. Horticulture Reviews. V. 10. Portland, Oregon: Timber Press; 1988. p. 63-105.

Feng Z, Guo A, Feng Z. Amelioration of chilling stress by triadimefon in cucumber seedlings. Plant Growth Regul 2003;39:277-83.

Fletcher RA, Arnold V. Stimulation of cytokinins and chlorophyll synthesis in cucumber cotyledons by triadimefon. Physiol Plant 1986;66:197-201.

Fletcher RA, Gilley A, Sankhla N, Davis TM. Triazoles as plant growth regulators and stress protectants. Hortic Rev 2000;24:56-138.

Fletcher RA, Hofstra G. Improvement of uniconazole induced protection in wheat seedlings. J Plant Growth Regul 1990;9:207-12.

Gopi R, Jaleel CA, Sairam R, Lakshmanan GM, Gomathinayagam M, Panneerselvam R. Differential effects of hexaconazole and paclobutrazol on biomass, electrolyte leakage, lipid peroxidation and antioxidant potential of Daucus carota L. Colloids Surf B Biointerfaces 2007;60:180-6.

Gopi R, Sujatha BM, Rajan SN, Karikalan L, Panneerselvam R. Effect of triadimefon in the sodium chloride stressed cowpea (*Vigna unguiculata*) seedlings. Indian J Agric Sci 1999;69:743-5.

Grossmann K, Kwiatkowski K, Hauser C, Siefert F. Influence of the triazole growth retardant BAS 111W on phytohormone levels in senescing intact pods of oilseed rape. Plant Growth Regul 1994;14:115-8.

Grossmann K, Siefert F, Kwiatkowski J, Scharudner M, Langebartels C, Sandermann JR. Inhibition of ethylene production in sunflower cell suspensions by the plant growth retardants BAS IIIW. Possible relations to changes in polyamine and cytokinin level. J. Plant Growth Regul 1993;12:5-11.

Hazarika BN. Morpho-physiological disorders in *in vitro* culture of plants. Sci Hortic 2006;108:105-20.

Jaleel CA, Gopi R, Manivannan P, Kishorekumar A, Gomathinayagam M, Panneerselvam R. Changes in biochemical constituents and induction of early sprouting by triadimefon treatment in white yam (*Dioscorea rotundata* Poir.) tubers during storage. J Zhejiang Univ Sci B 2007;8:283-8.

Jaleel CA, Gopi R, Manivannan P, Kishorekumar A, Sankar B, Panneerselvam R. Paclobutrazol influences on vegetative growth and floral characteristics of *Catharanthus roseus* (L.) G. Don. Indian J Appl Pure Biol 2006;21:369-72.

Kapur KK, Narula SL, Upadhyaya MD. Modification of physiological and biochemical responses in potato with CCC and triazole. Proceeding National Symposium Plant Physiology NBRL, Lucknow, India. 1993. p. 361-9.

Kim DO, Lee CY. Comprehensive study on vitamin C equivalent antioxidant capacity (VCEAC) of various polyphenolics in scavenging a free radical and its structural relationship. Crit Rev Food Sci Nutr 2004;44:253-73.

Kishorekumar A, Jaleel CA, Manivannan P, Sankar B, Sridharan R, Panneerselvam R. Comparative effects of different triazole compounds on growth, photosynthetic pigments and carbohydrate metabolism of *Solenostemon rotundifolius*. Colloids Surf B Biointerfaces 2007;60:207-12.

Kozak D. The effect of growth retardants applied *in vitro* on the acclimatization and growth of *Tibouchina urvilleana* cogn. *in vitro*. Acta Sci Pol 2006;5:65-70.

Lakshmanan GM, Jaleel CA, Gomathinayagam M, Panneerselvam R. Changes in antioxidant potential and sink-organ dry matter with pigment accumulation induced by hexaconazole in Plectranthus forskholii Briq. C R Biol 2007;330:814-20.

Lee SH, Oe T, Blair IA. Vitamin C-induced decomposition of lipid hydroperoxides to endogenous genotoxins. Science 2001;292:2083-6.

Mackay CE, Hall JC, Hofstra G, Fletcher RA. Uniconazole induced changes in abscisic acid, total amino acids and proline in *Phaseolus vulgaris*. Pest Biochem Physiol 1990;37:74-82.

Mehouachi J, Tadeo FR, Zaragoza S, Primo-Millo E, Talon M. Effects of gibberellic acid and paclobutrazol on growth and carbohydrate accumulation in shoots and roots of citrus root stock seedlings. J Hortic Sci 1996;71:747-54.

Moore S, Stein WH. Photometric ninhydrin method for use in the chromatography of amino acids. J Biol Chem 1948;176:367-88.

Pasian CC, Bennett MA. Paclobutrazol Soaked marigold, geranium and tomato seeds produce short seedlings. Hortic Sci 2001;36:721-3.

Rademacher W. Growth retardants: Effects on gibberellin biosynthesis and other metabolic pathways. Annu Rev Plant Physiol Plant Mol Biol 2000;51:501-31.

Sankari S, Gopi R, Gomathinayagam M, Sridharan R, Somasundaram R, Panneerselvam R. Responses of triazoles on growth and antioxidant levels in white radish. Indian J Appl Pure Biol 2006;21:77-80.

Sankhla N, Davis TD, Upadhyaya A, Sankhla D, Walser RH, Smith BN. Growth and metabolism of soybean as affected by paclobutrazol. Plant Cell Physiol 1985;26:913-21.

Sarkar S, Perras MR, Falk DE, Zhang R, Pharis RP, Fletcher RA. Relationship between gibberellins, height, and stress tolerance in barley (*Hordeum vulgare* L.) seedlings. Plant Growth Regul 2004;42:125-35.

Setia RC, Bhathal G, Setia N. Influence of paclobutrazol on growth and yield of *Brassica carinata*. Plant Growth Regul 1995;16:121-7.

Shanmugam M, Lakshmanan GM, Mathumathi S, Panneerselvam R. Effect of plant growth regulator fungicide and ABA on growth and biochemical properties of *Basella alba* Linn. Int J Res Plant Sci 2012;2:67-73.

Shao HB, Chu LY, Wu G, Zhang JH, Lu ZH, Hu YC. Changes of some anti-oxidative physiological indices under soil water deficits among 10 wheat (*Triticum aestivum* L.) genotypes at tillering stage. Colloids Surf B Biointerfaces 2007;54:143-9.

Steffens GL, Wang SY, Steffens CL, Brennan T. Influence of paclobutrazol (PP 333) on apple seedling growth

and physiology. Proc Plant Growth Regul Soc Am 1983;10:195-205.

Still JR, Pill WG. Germination, emergence and seedlings growth of tomato and impatients in response to seed treatment with paclobutrazol. Hortic Sci 2003;38:1201-4.

Tan Y, Liang Z, Shao H, Du F. Effect of water deficits on the activity of anti-oxidative enzymes and osmoregulation among three different genotypes of *Radix astragali* at seeding stage. Colloids Surf B Biointerfaces 2006;49:60-5.

Thakur R, Sood A, Nagar PK, Pandey S, Sobti RC, Ahuja PS. Regulation of growth of Lilium plantlets in liquid medium by application of paclobutrazol or ancymidol, for its amenability in a bioreactor system: growth parameters. Plant Cell Rep 2006;25:382-91.

Upadhyaya A, Davis TD, Sankhla N. Some biochemical changes associated with paclobutrazole induced adventitious root formation on bean hypocotyls cuttings. Ann Bot 1986;57:309-15.

Vu JC, Yelenosky G. Growth and photosynthesis of sweet orange plants treated with paclobutrazol. J Plant Growth Regul 1992;11:85-9.

Wang SY, Faust M. Effect of growth retardants on root formation and polyamine content in apple seedlings. J Am Soc Hortic Sci 1986;111:912-7.

Wang SY, Steffens GL. Effect of paclobutrazol on water stress-induced ethylene biosynthesis and polyamine accumulation in apple seedling leaves. Phytochem 1985;24:2185-90.

Wieland WF, Wample RL. Effect of paclobutrazol on growth, photosynthesis and carbohydrate content of delicious apple. Sci Hortic 1985;26:139-47.