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# Changes of Rutin Content and Photosynthesis Rate of Korean Buckwheat Cultivars under Various Environmental Stresses

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**ABSTRACT** : This study was conducted to classify photosynthesis rate and changes of rutin content of Korean buckwheat (cv. Chunchon-jaerae and Yangjeul-memil) treated with salinity, UV-C and low temperature. In case of cv. Chunchon-jaerae and Yangjeul-memil, according to the salt stress, transpiration rate, stomatal conductance and photosynthesis rate were decreased. Both cultivars also showed decrease of transpiration rate and photosynthesis rate under the UV-C. Rutin contents within leaf and stem of cv. Yangjeul-memil were decreased when NaCl concentration was high. Rutin contents within leaf and stem of cv. Yangjeul-memil were generally decreased when the time laps under the UV-C stress. Rutin contents within leaf and stem of cv. Chunchon-jaerae was also generally decreased when the time laps under the low temperature stress.

***Key words*** : buckwheat, rutin, photosynthesis rate, low temperature, salinity, UV-C

## INTRODUCTION

Buckwheat (*Fagpyrum esculentum*) as a significant content of rutin (quercetin-3-rutinosid) and other polyphenols (Luthar, 1992). The content of rutin is listed on important characteristics from the viewpoint of nutrition (Michalova, 1998). Rutin also has a potency of anticarcinogens against colon and other cancers. It's anticarcinogenic and antimutagenic potentials may be related to their antioxidative property, which is important in the protection against cellular oxidative damage (Kreft *et al.*, 1994).

Environmental stresses present major challenges in our quest to achieve sustainable food production. In general, environmental stresses, including salinity, drought, heat, chilling, anaerobiosis, heavy metals, gaseous pollutants, and UV-B radiations cause an alteration in gene expression in plants leading to the induction of specific genes and an increased abundance of their translatable mRNAs and proteins (Dubey, 1999). Soil salinity is a major environmental stresses that drastically affects crop productivity. Salinity poses a severe threat for the cultivation of crops in arid and semiarid agricultural lands. Salinity affects seed germination, plant growth, nutrient uptake, and metabolism owing to the osmotic inhibition of water availability, toxic effects of salt ions, and nutritional imbalance caused by such ions (Dubey & Pessarakli, 1995). UV-B radiation inhibits the growth of plants, causes inhibition in protein synthesis (Strid *et al.*, 1994) and induces the activities of peroxidase-related enzymes (Rao *et al.*, 1996) and the enzymes of flavonoid biosynthetic pathway (Kuhn *et al.*, 1984). Leaf protein biosynthesis is rapidly inhibited by UV-B radiation (Kuhn *et al.*, 1984). Chilling injury may occur at temperatures below 15℃, but by definition chilling occurs in the absence of ice-nucleation in plant

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cells.i.e. between 15 and 0℃. The concerns growth and development of plants during spring when temperatures are low or any time during the growth period when air temperatures drop below normal. Chilling injury to photosynthesis is much more severe if exposure occurs coincident with moderate or high light intensities. Low temperatures slow all metabolic reactions due to kinetic effects, but in terms of photosynthesis there are two that are particularly sensistive-those involved in $CO_2$ fixation, and those involved in regulating stomatal aperture.

Maeng *et al.* (1990) reported that the rutin contents in buckwheat groats were ranged from 8.84 ㎎ to 24.77 ㎎/100 g. Kim *et al.* (1994) reported that Suwon 11 (0.12%) and Suwon 5 (0.11%) had high contents of rutin in seeds among the improved kind. And they showed contents of rutin of Suwon 5 was 0.40% in the first growing stage, whereas 1.32% in final growing stage. Lee (2001) reported that the rutin content in buckwheat plant decreased in order of flower > leaf > stem. And he showed rutin content increased in the sweet buckwheat as the day length increased from 8 hours to 14 hours. However, changes of rutin content of buckwheat under the stresses condition were not clear. In this paper we present effects of environmental stresses on photosynthesis rate and rutin content of buckwheat.

## MATERIALS AND METHODS

### Testing cultivars

Two Korean buckwheat cultivars, Chunchon-jaerae and Yangjeul-memil of 10-day-old seedlings were planted in growth chamber at 25℃ under a 12-h daylight period (120 ㎛ol $m^{-2}$ $s^{-1}$). For each cultivar, 12 plants were then transfered in growth box and distributed among the box containing 30 ℓ of soil.

Environment stresses were applied on 55-day-old plants and imposed at 10 a.m. in the morning. Salts treatments of two transplanted buckwheat cultivars were carried out 0, 5, 10 and 25 mM of NaCl during one day. Two Korean cultivars were exposure to UV-C (254 ㎚) during 0, 3 and 5 hours. And also exposure to low temperature treatment during 0, 0.5, 3 and 5 hours at 5℃. And then we measured photosynthesis rate, transpiration rate and stomatal conductance (ADC-4, ADC, Ltd. UK). For each plant, stems and leaves were separated and measured rutin content (Table 1).

**Table 1.** Analysis condition of HPLC.

| Instrument | Shimadzu SPD-7AV UV Detector |
|---|---|
| Wave | 345 ㎚ |
| Column | Bondapak C18 |
| Column temperature | 30℃ |
| Mobil phase | Acetic acid (2,4%): Methanol: Acetonitrile (35: 5: 10, v/v) |
| Flow rate | 1.0 ㎖/min. |

## RESULTS AND DISCUSSION

### Treatment of salinity

In case of cv. Yangjeul-memil, according to the higher NaCl concentration, photosynthesis rate and transpiration rate were decreased (Table 2). And also cv. Chunchon-jaerae, according to the higher salts concentration, transpiration rate, stomatal conductance and photosynthesis rate were decreased. However, $CO_2$ concentration within a leaf were increased under the salts treatment. Especially, photosynthesis rate of cv. Chunchon-jaerae treated salts with 5 mM and 10mM were 6.45±0.80 ㎛ol $m^{-2}$ $s^{-1}$ and 1.54±0.07 ㎛ol $m^{-2}$ $s^{-1}$, respectively. So, there were an inverse proportion between salts concentration and photosynthesis rate. Generally, rutin content within a leaf and stem of cv. Yangjeul-memil, were decreased when the treatment of salts concentration were higher. Rutin content within a leaf of cv. Chunchon-jaerae was increased until 10 mM NaCl concentration. However, that of within a stem of cv. Chunchon-jaerae was decreased at 10 mM (Table 3).

### Treatment of UV-C

Both cv. Yangjeul-memil and cv. Chunchon-jaerae showed a decreased of transpiration rate and photosynthesis rate under the ultraviolet ray stress (Table 4). But, there were hardly changes in intercellular $CO_2$ concentration of a leaf. Especially, photosynthesis rate of cv. Yangjeul-memil were 5.64±2.40 ㎛ol $m^{-2}$ $s^{-1}$

**Table 2.** Parameters of related to leaf photosynthesis in Yangjeul-memil and Chunchon-jaerae treated with salinity.

| Cultivars and NaCl concentration | E†(mbar) | Gs (㏖) | A (㎛㏖ $m^{-2}$ $s^{-1}$) | Ci (ppm) |
|---|---|---|---|---|
| Yangjeul-memil | | | | |
| 0 mM | 1.15±0.37 | 0.11±0.05 | 5.64±2.40 | 277.6± 4.9 |
| 5 mM | 1.11±0.13 | 0.10±0.01 | 5.79±0.45 | 257.5± 8.8 |
| 10 mM | 0.85±0.07 | 0.03±0.00 | 1.80±0.37 | 269.3±14.1 |
| 25 mM | 0.59±0.09 | 1.03±0.01 | 1.54±0.07 | 264.1±12.7 |
| Chunchon-jaerae | | | | |
| 0 mM | 1.30±0.16 | 0.14±0.02 | 5.40±0.77 | 288.6± 5.2 |
| 5 mM | 0.98±0.21 | 0.09±0.02 | 6.45±0.80 | 230.7±19.1 |
| 10 mM | 0.59±0.09 | 0.03±0.01 | 1.54±0.07 | 264.1±12.7 |
| 25 mM | 0.34±0.07 | 0.03±0.00 | 0.47±0.32 | 331.4±20.9 |

† E, transpiration rate; Gs, stomatal conductance; A, photosynthesis rate; Ci, intercellular $CO_2$ concentration.

**Table 3.** Rutin contents in Yangjeul-memil and Chunchon-jaerae treated with salinity.

| Cultivars and NaCl concentration | rutin content (㎍/100 ㎍ MeOH-Ex) | |
|---|---|---|
| | Leaf | Stem |
| Yangjeul-memil | | |
| 0 mM | 17.21±0.15 | 9.05±0.23 |
| 5 mM | 16.23±0.11 | 8.12±0.08 |
| 10 mM | 14.27±0.35 | 5.42±0.22 |
| 25 mM | 9.34±0.21 | 3.39±0.07 |
| Chunchon-jaerae | | |
| 0 mM | 12.85±0.23 | 7.83±0.14 |
| 5 mM | 16.57±0.25 | 7.58±0.38 |
| 10 mM | 17.96±0.27 | 6.54±0.09 |
| 25 mM | 8.65±0.26 | 5.24±0.30 |

in 0 hour treatment and 0.69±0.28 ㎛ol $m^{-2}$ $s^{-1}$ at 3 hours treatment. There was a great decreased of photosynthesis rate under the ultraviolet rays. Rutin content within a leaf and stem of cv. Yangjeul-memil were generally decreased when the time laps under the ultraviolet rays. In the while, within a leaf of cv. Yangjeul-memil showed little change (Table 5). Alan *et al.* (1990) reported that effects of UV-B radiation on soybean yield and seed quality. They showed the cultivar Essex was found to be sensitive to UV-B radiation while the cv. Williams was tolerant. A number of rice cultivars are sensitive to potential increases in UV-B radiation and the diversity exhibited by rice in response to increased levels of UV-B suggests that selective breeding might be successfully used to develop UV-B tolerant rice cultivars (Alan *et al.*, 1991).

### Treatment of Low temperature

Transpiration rate, stomatal conductance and photosynthesis rate of cv. Yangjeul-memil were decreased when the time laps under the low temperature (Table 6). Especially, photosynthesis rate and transpiration rate of that showed large decrease 3 hours rather than 30 minutes. There were nearly changes in $CO_2$ concentration within a leaf until 3 hours. $CO_2$ concentration within a leaf treated 5 hours of low temperature was decreased a half than that of 3 hours treatment. Transpiration rate, stomatal conductance and photosynthesis rate of cv. Chunchon-jaerae were decreased until 3 hours under the low temperature treatment. However, those of cv. Chunchon-jaerae showed a small increase at 5 hours treatment. In the while, intercellular $CO_2$ concentration of leaf was hardly changed at 3 hours under low temperature. Stomatal aperture is generally reduced at low temperatures, in part because water

**Table 4.** Parameters of related to leaf photosynthesis rate in Yangjeul-memil and Chunchon-jaerae treated with UV-C.

| Cultivars and treatment time | E† (mbar) | Gs (mol) | A (μmol $m^{-2}$ $s^{-1}$) | Ci (ppm) |
|---|---|---|---|---|
| Yangjeulmemil | | | | |
| 0 hour | 1.15±0.37 | 0.11±0.05 | 5.64±2.40 | 277.6± 4.9 |
| 3 hours | 0.50±0.08 | 0.02±0.00 | 0.69±0.28 | 300.3± 8.8 |
| 5 hours | 0.56±0.21 | 0.02±0.01 | 0.83±0.37 | 263.7±21.8 |
| Chunchonjaerae | | | | |
| 0 hour | 1.30±0.16 | 0.14±0.02 | 5.40±0.77 | 288.6±5.2 |
| 3 hours | 0.78±0.18 | 0.04±0.01 | 1.23±0.34 | 278.9±1.3 |
| 5 hours | 1.08±0.37 | 0.04±0.02 | 1.96±0.30 | 283.5±2.3 |

† E, transpiration rate; Gs, stomatal conductance; A, photosynthesis rate; Ci, intercellular $CO_2$ concentration.

**Table 5.** Rutin contents of leaf and stem in Yangjeul-memil and Chunchon-jaerae treated with UV-C.

| Cultivars and treatment time | rutin content (μg/100 μg MeOH-Ex) | |
|---|---|---|
| | Leaf | Stem |
| Yangjeul-memil | | |
| 0 hour | 18.34±0.21 | 3.69±0.18 |
| 3 hours | 16.49±0.31 | 3.19±0.06 |
| 5 hours | 12.61±0.33 | 3.16±0.21 |
| Chunchon-jaerae | | |
| 0 hour | 14.54±0.27 | 4.44±0.16 |
| 3 hours | 14.69±0.31 | 4.53±0.23 |
| 5 hours | 14.74±0.37 | 5.78±0.28 |

conductivity is decreased through the root plasma membrane (McWilliam *et al.*, 1982) but also because the response of stomates is slow of sluggish under low temperatures (Guye & Wilson, 1987). Rutin content within a leaf and stem of cv. Chunchon-jaerae was generally decreased when the time laps under the low temperature treatment (Table 7).

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**Table 6.** Parameter of related to leaf photosynthesis in Yangjeul-memil and Chunchon-jaerae treated with low temperanture (5℃).

| Cultivars and treatment time | E† (mbar) | Gs (mol) | A (μmol $m^{-2}$ $s^{-1}$) | Ci (ppm) |
|---|---|---|---|---|
| Yangjeulmemil | | | | |
| 0 hour | 4.80±0.52 | 0.32±0.08 | 11.59±0.42 | 263.5±21.7 |
| 0.5 hour | 2.13±0.67 | 0.18±0.08 | 7.97±1.59 | 266.0±17.9 |
| 3 hours | 0.28±0.10 | 0.02±0.01 | 0.60±0.22 | 318.6± 5.2 |
| 5 hours | 0.23±0.08 | 0.01±0.01 | 1.94±0.98 | 167.1±39.8 |
| Chunchon-jaerae | | | | |
| 0 hour | 3.68±0.67 | 0.28±0.06 | 12.31±0.74 | 243.8± 9.1 |
| 0.5 hour | 1.55±0.17 | 0.12±0.02 | 7.83±0.51 | 242.1±12.3 |
| 3 hours | 0.23±0.04 | 0.01±0.00 | 0.97±0.4 | 262.8±36.1 |
| 5 hours | 0.49±0.21 | 0.04±0.02 | 3.84±0.93 | 164.4±32.5 |

† E, transpiration rate; Gs, stomatal conductance; A, photosynthesis rate; Ci, intercellular $CO_2$ concentration.

**Table 7.** Rutin contents of leaf and stem in Yangjeul-memil and Chunchon-jaerae treated with low temperanture (5℃).

| Cultivars and treatment time | rutin content (μg/100 μg MeOH-Ex) | |
|---|---|---|
| | Leaf | Stem |
| Yangjeul-memil | | |
| 0 hour | 25.54±0.15 | 4.90±0.12 |
| 0.5 hour | 24.84±0.20 | 6.35±0.31 |
| 3 hours | 25.80±0.17 | 6.01±0.14 |
| 5 hours | 27.55±0.27 | 7.03±0.25 |
| Chunchon-jaerae | | |
| 0 hour | 23.88±0.23 | 7.22±0.19 |
| 0.5 hour | 22.29±0.26 | 5.09±0.37 |
| 3 hours | 18.16±0.04 | 4.51±0.27 |
| 5 hours | 18.06±0.06 | 9.64±0.06 |

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