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EFFECT OF GIBBERELLIN ON THE GROWTH AND INTERNAL COMPONENTS OF *ASTRAGALUS SINICUS* L.

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車鐘煥 : 자운영의 生育 및 成分에 미치는 지베레린의 影響

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ABSTRACT

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The effect of GA on the growth as well as on the internal components of the leaves of *Astragalus sinicus* L. under the soil culture was investigated. The result has indicated that small variation in the relative concentration of GA treated on the leaves shows a marked influence on the internal components of the plants.

The increase of growth was associated with increasing intensity of GA. Chlorophyll and carotene contents in the leaves were depressed with increasing concentration of GA. It was noticed that the growth was promoted with the decrease of the contents of chlorophyll and carotene. In contrast the ascorbic acid in the leaves treated with GA decreased in proportion to the degree of the concentration of GA. Carotene content varied with chlorophyll, although the ratio of chlorophyll to carotene was not so high as the results obtained by Beck and Redman[1]. Chlorophyll and ascorbic acid values with respect to growth differed greatly during the two experimental periods. The chlorophyll content was found highly significant in this experiment. As the concentration of GA was increased, it was noticed that there was a reduction of anthocyanin, sucrose, and reducing sugar contents. The anthocyanin content was not so high in this study as in the results obtained from the corn by Jacob Straus[6].

INTRODUCTION

Ever since the discovery of gibberellin (GA), its effect has been investigated with much interest in Japan and more recently in the western countries. In the previous paper of the author(3), the effects of GA on the growth and internal components of some vegetable plants were studied. In the present paper, however, other plant samples were examined. The following experiments with *Astragalus sinicus* L. have been designed to investigate the effects of GA on the nutrition of the plants grown on a selected soil under favourable conditions. The stated plant, *Astragalus sinicus* L., was chosen for the study on the ground that it is not only the most important green manure crop but also a familiar edible plant in

Korea.

MATERIALS AND METHODS

The seeds were sown two times on 17 June and on 30 July 1960 respectively in pots filled with loam. After germination the seedlings were thinned, leaving uniform seedlings in each pot. The plants were timely watered, each time up to the field capacity, so that a favourable moisture in the soil might be maintained. Two weeks after germination, the seedlings of each pot were treated with different concentrations of GA, spraying sufficiently on all leaves every four days, five times altogether. Three days after the last treatment, the plants were used for the first experiment. The pH value of the soil solution indicated 6.2-6.6. The concentrations on GA used were 0(control), 0.1, 1, 10, 50 and 100 ppm respectively. The second experiment in which all procedures were the same as in the first, was performed 3 weeks after the first. A portion of the plant was harvested from each series and details of appearance, the fresh and dry weights were recorded. The growth was checked every week. The method of determination of the ascorbic acid, the chlorophyll and the carotene contents was the same as that of the previous paper of the author[3]. For quantitative determination of the anthocyanin pigments, the tissue was removed from the stems and the leaves, weighed and placed in a flask. 2% HCl in 95% ethanol (v/v) was poured over the tissue and the mixture permitted to steep in it for 4 hours at room temperature. And then, the tissue was removed by filtration and the pigment was extracted two times with fresh solvent. This procedure was repeated. The volume of the combined extracts was determined and 30ml was used to determine the relative pigment concentrations. A electro-photometer with a green filter (525) was used for this purpose. The photocolorimeter reading was substituted in the formula that Thimann and Edmundson[9, 10] used for the pigments in Spirodela to give relative pigment concentration. P.U./g stands for the pigment units per gram of tissue in 30ml of the extract.

For the sucrose and the reducing sugar estimation, 5 grams of the fresh weight was weighed before the determination was made. Then the sucrose and the reducing sugar were determined by the Schaffer-Somogyi's method [7].

RESULTS

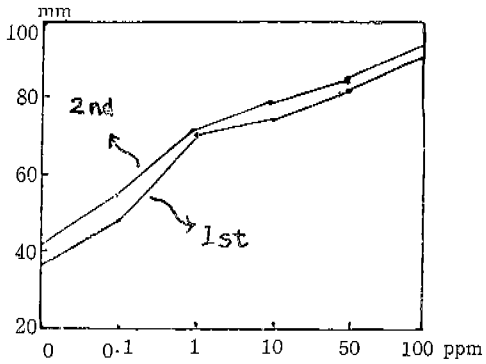

Fig. 1 Relation of growth and gibberellin concentration.

The height was measured periodically once a week. Fig. 1 represents a part of the measurement made the day before the second experiment. Plants of each series grew uniformly, and it was further observed that the growth was promoted as the concentration increased. The treatment caused the color of leaves somewhat pale, but chlorosis was not apparent. Fig. 1 represents the relationship between growth and concentration. In root growth, however, the effect of GA was not evident. Fresh and dry weights were determined in terms of aerial parts. High concentration tends to result in increased fresh and dry weights. But the leaf-area did not correspond to the GA concentration. The chlorophyll content was decreased with the increase of GA concentration. But the plants of the first

series showed considerably higher chlorophyll content than those of the second series. GA promotes linear growth of the plants, but this had nothing to do with photosynthesis of chlorophyll. The carotene content of the plants grown under various treatments varied remarkably. As the concentration of GA increased, there was a reduction of carotene content. The carotene content was higher in the plants of the first series than in those of the second. Table 1 also shows that there was always considerably more chlorophyll present than carotene. Deleano[4] and investigators found that changes in the content of carotene in the willow and soy bean advance parallel with the changes in the content of chlorophyll, and consequently the ratio of yellow and green pigment remains constant. According to Beck and Redman the content of chlorophyll, on an average, was 36.5 times greater than that of carotene. In this study the result shows no similar relationship, but the content of chlorophyll, on an average, was only about 12.5 times greater than that of carotene. The comparisons did show, however, that the distribution of carotene paralleled with that of chlorophyll. The content of ascorbic acid of plants in this experiment was also reduced with the increasing GA concentration(Table 1). It was also noticed that the ascorbic acid content increased with the time. That is, the content of the ascorbic acid was higher in the leaves of plants in the second experiment than those used in the first experiment. The ascorbic acid of reduced and oxidized forms was not affected by GA concentration or the time of its application. With the increase of the GA concentration the content of anthocyanin, sucrose, and reducing sugar was decreased, as Table 2 shows. In the first experiment quantitative analysis of the anthocyanin, sucrose, and reducing sugar content was not made. The results of pigment production correspond to those obtained by Thimann et al for Spirodela. Jacob Straus also recognized a similar condition as in this experiment. The increase in pigment does not appear to be commensurate with the increase of sugar content. The pigment content was not so high in this study as that obtained by Jacob Straus with corn.

Table 1. Effect of concentrations of gibberellin in soil culture on the contents of chlorophyll, carotene and ascorbic acid(in mg/100g fresh weight) of *Astragalus sinicus* L.

			Chlorophyll	Carotene	Chlorophyll/Carotene	Total Vitamin C	Reduced Form Vitamin C	Oxidized Form Vitamin C
	0	ppm	215.35	17.20	12.5	20.13	11.95	8.18
	0.1	〃	224.20	16.95	13.2	20.13	16.35	3.78
1st	1		214.76	17.20	12.5	20.85	12.71	8.14
	10	〃	219.48	16.70	13.1	19.50	15.98	3.52
	50	〃	209.45	16.13	13.0	18.24	12.58	5.66
	100	〃	204.14	16.55	12.3	18.87	13.08	5.79
	0	〃	217.27	16.15	13.4	20.76	15.72	5.04
	0.1	〃	198.85	16.13	12.4	20.13	15.10	5.03
2nd	1	〃	191.16	15.53	12.3	21.39	11.32	10.07
	10	〃	191.75	15.20	12.6	19.50	13.83	5.67
	50	〃	163.82	14.55	11.3	19.50	12.58	6.92
	100	〃	172.90	15.08	11.5	18.87	15.10	3.77

Table 2. Effect of concentrations of the gibberellin in the soil culture on the contents of anthocyanin, sucrose and reducing sugar (in 1g fresh weight) of *Astragalus sinicus* L.

		Anthocyanin	Sucrose	Reducing Sugar
0	ppm	79.5P.U.	7.8 mg	4.0 mg
0.1	〃	78.0 〃	7.7 〃	3.6 〃
1	〃	61.5 〃	7.6 〃	3.2 〃
10	〃	76.5 〃	7.8 〃	3.3 〃
50	〃	72.6 〃	6.8 〃	3.5 〃
100	〃	56.4 〃	7.2 〃	3.2 〃

DISCUSSION

The data presented in the preceding section show that slightly varied concentrations of GA sprayed on the leaves of *Astragalus sinicus* L. tended to reduce the amounts of chlorophyll, carotene, ascorbic

acid, anthocyanin, sucrose, and reducing sugar. Besides, a rapid, often remarkable, lengthening of stems or internodes and an increase in height were observed. Namely, the GA treatment promoted the growth, while the concentrations of the stated components were thereby decreased. In other words, the growth rate did not correspond to the content of chlorophyll and carotenoid pigments in the plant. Such relationship would not agree with those results obtained by Beck aud Redman that all energy involved in growth processes would be introduced to the plants through the catalytic activity of chlorophyll. Carotene serves directly as a growth promoter. These experiments show that the content of chlorophyll is probably irrelevant to the growth of the plant. These results indicate no direct relationship between elongation of cells and photosynthesis in the presence of chlorophyll. In order to evaluate the interrelationships among the internal components quantitatively, the data obtained in these experiments were analyzed statistically; $\Sigma(y^2)t$: Total sum squared, (degree of freedom 11); $\Sigma(y^2)c$: Ratio of variance of GA concentration, (degree of freedom 5); $\Sigma(y^2)h$: Ratio of variance of the period on sample collection, (degree of freedom 1); $\Sigma(y^2)e$: Variance on error, (degree of freedom 5). The statistics show that the variations of the chlorophyll contents in the plants between two periods were found to be significant, although no significant differences were evident between the concentrations. The chlorophyll content of the plants treated with GA was less than that of those plants grown under non-treatment of GA. Yabuta et al [13] also obtained similar results as in this experiment. It was also noticed that the relation of chlorophyll content to the concentration of GA treated was more evident in later stage of growth. According to Sideris and Young [8] the content of chlorophyll in the leaves of *Ananas comosus* was reduced remarkably toward the end of the growing period. This is in agreement with the belief that the conditions reducing the development of chlorophyll are concomitant with the senility of leaves. Carotene content in the leaves treated with GA varied in parallel with that of chlorophyll. The GA treatment seems to have a direct effect on carotene content. Bernstein et al [2] recognized a similar condition as in this experiment when they found that although the leaves of different ages had nearly the same carotene concentration the concentration in the oldest leaves was lower than in the other age groups.

Table 3. Relation of various components of *Astragalus sinicus* L. to different treatment of gibberellin.

Dependent variable Components	$\Sigma(y^2)t$	$\Sigma(y^2)c$	$\Sigma(y^2)h$	$\Sigma(y^2)e$
Chlorophyll	3919	2.33	*15.70	121
Carotene	9.181	**12.30	**145.8	0.043
Total Vitamin C	9.306	*6.822	2.221	0.224
Reducing form V-C	32.61	1.50	0.02	2.61
Sucrose	44.9	0.095	—	—
Reducing Sugar	20.8	0.136	—	—
Anthocyanin	424.5	6.14	—	—

** : Significant at the 1% level.
* : Significant at the 5% level.

The content of total ascorbic acid influenced the concentrations of treatment to a high degree of significance. Bernstein et al stated that average ascorbic acid values differed greatly during different seasons. The differences in the amount of ascorbic acid between the first and second experiments may be explained by the fact that ascorbic acid is produced in greater amounts in leaves of great vigor than in immature leaves. The phase of distribution of ascorbic acid in leaves suggests that certain phases of metabolism rather than amounts of chlorophyll in these tissues are responsible for their ascorbic acid content. As in the results by Ergle [5], there seems to be no relationship between the stated components and growth rate. Wittwer et al. [11] found that, although dry matter and inorganic substances in Kentucky Bluegrass were not changed with GA treatment, the growth was promoted thereby. The

content of anthocyanin, sucrose, and reducing sugar was not investigated to compare in relation to the growing period. Although not significant, differences were evident between the concentrations. According to Jacob Straus, it was suggested that the synthesis of anthocyanin was possible when the stored carbohydrate was consumed. It was shown in this experiment that the contents of carbohydrate and anthocyanin pigments increased simultaneously. But, the increase of pigments does not correspond to that of sugar content.

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摘 要

本 實驗에서 지베레린이 자운영의 生育및 內部 成分에 미치는 영향을 土壤栽培를 通하여 조사하였다. 잎에 撒布한 지베레린의 比較的 적은 농도 차는 자운영의 內部 成分에 현저한 差異를 나타내고 生育의 증가는 지베레린의 농도증가에 關連되었다. 葉綠素및 Carotene 含量은 지베레린 농도와 相反되고 生長率은 葉綠素와 Carotene 含量과 크게 相反되었다.

Carotene 含量은 葉綠素量과 함께 變하였는데 葉綠素와 Carotene의 比는 Beck와 Redman이 얻은 結果처럼 높지않았다. 葉綠素와 Vitamin C의 含量은 發育이 진전함을 따라 차이가 생기는데 이차이는 葉綠素란 有意하다. Anthocyanin 含量은 지베레린의 농도가 증가함에 따라 Sucrose 및 Reducing Sugar의 함량과 함께 감소되었다. Anthocyanin 含量은 Jacob Straus의 옥수수에 對한 實驗 結果와 같이 많지 않다.

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