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Ethylene Release of *Panax ginseng* in Relation to Plant Part and Various Conditions

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Abstract□ Ethylene was released from leaf and fruit but root of *Panax ginseng*. Root callus showed higher ethylene release (ER) than fruit. ER increased with leaf senesence. Fruit during ripening showed decreasing ER in the order of green stage, early stage of reddening and fully ripened stage. Green leaves from the plant with fruits in different stages of ripening showed similar trend of fruit in ER but it was about 10 times higher in leaves than in fruits. Leaves of *P. quinquefolius* showed about 200 times higher ER than that of *P. ginseng* on 22 July. Fruits from the plant treated with ethephon showed higher ER after 109 days. Fortyfive day-old seedlings grown with various growth regulators showed a significant decrease of stem length and significant increase of ER only in Uniconazole (0.1 ppm) and B-9 (0.05 ppm) solution.

Keywords□ *Panax ginseng*, ethylene release, senesence, growth regulators.

Introduction

Studies on endogenous growth regulators of *Panax* species were hardly to be found. Existence of IAA, ABA and GA-like substance[1] was reported in *Panax ginseng* but ethylene production was not reported. Ethephon was tested for growth and yield in *Panax quinquefolius*.[2] We made short stem by application of Ethephon to *P. ginseng* at early stage (unpublished data). These facts strongly suggests that endogenoud ethylene involves in growth regulation of *Panax* species. We found ethylene production from various parts of *P. ginseng* and leaves of *P. quinquefolius* by gas chromatography.

Materials and Methods

Plant materials

Four dehisced seeds were germinated on the gauze immersed into 5 m*l* solution of each growth regulator in a glass vial (2.5 cm I), 15 cm L, 50 m*l*) at 15 °C and grown with 12 hr light/12 hr dark cycle. After 20 days 5 m*l* of regulator solution was added. Plant growth status and ethylene release during 24 hours was measured after 45 days. Ethylene released from detached palmated leaves and fruits in different maturity of 4th year *P. ginseng* in different degree of senescence in a field were used. Ginseng root callus normally grown on MS medium[3] and 6 year old root without top were subjected to ethylene measurement. Detached palmate leaves of 5 year old *P. quinquefolius* was compared with those of *P. ginseng*.

C_2H_4 analysis

Ethylene was collected by sealing vial for 24 hours. Gas sample was injected into Varian Model 3700 gas chromatograph. Nitrogen was flowed at 180 m*l*/min through glass column packed with POPAPAK^N. Temperature was 50 °C, 60 °C and 100 °C for injector, column and detector, respectively. Standard ethylene was cochromatographed for authenticity of the peak.

CO_2 analysis

Gas samples were injected to HORIBA (PIR-

2000) intra red gas analyzer.

Results

Effect of leaf senescence

Ethylene and CO_2 release from leaves of 4 year old *P. ginseng* with three degrees of chlorosis by senescence was shown in Table 1. Ethylene release slightly increased at 25% chloresis and tended to decrease at 50% chlorosis. But ethylene release continuously increased. Early stage of senescence seemed to be more active in ethylene release than in later stage.

Effect of fruit senescence

The clusters of fruits with peduncles in a sealed vial released ethylene (Table 2). Green fruits in early stage of ripening showed much higher release of ethylene than those in the begining of redening (mid-ripening stage). Fully ripened red berry showed the least ethylene production but after 114 hours showed greater release than those at mid-ripening stage. The leaves of the same plant of the fruits showed similar tendency of fruit in ethylene release. Ethylene release of leaves was 5 to 60 times higher than that from the fruit.

Table 1. C_2H_4 and CO_2 release from leaves in relation to chlorosis (4-year old ginseng July 25)

Chlorosis area (%)	C_2H_4 (nmol/100g. fw/24 hr)	CO_2 (mmol/100g. fw/24 hr)
0	78	12.6
25	152	18.0
50	194	17.3

Table 2. C_2H_4 release of ginseng fruits and leaves in relation to ripening of fruit (4-year old ginseng, July 24)

Maturity of fruit		C_2H_4 (nmol/100g. fw) In sealed vial		
		16 hr	71 hr	114 hr
Fruit	Green	15	69	63
	Early redening	13	19	22
	Fully red	10	15	26
Leaf	Green	163	232	401
	Early redening	151	164	150
	Fully red	89	78	187

Table 3. C_2H_4 release of ginseng callus and 6-year old root

Ginseng (g. fw)	C_2H_4 (nmol/100g. fw/24 hr)
Callus (3.1)	89.0
Root (85)	0.0

Effect of tissue culture

Root callus grown on MS medium produced ethylene but it was not detected in 6-year old root (Table 3). Releasing rate of ethylene from callus was much higher than the fruits but lower than leaves (Table 2). Information on ethylene release from root seemed to be very rare[4].

Species specificity

There are nine species in genus *Panax* and *P. quinquefolius* is most similar to *P. ginseng* in plant type and ginsenosides[5]. Leaves of *P. quinquefolius* released about 20 times more ethylene in comparison with *P. ginseng* (Table 4). They were grown in the same field. The leaves of both species did not show any senescent symptom. Carbondioxide release was also higher in *P. quinquefolius* but the difference was too small to compare with the difference in ethylene release.

Ethephon pretreatment

When the shoots emerged ethephon was applied. After 109 days ethylene release of fruit was investigated. Ethephon pretreatment increased ethylene release from fully ripened fruit than that of control (Table 5). Ethephon treatment reduced stem length.

Effect of various growth regulators on young seedling

Stem length, fresh weight and ethylene release of *P. ginseng* seedlings at 45 days after germination when grown with various growth regulators were shown in Table 6. All regulators tested reduced

Table 4. C_2H_4 and CO_2 release from leaves of Panax species.

Panax species	C_2H_4 (nmol/100g. fw) In sealed vial			CO_2 (mmol/100g.fw) In sealed vial		
	16 hr	71 hr	114 hr	16 hr	71 hr	114 hr
P. ginseng	0	20	60	4.0	8.0	20.1
P. quinquefolius	201	356	1280	6.3	18.8	35.3

Table 5. C_2H_4 and CO_2 release (July 23) from matured fruit at 109 days after ethephon treatment on ginseng shoot (4-year old ginseng)

Treatment	C_2H_4 (nmol/100g. fw/24 hr)	CO_2 (mmol/100g. fw/24 hr)
Without	2.5	0.85
Ethephon	5.9	0.61

stem height but Uniconazole and B-9 showed significant effect. All tested growth regulators except IAA showed higher ethylene release than control. But variation was very high.

Uniconazole and B-9 showed significantly higher release of ethylene than control. Ethylene release was higher in B-9 treatments than in Uniconazole. Thus the effect of growth regulators on stem length were well accordance with C_2H_4 release in two growth retardants. Fresh weight significantly decreased only in Uniconazole treatment. Ethylene was not detected at 24 days after germination in all treatments. The effect of growth regulators will be different according to dose. In this experiment all growth regulators were tested at 0.1 ppm except B-9 at 0.05 ppm.

Discussion

From above data it is clear that *P. ginseng* release ethylene from leaf, fruit, callus and young seedling except root (Table 1,2,3). The effect of cutting of petiol and peduncle on ethylene release is not clear in this investigation. Since the intact young seedling released ethylene (Table 6) it is certain that ethylene system plays some roles for normal growth. It is interesting that the field grown root did not release any ethylene while root callus release (Table 3). Since root was digged and the aerial part was cutted the root had considerable wounds such as the damage of fine roots. It must be retested in relation to growth stages. Ethylene release rate in *P. ginseng* seems to be in decreasing order of leaf, young seedling, callus and fruit (Table 2,3,6).

Table 6. Growth and C_2H_4 release from early seedling of *P. ginseng* at 45 days after treatment

Regulator	concentration (ppm)	Stem length (cm)	Fresh weigth (mg. fw/plant)	C_2H_4 (nmol/100g. fw/24 hr)
GA	0.1	6.8ns	161	210ns
IAA	0.1	5.6ns	170ns	56ns
2, 4-D	0.1	6.7ns	203ns	80ns
Kinetin	0.1	6.3ns	187ns	85
Ethephon	0.1	7.2ns	202ns	393ns
ABA	0.1	7.7ns	185ns	108ns
Uniconazole	0.1	5.5*	154*	82*
B-9	0.05	0.8*	170ns	108*
Control	Water	7.8	175ns	59

F-test: control vs each treatment, ns: non significant, *: significant at p=0.05

The release rate of ethylene of *P. ginseng* appeared to be in similar range of mung bean[6] and apple[7]. The stimulation effect of IAA on ethylene release in other plants[6] seemed not to be such in *P. ginseng* (Table 6). The higher ethylene release of *P. quinquefolius* appeared to be due to genetical difference, but the effect of environmental condition could not be ruled out since *P. quinquefolius* was grown in Korea, non habitat. Investigation in its habitat is needed. In Korea *P. quinquefolius* usually tends to show rapid senescence.

From this investigation it is clear that ethylene plays roles for reducing stem length. The decrease of stem length by application of ethephon on *P. quinquefolius*[2], the higher ethylene release from the fruit of pretreated plants (Table 5), and from the short-stem seedling by Uniconazole and B-9 treatment (Table 6) are well in accordance in the "Jugjolim" a kind of dwarfism by the exposure to sun light that has long been practiced in the traditional cultivation method in Korea.

This investigation (Table 1,2) indicates the strong involvement of endogenous ethylene system to leaf senescence. However/ethylene release during leaf senescence in *P. ginseng* might be different according to senescence stages. Although the leaves with green fruit were younger than those with the fully reddened the former released more ethylene than the latter did (Table 2). This fact appeared to be contradict to the higher ethylene release of severe chlorotic leaves (Table 1). Ethylene must be studied more for the better understand of growth process of Panax species.

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