

## GROWTH AND PHOTOSYNTHETIC CHARACTERISTICS AS AFFECTED BY TRIAZOLES IN *Amorphophallus campanulatus* Blume

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Received 7 November 2005

**Summary.** *Amorphophallus campanulatus* (Elephant Foot Yam) is a rich source of starch, essential amino acids and therefore, used as a vegetable. It is cultivated and utilized in various regions of South India. Triazole compounds are widely used systemic fungicides to control diseases in plants and animals. Many of the triazole compounds have both fungi toxic and plant growth regulating properties. Hence, an attempt was made to study the effect of triadimefon, paclobutrazol, and propiconazole on growth and photosynthetic characteristics of *Amorphophallus campanulatus*. Triazole compounds increased total root length, dry weight, moisture content, chlorophyll and carotenoid contents, intercellular CO<sub>2</sub> concentration, net photosynthetic rate (P<sub>N</sub>) and water use efficiency (WUE). On the other hand, petiole length, total leaf area, transpiration rate (T<sub>R</sub>) and stomatal conductance were decreased. Among the triazole compounds, paclobutrazol showed higher effectiveness than the other two triazole compounds tested.

**Keywords:** *Amorphophallus campanulatus*, paclobutrazol, plant growth regulators, propiconazole, triadimefon.

**Abbreviations:** ABA – abscisic acid, C<sub>i</sub> – intercellular CO<sub>2</sub> concentration, C<sub>v</sub> – cultivar, CRBD – completely randomized block design, DAP – days after planting, EC – electrical conductivity, FYM – farm yard manure, GA – gibberelic acid, IRGA – infra red gas analyzer, PBZ – Paclobutrazol, PCZ – Propiconazole, P<sub>N</sub> – photosynthetic rate, RH – relative humidity, TDM – Triadimefon, T<sub>R</sub> – transpiration rate, WUE – water use efficiency

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## INTRODUCTION

Plant growth regulators play a regulatory role in many physiological processes associated with growth and development of plants (Thakur and Thakur, 1993). The triazole compounds are the largest and most important group of systemic compounds developed for control of fungal diseases in plants (Siegel, 1981). They tend to be much more effective than many other plant growth regulators and they generally require relatively low levels of application (Davis et al., 1988, Gilley and Fletcher, 1997). The effects of triazoles on hormonal changes, photosynthetic rate, enzyme activities and yield components have been reported by various researchers (Ye et al., 1995, Zhou and Ye, 1996).

Besides cereals and legumes, the tuber crops are regarded as an important food crop with the highest dry matter production (Kurup and Nambiar, 1993). Elephant foot yam (*Amorphophallus campanulatus* Blume) is one of the very high yielding tuber crop used in certain medicinal preparations recommended for piles and dysentery (Sambamurthy and Subramanyam, 1989).

The triazole compounds are mainly used as growth retardants and also stress protectants in many crop plants (Fletcher et al, 2000). However, data on the use of triazole compounds to increase the yield of tuber crops are scanty. Hence, the present study becomes essential to investigate the effect of triazole compounds on the growth and photosynthetic characteristics of *Amorphophallus campanulatus* cv. Pidikarani.

## MATERIALS AND METHODS

### Plant material

*Amorphophallus campanulatus* is a robust herbaceous plant with an erect long pseudo stem arising from the underground corm apex bearing a tripartite leaf which is deeply dissected. The root system is fibrous and confined to the top layers of the soil. The corms produced at 60 to 80 DAP. Fresh corms of uniform size were harvested and surface sterilized with 0.2% HgCl<sub>2</sub> solution for 3 min with frequent shaking and thoroughly washed in tap water. The field experiments were laid in CRBD with 7 replicates. The pits with a size of 60x60x45cm were dug at a spacing of 90x90cm. The pits were filled with a soil mixture containing FYM, red soil and sand in a 1:1:1 ratio. The plot size was 5 X 4m with 20 pits in each plot. One cormel was planted in each pit and irrigated with bore well water at a 10-day interval. The soil pH was 6.8. Each plant was treated separately with 1L of aqueous solution containing 20 mg triadimefon, 20 mg paclobutrazol and 20 mg propiconazole on 30, 70 and 110 DAP. Treatment was given by soil drenching. During the study the average day and night temperatures were 30±2 °C and 22±2 °C, respectively and the average RH was 70-

80%. The plants were harvested randomly on 80, 160 and 200 DAP for determination of growth and photosynthetic pigments.

### **Growth parameters**

Total root length, petiole length, leaf area and dry weight of root, tuber and leaves were measured. Moisture content was calculated by subtracting the dry weight from the fresh weight.

### **Photosynthetic pigments determination**

Total chlorophyll and carotenoids in the second leaf of the *Amorphophallus* plants were extracted in 80% acetone. The amount of pigments was determined spectrophotometrically after centrifugation at 3000rpm for 10 min (Welschen and Bergkotte, 1994) and calculated according to Lichtenthaler and Wellburn (1983).

### **Gas exchange measurements**

Net photosynthetic rate ( $P_N$ ), transpiration rate ( $T_R$ ), intercellular  $CO_2$  concentration ( $C_i$ ) and stomatal conductance were measured on fully expanded leaves of three individual plants for each treatment at the respective intervals. Gas exchange measurements were done using IRGA (ADC makes model LCA-3). Measurements of  $P_N$ ,  $T_R$ ,  $C_i$  and stomatal conductance were done at  $CO_2$  concentration ( $C_a$ ) of  $340 \mu mol^{-1}$ , leaf to air vapor pressure difference of 2.5 to 3.5 kPa and photosynthetically active irradiance of  $1400 \pm 50 \mu mol m^{-2} s^{-1}$ . Water use efficiency (WUE) represents the ratio of carbon assimilated to water lost by transpiration (Turner, 1986). It was calculated by dividing  $P_N$  by  $T_R$  (Todorov et al., 1992).

## **RESULTS AND DISCUSSION**

Our results indicated that total root length increased significantly after triazole treatment (Table 1, 2, Fig.1). Among the triazoles, TDM showed the strongest effect, followed by PBZ and PCZ. Triazole treatment was found to increase the root growth in cucumber and this was associated with increased levels of endogenous cytokinins (Fletcher and Arnold, 1986). The stimulatory effect of TDM in rooting may be due to an inhibition of GA synthesis and this effect was entirely blocked by the addition of GA (Vettakkorumakankav et al., 1999, Sankhla and Davis, 1999).

Triazole treatment decreased the petiole length in *Amorphophallus* plants (Table 1, 2, Fig.1). Triadimefon causes several pronounced side effects in plants including the development of shorter and more compact shoots in wheat plants (Fletcher and Nath, 1984) and cow pea (Gopi et al., 1999). The possible reason for the shorter stem could be attributed to the inhibition of cell division and elongation of the subapical

**Table 1.** Triazole-induced changes in growth and photosynthetic parameters of *Amorphophallus campanulatus* on 80th DAP. (values are means of 7 samples, P=0.05 Least Significant Difference)

Parameters	Control	TDM (20mg l <sup>-1</sup> )	PBZ (20mg l <sup>-1</sup> )	PCZ (20mg l <sup>-1</sup> )	LSD (P=0.05)
Total root length [cm plant <sup>-1</sup> ]	365.81	644.82	498.3	383.22	17.097
Petiole length [cm plant <sup>-1</sup> ]	21.8	18.3	16.8	17.4	0.672
Total leaf area [cm <sup>2</sup> plant <sup>-1</sup> ]	24.03	17.73	16.56	16.7	2.312
Dry weight of whole plants [g plant <sup>-1</sup> ]	24.56	49.06	43.52	43.56	1.541
Moisture content of whole plants [g plant <sup>-1</sup> ]	109.79	136.16	121.78	128.15	2.318
Total chlorophyll (a+b) [mg g <sup>-1</sup> FW]	0.11	0.131	0.127	0.12	0.016
Carotenoids [mg g <sup>-1</sup> FW]	0.018	0.04	0.037	0.033	0.006
Net photosynthesis rate (P <sub>N</sub> ) [μmol CO <sub>2</sub> m <sup>-2</sup> s <sup>-1</sup> ]	9.25	11.24	11.38	11.31	1.39
Transpiration rate(T <sub>R</sub> ) [μ mol H <sub>2</sub> O m <sup>-2</sup> s <sup>-1</sup> ]	7.92	5.37	5.67	5.98	0.31
Intercellular CO <sub>2</sub> concentration [μmol s <sup>-1</sup> ]	125	145	143	147	10.09
Stomatal conductance [μmol H <sub>2</sub> O m <sup>-2</sup> s <sup>-1</sup> ]	112.15	94.28	93.92	94.12	7.82
Water use efficiency (WUE) [μmol CO <sub>2</sub> m <sup>-2</sup> s <sup>-1</sup> / μmol H <sub>2</sub> O m <sup>-2</sup> s <sup>-1</sup> ]	1.168	2.141	2.007	1.891	–

meristem (Sachs et al., 1960). It was shown that S-3307 retarded the plant height in rice plants (Izumi et al., 1984). The growth retarding effects of triazoles could probably be due to an inhibition of GA biosynthesis (Fletcher et al, 2000).

Triazole treatment decreased significantly the total leaf area when compared to the respective controls (Table 1, 2, Fig.1). PBZ treatment was found to reduce the total number of leaves and leaf size in citrus (Swietlik and Fucik, 1988) and *Cymbidium sinense* (Pan and Luo, 1994). The inhibition of GA biosynthesis as well as increased ABA content induced by triazole treatment could be the reason for the inhibition of leaf expansion in the triazole-treated *Amorphophallus campanulatus* plants.

Our results showed that both the dry weight and moisture content of roots and tubers were increased when compared to controls. Paclobutrazol and triadimefon treatments increased the root, tuber dry weight and moisture content to a larger extent (Table 1, 2, Fig.1). It was shown that triadimefon treatment increased the dry weight and moisture content of roots in cucumber (Fletcher and Arnold, 1984), radish (Fletcher and Nath, 1988) and peanut (Muthukumarasamy and Panneerselvam, 1997). The mode of action of PBZ in relation to early tuber development can be

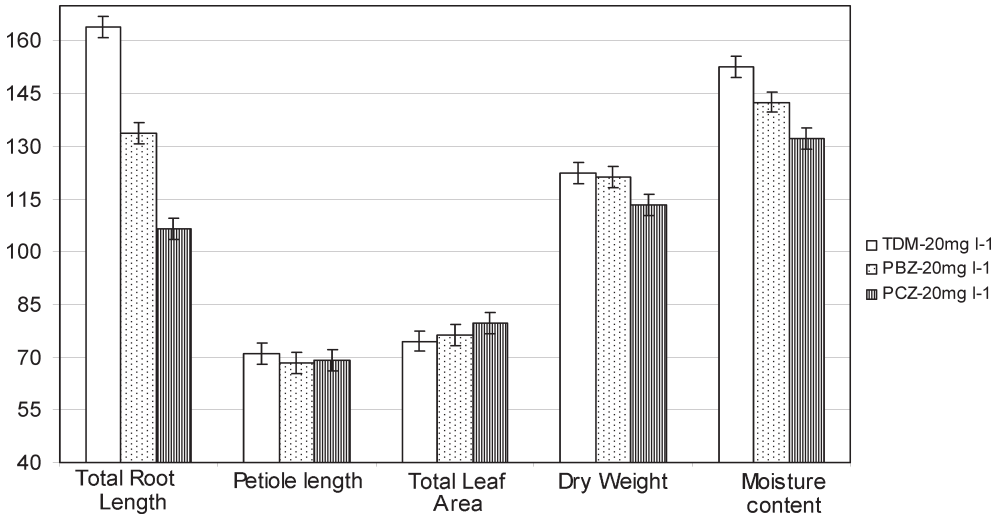
**Table 2.** Triazole-induced changes in growth and photosynthetic parameters of *Amorphophallus campanulatus* on 160<sup>th</sup> DAP. (Values are means of 7 samples, P=0.05 Least Significant Difference)

Parameters	Control	TDM (20mg l <sup>-1</sup> )	PBZ (20mg l <sup>-1</sup> )	PCZ (20mg l <sup>-1</sup> )	LSD (P=0.05)
Total root length [cm plant <sup>-1</sup> ]	452.3	795.7	628.62	492.31	19.512
Petiole length [cm plant <sup>-1</sup> ]	37.9	29.21	26.2	27.02	1.154
Total leaf area [cm <sup>2</sup> plant <sup>-1</sup> ]	34.58	26.56	25.71	27.31	1.199
Dry weight of whole plants [g plant <sup>-1</sup> ]	92.33	170.73	164.82	158.29	6.479
Moisture content of whole plants [g plant <sup>-1</sup> ]	290.15	408.09	391.2	391.17	3.878
Total chlorophyll (a+b) [mg g <sup>-1</sup> FW]	0.145	0.174	0.168	0.167	0.014
Carotenoids [mg g <sup>-1</sup> FW]	0.023	0.052	0.042	0.039	0.01
Net photosynthesis rate (P <sub>N</sub> ) [μmol CO <sub>2</sub> m <sup>-2</sup> s <sup>-1</sup> ]	18.46	21.68	23.8	21.36	1.45
Transpiration rate [T <sub>R</sub> ] [μmol H <sub>2</sub> O m <sup>-2</sup> s <sup>-1</sup> ]	13.15	9.81	10.36	9.36	1.06
Intercellular CO <sub>2</sub> concentration [μmol s <sup>-1</sup> ]	215	275	269	271	17.08
Stomatal conductance [μmol H <sub>2</sub> O m <sup>-2</sup> s <sup>-1</sup> ]	82.12	73.95	72.81	73.21	6.72
Water use efficiency (WUE) [μmol CO <sub>2</sub> m <sup>-2</sup> s <sup>-1</sup> / μmol H <sub>2</sub> O m <sup>-2</sup> s <sup>-1</sup> ]	1.403	2.209	2.2	2.282	–

explained by the inhibitory effect of triazoles on GA levels. The lower GA levels as a prerequisite for tuber formation (Hammes and Nel, 1975) increase the ability of partitioning of assimilates to tuberous organ as observed in potato (Deng and Parange, 1988) and gladiolus (Steinitz et al., 1991).

The results of the present study support the observation of Sankhla et al. (1985) and Williamson et al. (1986) for increased leaf dry weight per unit leaf area under triazole treatment in soybean and peach. Triazoles were found to increase the cytokinin content in many plants like pumpkin, oil seed and rape seedlings (Grossmann, 1992). The increased cytokinin levels might increase cell division and thereby lead to increased dry weight in the triazole-treated Elephant Foot Yam plants.

Treatment with triazoles increased chlorophyll and carotenoid contents (Table 1, 2, Fig. 2). Earlier data have shown that TDM treatment increases chlorophyll content in leaves of tomato (Buchenauer and Rohner, 1981), radish (Muthukumarasamy and Panneerselvam, 1997) and cowpea (Gopi et al., 1999). PBZ increased chlorophyll content, fresh weight and leaf area basis and this may be partly due to the observed increase in mass of the root system which is the major site of cytokinin biosynthesis



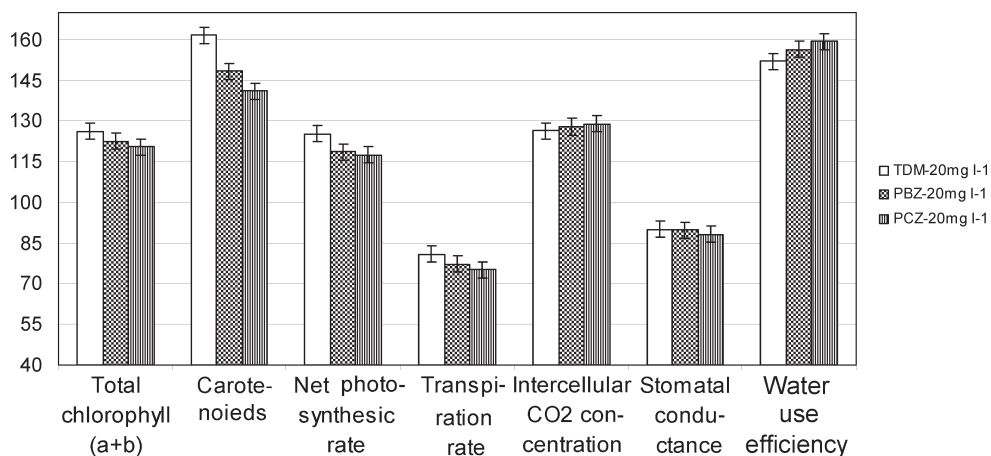
**Fig.1.** Effect of triazoles on percentage changes in different growth parameters of *Amorphophallus campanulatus* 200 DAP.

(Sopher et al., 1999). The increase in cytokinin levels was associated with stimulated chlorophyll biosynthesis (Fletcher et al., 2000).

Net photosynthetic rate was increased after triazole application (Table 1, 2, Fig. 2). Similar results were observed in PBZ-treated apple (Hong et al., 1995) and triadimefon-treated radish (Panneerselvam et al., 1997). In radish TDM increased  $P_N$  along with intercellular  $CO_2$  concentration and stomatal conductance (Panneerselvam et al., 1997). The increased intercellular  $CO_2$  concentration and stomatal conductance may be the reason for the increased  $P_N$  in *Amorphophallus* plants. Both increased chlorophyll content and photosynthesis after triazole application were also reported for rice seedlings (Guirong et al., 1995) and bhendi (Sujatha et al., 1999).

The rate of transpiration was lowered in triazole-treated plants at all stages of growth (Table 1, 2, Fig.2). Triadimefon treatment increased the level of ABA content in various plants (Davis et al., 1986, Fletcher and Hofstra, 1988). This in turn induced stomatal closure, thereby decreasing the transpiration rate. A decrease in transpiration rate may have increased the moisture content in the *Amorphophallus campanulatus* plants. Similar results were observed in triadimefon-treated wheat (Sairam et al., 1989) and radish plants (Panneerselvam et al., 1997). Besides, triadimefon treatment increased the ABA content in bean (Asare-Boamah et al., 1986).

Triazole treatment increased the intercellular  $CO_2$  concentration (Table 1, 2, Fig. 2). Similar results were observed in BAS. III W treated maize (Kasele et al., 1995) and *Raphanus sativus* (Panneerselvam et al., 1997). On the other hand, triazole treatment decreased stomatal conductance in *Amorphophallus* plants (Table 1, 2, Fig. 2). Triazole caused partial closure of stomata in mulberry, thereby reducing the  $T_R$



**Fig.2.** Effect of triazoles on percentage changes in different photosynthetic parameters of *Amorphophallus campanulatus* 200 DAP..

(Sreedhar, 1991) in bean (Asare-Boamah et al., 1986) and oil seed rape (Butler et al., 1988). Our results showed increased WUE in *Amorphophallus* plants (Table 1, 2, Fig. 2). Similar results were reported for TDM-treated sunflower (Wamble and Culver, 1983). PBZ increased the WUE in *Pseudotsuga menziesisi* and *Pinus cornata* seedlings (Vanden, 1996). Triazole induced partial closure of stomata and increased intercellular CO<sub>2</sub> concentration. This may be the reason for the increased WUE in the treated plants.

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