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Studies on the Uptake of Mineral Nutrients by Ginseng Plant

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Abstract

Seasonal absorption of inorganic nutrients and dry matter production were studied with four-year-old ginseng plant. The residuary amounts of the nutrients supplied to ginseng plantation were decreased with time elapsed. The decreasing rate was greater in chemical plots than in Yacto plots. The amounts of manure applied in this current year and growth in dry matter production of ginseng showed no signficant difference. The amounts of mineral nutrients per unit dry matter were proportional to the amounts of supplied with chemical fertilizer in the early period of growing season but with Yacto in the late season of growing. Seasonal changes of nitrogen, phosphorus and potassium contents per unit dry weight in each organ were high in the middle of May. They decreased sharply in the middle of June and then slowly decreased in both leaves and stems but gradually increased in roots. The absorption ratio of nitrogen to phosphorus (N/P) was high, and that of nitrogen to potassium(N/K) was low. The amounts of nitrogen, phosphorus and potassium in leaves became lower with increasing the relative light intensity, but in stems, the concentrations were different with the kind of mineral nutrients. The requisite amounts of mineral nutrient of ginseng plant were 8.3~9.9 *kg of nitrogen,* 1.2~1.5 *kg of phosphorus,* 6.4~7.9 *kg of potassium per* 10 *a for five years.*

Since ginseng plant(*Panax ginseng*) is a forest floor plant, it grows well under the shade in natural habitat and under the shade roof in plantation. The leaf area and stem of ginseng do not grow further in the current year after it grows to a certain size in spring, and all the leaves of an individual plant have an arrangement on a horizontal plane. A few functional characteristics of ginseng were low not only in the productivity of the plant but also in the photosynthetic and respiratory rates.[19] Practically, from the view point of a medicinal and economic plant, the studies of using fertilizers for the uptake of inorganic nutrients and the culture management are needed urgently because such studies have never been conducted as the shade plants yet. Comparing the sand culture of ginseng plant in standard solution, double-strength solution and element deficient media, Kuribayashi *et al.*[21] insisted on that the phosphate absorption by the two-year-old plant in double-strength solution showed twice

amount as much as those in standard solution but that there were no differences in the amount of nitrogen and potassium uptake. And the leaf area of the plant was somewhat different, but there was no difference in the dry weight of root. Each medium lacking individual inorganic element except sulfur inhibited the growth of the plant and in the case of calcium-deficient medium many of the plants withered.

Nam *et al.*[35] reported the results of the quantitative amount of inorganic components in each organ of one- to six-year-old ginseng plants. It was that the nitrogen content of the stem was less than those of the root and leaf, but there were no differences owing to ages. The root contained the highest but the leaf the lowest, and the stem moderate in contents of P_2O_5. One-year-old plant showed higher content of P_2O_5 than plants over the two-year-old. K_2O content tended to be larger in the stem, however any differences in ages.

This paper is to deal with an analysis of inorganic components absorbed by ginseng plant with seasonal growth and to estimate the requisite amounts of nutrients of two- to six-year-old plants on basis of the measurements of the amounts of absorbed inorganic components in four-year-old plant.

Material and Method

1. Material

Four-year-old ginseng plant (*Panax ginseng*) was raised in the ginseng plantation, where is located at San 161-11, Galkok-ri, Chunhynmyeon, Paju-gun, Gyunggi-do. This plantation has been to be treated the Yacto(specially prepared soil manure enriched with humus, a component of clay wall of old houses, a powder of bone mill and etc.) by the usual means in spring when the plant became a three-year-old. At the beginning of the experiment, the soil contained 81mg of total-nitrogen(T-N), 0.95mg of available phosphorus(A-P) and 28 mg of potassium(K) per 100g of dry soil. The pH value of soil was 4.76 and the loss in ignition of soil was 5.27%.

2. Method

According to the cultivated conditions, this experimental plots were divided into three: Yacto, chemical fertilizer and light controlled plots. A well-prepared Yacto containing N, 10.00; P, 1.24 and K, 2.59 mg/g. d. wt. and 11% of water was used in Yacto plots. The quantity of Yacto to supply in the cultivation was divided four levels, Y_0, Y_1, Y_2, and Y_3, triplicately. The Yacto was applied at May 15 to each plot.

Table I. Fresh and dry weight, and chemical components of Yacto supplied as top-dressing.

Plot	Fresh weight (kg/m^2)	Dry weight (kg/m^2)	Chemical components(g/m^2)		
			N	P	K
Y_0	0.0	0.00	0.00	0.000	0.000
Y_1	0.4	0.35	3.50	0.434	0.906
Y_2	0.8	0.70	7.00	0.868	1.812
Y_3	1.6	1.40	14.00	1.736	3.624

In chemical fertilizer plots(chemical ptot), urea, fused phosphate and potassium sulfate as nutrients were used for four divided levels, $N_0P_0K_0$, $N_1P_1K_1$, $N_2P_2K_2$ and $N_3P_3K_3$, triplicately. The nutrient was applied at May 2 to the plots as shown in Table Ⅱ.

In the light controlled plots, the relative light intensity was controlled with the reed, rice-straw and polyethylene film so that the average relative intensity of illumination controlled as 5, 10 and 20% on four-year-old ginseng plants. The chemical nutrients were applied the same as the plot of $N_2P_2K_2$ on Table Ⅱ for all the light plots at May 2.

All nutrients were manured at the upper layer of the surface soil of ridge so as to mix it with soils evenly under the 5~10 cm depth. During the experiment, Dyzen solution in May-June and then Bordeaux mixture were sprayed at the intervals of 10 days and the weeding was also controlled. Whole parts of plant and soil samples were taken at intervals of a month from June 16 in the Yacto plots and in the chemical plots from May 16 to August, but root was harvested at October 3 because the

Table II. The comosition of chemical fertilizer suppied(g/m^2)

Plot	N	P	K
$N_0P_0K_0$	0.0	0.0	0.0
$N_1P_1K_1$	1.0	0.5	1.0
$N_2P_2K_2$	3.0	1.5	3.0
$N_3P_3K_3$	6.0	3.0	6.0

leaves had fallen. Twelve individuals harvested from each plot were washed, separated into leaf, stem and root, and then dried in a dry oven at 80°C and determined dry weight in every parts of organs. Dried samples were ground, sieved with a 24 meshed sieve and stored for chemical analyses. The total nitrogen content of each sample was determined by microkjeldahl digestion method. Phosphorus contents were measured by molybdenphosphoric blue color method. Samples such as Yacto and dried plant organs were ashed at 600°C of electric muffle furnace, extracted with 2 N H_2SO_4 solution, filtered, but soil samples were extracted with 0.002 N H_2SO_4 solution, shaken for an

hour and filtered. Each filtrate was added with a color reagent and extinctions were measured with Beckman DU spectrophotometer. For determination of potassium, the powders of plant organs were extracted with 0.2 N HCl solution and soil samples were treated with 2N ammonium acetate solution to shake for an hour and then measured by flame photometer.

Results

1. Quantitative Changes of Inorganic Components in the Soil

Total nitrogen(T-N), available phosphorus(A-P) and potassium(K) contents in soils of all the experimental plots were decreased with time elasped in Yacto and chemical fertilizer plots as shown in Figs. 1, 2 and 3. At 14 days(May 16) after the chemical fertilizer were applied the T-N contents showed a large variance as follows; $N_0P_0K_0$: $N_1P_1K_1$: $N_2P_2K_2$: $N_3P_3K_3$=1.00 : 1.19 : 1.64 : 1.52, but this variance became a little diminished as 1.00 : 1.15 : 1.13 : 1.27 at August 21. Changes of A-P and K contents also showed as similar pattern to the T-N.

The T-N and A-P contents of Yacto plots were a large difference as compared with those of chemical plots, but K contents were not so. Considering the decrease of mineral salts in soils with time elapsed, most of them were denitrificated[12], were not dissolved by combining with soil components[2] or were removed from soils by leaching[24] though only a portion of them was absorbed and assimilated by the plants.

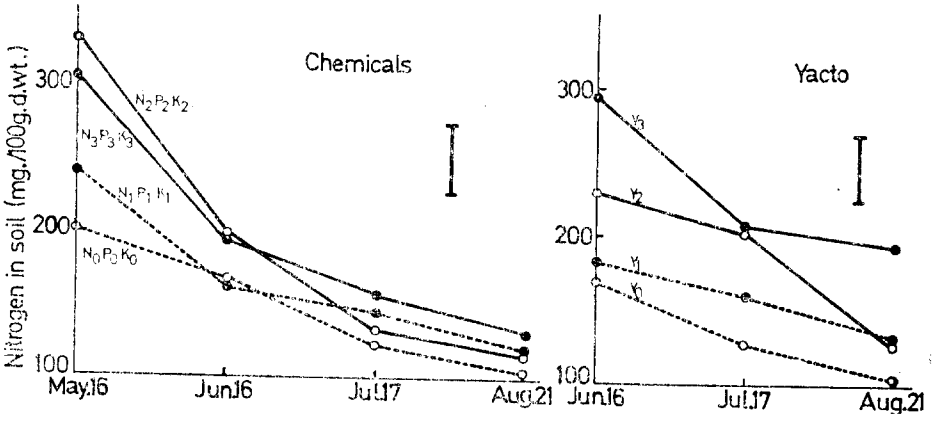

Fig. 1. Changes of total nitrogen content in soil. Histograms in figure indicate t-value at 5% of significant level.

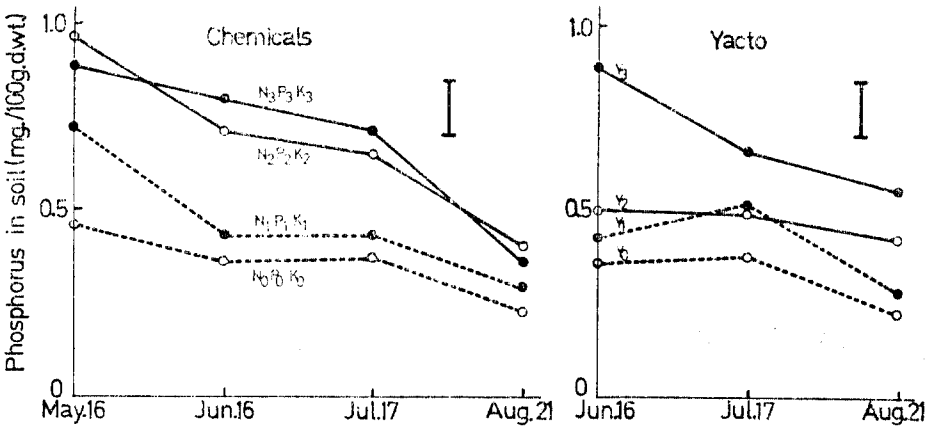

Fig. 2. Changes of available phosphorus content in soil. Histograms in figure indicate t-value at 5% of significant level.

2. Growth in Dry Matter Production

Fig. 4 showed growth in dry matter of leaf, stem, root and total plant dry weight of four-year-old ginseng plants. According to the harvesting time, this figure was used in calculating average value and standard deviation for the individual numbers because there were no significant differences in the plots of chemical and Yacto in accordance with the amounts of the fertilizer manured. The dry weight of the leaf and stem steeply increased till June 16, but there were no significant changes thereafter. The dry weight of root also increased rapidly by August 21, but, stagnated since then. The comparison of dry weights of roots in Yacto with chemical plots was as followed; the former was less 6% at August 21, but there was no difference between both of them at October 3.

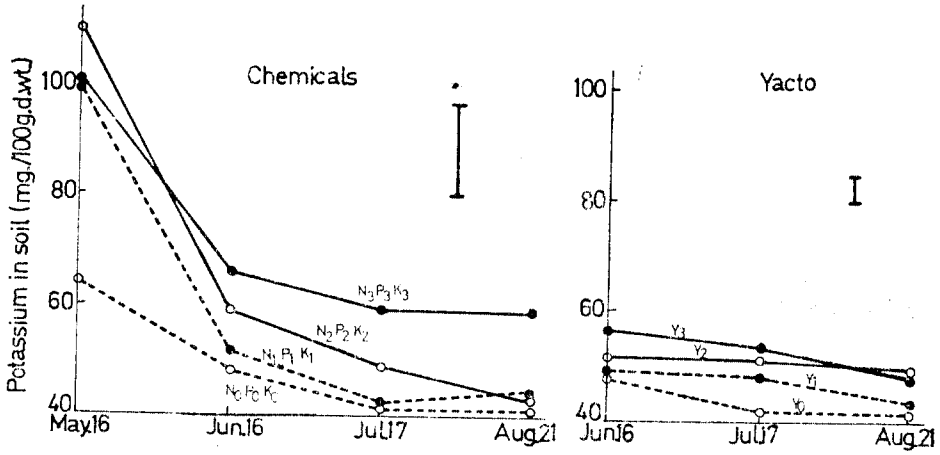

Fig. 3. Changes of potassium content in soil. Histograms in figure indicate t-value at 5% of significant level.

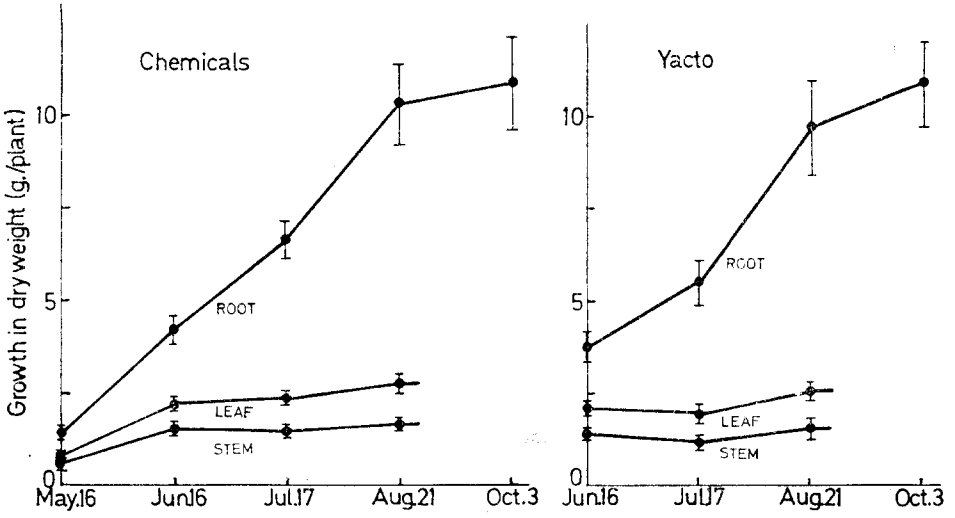

Fig. 4. Seasonal growth in dry weight of each organ of 4-year-old ginseng plant.

The perennial growth in dry weight showed exponential patterns in each organ so for as the 3 year old, thereafter stagnated. The datas on Fig. 5 are average values obtained from more than 30 individuals harvested at different raws in each age. The

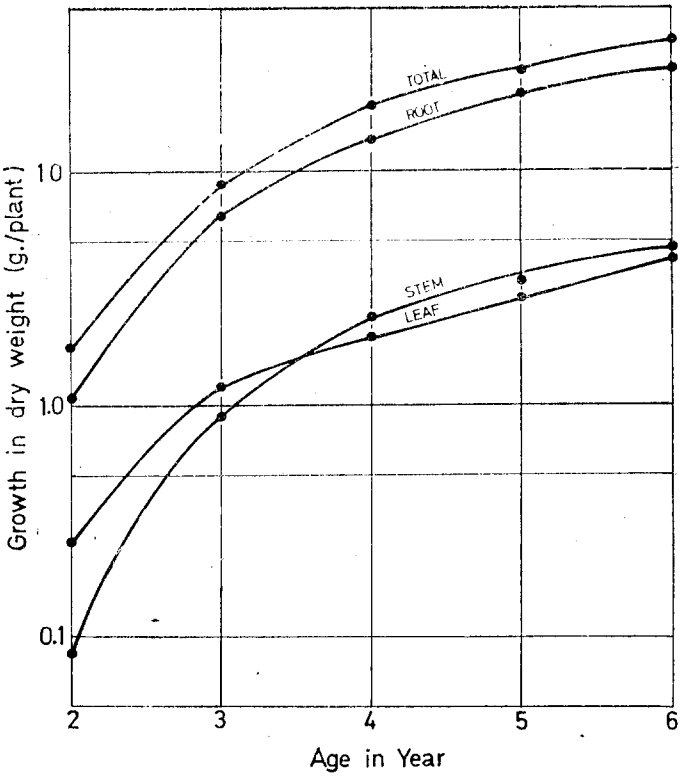

Fig. 5. Perennial growth on based of dry weight in each organ of ginseng plant.

seasonal and perennial growth patterns in this work were corresponding the previous data[17,18] but the latter generally showed a larger value than that of Nam *et al.*[35]

3. Changes of Mineral Nutrients in Plants

(1) Total Nitrogen

Total nitrogen contents of plant organs from Yacto and chemical plots showed in Tables Ⅲ and Ⅳ. The T-N contents of leaves in each fertilizer level were respectively unvariable, but in the case of stem a little increase showed and in root a large increase could be seen with time elapsed in Yacto plots. The increase of the T-N content in root was 66% at October 3 as compared with at June 16. The T-N contents of leaf, stem and root in chemical plots decreased at June 16 against at May 16, thereafter the contents of stem were constant, those of leaf showed a little decrease and those of root showed 58% increase at October 3 against at June 16.

The T-N contents in Yacto and chemical plots have no variations against the difference of the amount of nutrients supplied, but according to going to the late of growth the T-N contents in each organ tended to be in somewhat proportion to the amounts of manures(see Table Ⅴ). The T-N contents of stem and leaf in the early and the middle of growth period were showed rather higher in chemical plots than those in Yacto ones, but in the late of growth period *vice versa*. The T-N contents

Table III. Nitrogen content in each organ of ginseng plant supplied with Yacto (mg/g. dry matter)*

Organ	June 16	July 17	Aug. 21	Oct. 3
Leaf				
Y_0	23.90	22.45	21.10	—
Y_1	23.52	20.44	22.23	—
Y_2	21.79	22.24	21.67	—
Y_3	23.68	22.12	22.81	—
Stem				
Y_0	8.21	7.43	8.15	—
Y_1	6.93	7.95	8.84	—
Y_2	7.01	7.52	9.91	—
Y_3	7.28	7.44	9.64	—
Root				
Y_0	14.43	14.84	16.45	19.41
Y_1	9.91	13.07	16.63	19.15
Y_2	12.64	13.29	19.63	21.08
Y_3	13.44	12.67	21.32	23.92

* Mean values of three replicates. The t-values at 5% significant level are respectively 0.88, 0.84, and 2.88 within leaves, stems and roots

Table IV. Nitrogen content in each organ of ginseng plant applied with chemical fertilizers (mg/g. dry matter).*

Organ	May 16	June 16	July 17	Aug. 21	Oct. 3
Leaf					
$N_0P_0K_0$	40.56	23.90	22.45	21.10	—
$N_0P_1K_1$	42.83	23.43	26.81	20.59	—
$N_2P_2K_2$	39.44	25.39	25.12	21.28	—
$N_3P_3K_3$	46.96	25.79	23.37	21.41	—
Stem					
$N_0P_0K_0$	17.52	8.21	7.43	8.15	—
$N_1P_1K_1$	16.52	7.92	8.32	8.48	—
$N_2P_2K_2$	17.97	8.95	8.91	8.40	—
$N_3P_3K_3$	21.07	8.77	7.97	8.60	—
Root					
$N_0P_0K_0$	24.57	14.43	14.84	14.45	19.41
$N_1P_1K_1$	24.19	11.99	14.28	17.21	22.91
$N_2P_2K_2$	23.64	14.01	16.57	19.55	23.16
$N_3P_3K_3$	27.79	15.80	14.59	20.39	23.52

* Mean values of three replicates. The t-values at 5% significant level are respectively 6.41, 3.30 and 2.98 within leaves, stems and roots.

Table V. Analyses of variance for nitrogen content in ginseng plants supplied with Yacto or chemical fertilizers.

Item	D.F.	S.S.	M.S.	F.	D.F.	S.S.	M.S.	F.
Leaf		Yacto				Chemicals		
Replication	11	2.81	0.255	N.S.	15	61.18	4.078	N.S.
Fertilizer level	8	5.21	0.651	N.S.	11	35.86	3.260	N.S.
Sampling period	11	14.36	1.306	N.S.	11	3,356.45	305.132	9.593**
Error	5	67.95	13.590	—	10	318.08	31.808	—
Total	35	90.33	—	—	47	3,771.57	—	—
Stem								
Replication	11	1.43	0.130	N.S.	15	1.27	0.085	N.S.
Fertilizer level	8	0.42	0.053	N.S.	11	14.14	1.285	N.S.
Sampling period	11	22.39	2.035	N.S.	11	887.07	80.643	10.955**
Error	5	25.82	5.165	—	10	73.61	7.361	—
Total	35	50.07	—	—	47	976.09	—	—
Root								
Replication	15	3.69	0.246	N.S.	19	5.11	0.269	N.S.
Fertilizer level	11	60.92	5.538	N.S.	14	101.71	7.265	N.S.
Sampling period	11	571.35	51.941	3.076**	11	1,085.21	98.655	4.420**
Error	10	168.87	16.887	—	15	334.75	22.316	—
Total	47	804.83	—	—	59	1,526.77	—	—

N.S. indicates no significance.
** 1% of significant level.

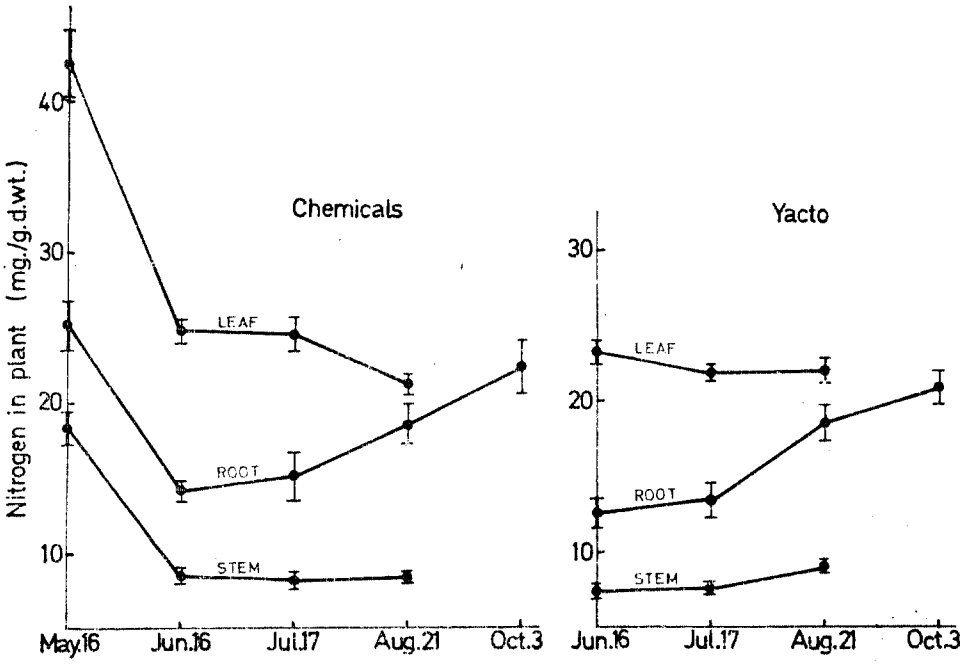

Fig. 6. Changes of total nitrogen content on the basis of dry weight in each organ of ginseng plant.

Table VI. The content of phosphorus in each organ of ginseng plant supplied with Yacto (mg P/g. dry matter)*

	Jun. 16	July 17	Aug. 21	Oct. 3
leavf				
Y_0	1.59	1.76	1.70	—
Y_1	1.79	1.89	1.63	—
Y_2	1.29	1.78	1.75	—
Y_3	1.71	1.86	1.84	—
stem				
Y_0	1.38	1.30	1.28	—
Y_1	1.52	1.36	1.42	—
Y_2	1.28	1.19	1.70	—
Y_3	1.33	1.48	1.75	—
root				
Y_0	1.90	2.18	2.69	3.14
Y_1	1.50	2.17	2.53	2.79
Y_2	1.86	2.22	2.92	3.02
Y_3	1.80	2.26	3.22	3.45

* Mean velue of three replicates. The t-value at 5% significant lvel are respectively 0.14, 0.15 and 0.41 within leaves, stems and roots.

Table VII. The content of phosphorus in each organ of ginseng plant supplied with chemical fertilizer, (mg P/g. dry matter)*

	may 16	Jun. 16	July 17	Aug. 21	Oct. 3
Leaf					
$N_0P_0K_0$	3.46	1.59	1.60	1.70	—
$N_1P_1K_1$	4.08	1.69	1.63	1.62	—
$N_2P_2K_2$	4.10	1.64	1.53	1.48	—
$N_3P_3K_3$	4.72	1.86	1.60	1.45	—
Stem					
$N_0P_0K_0$	3.65	1.38	1.30	1.28	—
$N_1P_1K_1$	3.74	1.19	1.13	1.52	—
$N_2P_2K_2$	3.47	1.30	1.14	1.30	—
$N_3P_3K_3$	3.91	1.58	1.34	1.44	—
Root					
$N_0P_0K_0$	3.05	1.90	2.18	2.69	3.04
$N_1P_1K_1$	3.26	1.71	2.19	2.95	3.82
$N_2P_2K_2$	4.05	2.02	2.42	2.97	2.96
$N_3P_3K_3$	4.25	2.17	2.15	2.93	3.01

* Mean velue of three replicates. The t-values at 5% significant level are respectively 0.82, 0.78 and 0.46 within leaves, stems and roots.

in root in chemical plots were maintained high contents through growing period(Fig. 6).

(2) Phosphate

Tables Ⅵ and Ⅶ showed the changes of phosphorus content in each organ. The phosphorus content of leaf was almost constant during experiment in Yacto plots, but the content of stem showed to increase in Y_2 and Y_3 plots and to decrease in Y_0 and Y_1 plots according to the amounts of Yacto manured. Therefore there was significant difference among Y_0, Y_2 and Y_3 plots at August 21. Not only P content of root was increased in accordance with the growth, but also the content was increased with the amount of manured level in the late of growth period(Table VI).

The phosphorus contents in chemical plots like in case the pattern in the changes of T-N contents were high at May 16, but low at June 16, and then decreased a little in stem and leaf, however, enhanced rapidly in root(Table VII). The phosphorus contents of each organ in chemical plots were in proportion to the amounts of chemicals supplied in the early of growth period, but there were no differences in the middle of and the late of growth. This result made a good contrast that the phosphorus contents in Yacto plots had no difference among each plot at the early and the middle growth period regardless of manured levels but the contents were in

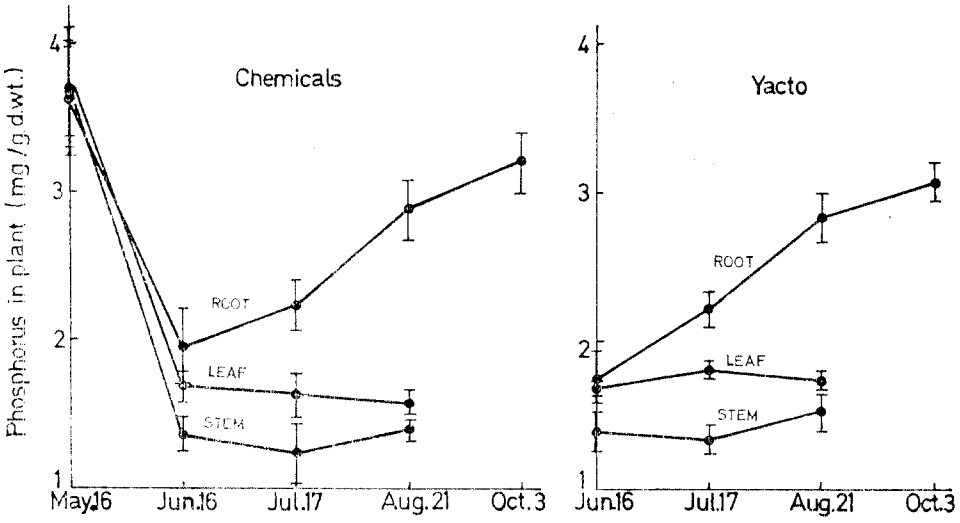

Fig. 7. Changes of available phosphorus content on the basis of dry weight in each organ of ginseng plant.

Table VIII. Analyses of variance for phosphorus content in ginseng plants at Yacto and chemical fertilizer plots.

	D.F.	S.S.	M.S.	F.	D.F.	S.S.	M.S.	F.
	Yacto				Chemicas			
Leaf								
Replication	11	0.01	0.000	N.S.	15	2.35	0.158	N.S.
Fertilizer level	8	0.08	0.010	N.S	11	1.60	0.146	N.S.
Sampling period	11	0.13	0.012	N.S.	11	39.87	3.624	N.S.
Error	5	0.43	0.086	—	10	24.85	2.485	—
Total	35	0.65	—	—	47	72.71	—	—
Stem								
Replication	11	0.03	0.002	N.S.	15	0.40	0.027	N.S.
Fertilizer level	8	0.18	0.023	N.S.	11	1.38	0.126	N.S.
Sampling period	11	0.27	0.025	N.S.	11	36.50	3.318	N.S.
Error	5	2.03	0.406	—	10	34.93	3.493	—
Total	35	2.51	—	—	47	73.21	—	—
Root								
Replication	15	0.13	0.008	N.S.	19	0.18	0.009	N.S.
Fertilizer level	8	1.13	0.103	N.S.	14	1.04	0.074	N.S.
Sampling period	11	12.87	1.170	3.966**	11	23.25	2.114	2.543*
Error	10	2.95	0.295	—	16	12.46	0.831	—
Total	47	17.08	—	—	59	36.93	—	—

N.S. indicates no significance.
** significant at 1% level.
* significant at 5% level.

Table IX. The content of potassum in each organ of ginseng plant supplied with Yacto(mg/g. dry matter)*

	Jun. 16	July. 17	Aug. 21	Oct. 3
Leaf				
Y_0	15.70	13.40	10.31	—
Y_1	10.95	13.60	11.06	—
Y_2	10.00	13.70	11.06	—
Y_3	9.90	13.20	12.76	—
Stem				
Y_0	14.30	12.50	11.06	—
Y_1	8.67	10.90	12.65	—
Y_2	8.67	13.73	12.54	—
Y_3	7.90	13.60	13.71	—
Root				
Y_0	9.80	10.20	11.41	12.96
Y_1	6.76	11.93	11.96	12.48
Y_2	6.57	10.40	11.40	13.40
Y_3	5.24	9.80	13.20	13.65

* Mean value of three replicates. The t-values at 5% signicant level are respectively 1.56, 1.90 or 1.86 within leaves, stems or roots.

Table X. The content of potassium in each organ of ginseng plant supplied with chemical fertilizers (mg K/g. dry matter)*

Plot	May 16	June 16	July 17	Aug. 21	Oct. 3
Leaf					
$N_0P_0K_0$	12.28	15.70	13.40	10.31	—
$N_1P_1K_1$	12.57	15.50	14.40	12.24	—
$N_2P_2K_2$	13.05	15.73	14.20	11.88	—
$N_3P_3K_3$	13.14	14.70	13.70	12.75	—
Stem					
$N_0P_0K_0$	18.00	14.30	12.50	11.06	—
$N_1P_1K_1$	17.81	14.70	13.80	12.38	—
$N_2P_2K_2$	17.43	15.20	13.90	12.75	—
$N_3P_3K_3$	14.86	13.20	12.40	12.50	—
Root					
$N_0P_0K_0$	10.86	9.80	10.20	11.41	12.96
$N_1P_1K_1$	9.52	10.70	10.40	12.85	13.99
$N_2N_2K_2$	9.33	10.60	11.00	12.07	13.57
$N_3N_3K_3$	8.95	10.40	9.90	11.77	13.77

* Mean value of three replicates. The t-values at 5% siginificant level are respectively 1.10. 1.51 and 0.99 within leaves, stems and roots.

proportion to the amount of Yacto at the late growth stage.

The phosphorus contents of leaf, stem and root were nearly similar at the early growth stage in chemical plots, but the contents of leaf and stem showed large differences in accordance with the growth proceeded. In comparison with Yacto and chemical plots, leaf contained high level of phosphorus in the former but root did that in the later. Table VIII showed analyses of deviation of phosphorus content in each organ of both plots.

(3) Potassium

Tables IX and X indicate the changes of potassium content in each organ on dry weight basis. Except the treatment of Y_0, K contents of stem and leaf in Yacto plots increased rapidly till July 17, and then decreased, however those of root increased during experiment.

K contents of leaf in chemical plots increased till June 16. The highest amount of K content in chemical plots appeared a month sooner than that in Yacto plots. K contents of root increased with time elapsed as shown increase tendency of both phosphorus and nitrogen in the root. In the late of growth period, both leaf and stem in Yacto and chemical plots showed significant differences for K contents in accordance with the amounts of nutrients supplied, but the root did not show any significance. Fig. 8 shows a pattern which takes the average value of K contents in each organ with sampling periods. This indicated the great effect of chemical nutrients on the contents of organs in the early and the middle of growth period followed as; the ratio of K contents in Yacto and chemical plot was 100 : 75 in leaf, 100 : 69 in stem and 100 : 95 in root. In the late of growth, however, they had almost equal contents through all the organs. Table XI indicated analyses of variance of potassium content in both experimental plots.

4. Uptake of the Mineral Nutrients in Ginseng Plant

The amount of inorganic nutrients absorbed by four-year-old ginseng plants with seasonal changes was obtained to multiply the growth in dry weight by the inorganic contents in each organ(Figs. 4, 6, 7, and 8). The absorption processes of T-N, P and K were estimated on basis of the data in chemical plots from at Figs. 9, 10 and 11. T-N, P and K amounts which were being translocated into the leaf were increased more 75, 86 and 263%, respectively at June 16 than those at May 16, thereafter they kept on constantly contents of T-N, P and K of stem and leaves were maintained a given amount from May to Sptember but those of root showed to increase with the sigmoid

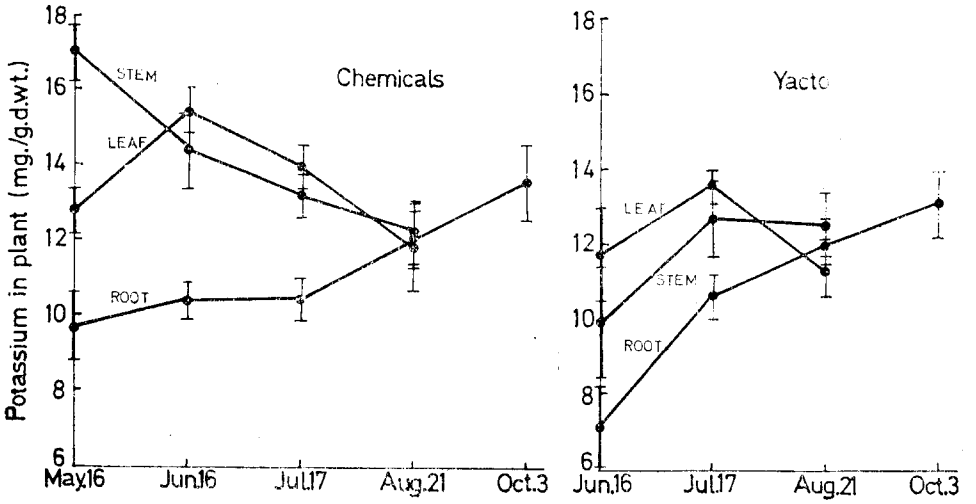

Fig. 8. Changes of potassium content on the basis of dry weight in each organ of ginseng plant.

Table XI. Analyses of variance for potassium content in ginseng plants at Yacto and chemical fertilizer plots.

	D.F.	S.S.	M.S.	F.	D.F.	S.S.	M.S.	F.
	Yacto				Chemicals			
Leaf								
Replication	15	16.67	1.111	N.S.	11	12.30	1.118	N.S.
Fertilizer level	11	4.94	0.449	N.S.	8	13.32	1.665	N.S.
Sampling period	11	87.24	7.931	N.S.	11	33.76	3.069	N.S.
Error	10	89.18	8.918	—	5	69.76	13.952	—
Total	47	198.03	—	—	35	141.44	—	—
Stem								
Replication	15	3.07	0.205	N.S.	11	5.95	0.541	N.S.
Fertilizer level	11	18.85	1.709	N.S.	8	15.96	1.995	N.S.
Sampling period	11	152.76	13.887	N.S.	11	58.38	5.307	N.S.
Frror	10	96.08	9.608	—	5	152.55	30.610	—
Total	47	270.76	—	—	35	232.84	—	—
Root								
Replication	19	6.83	0.359	N.S.	15	5.64	0.376	N.S.
Fertilizer level	14	2.72	0.194	N.S.	11	4.60	0.418	N.S.
Sampling period	11	117.41	10.674	N.S.	11	246.86	22.442	N.S.
Error	15	122.19	8.146	—	10	103.83	10.383	—
Total	59	249.15	—	—	47	360.93	—	—

N.S. indicates no significance.

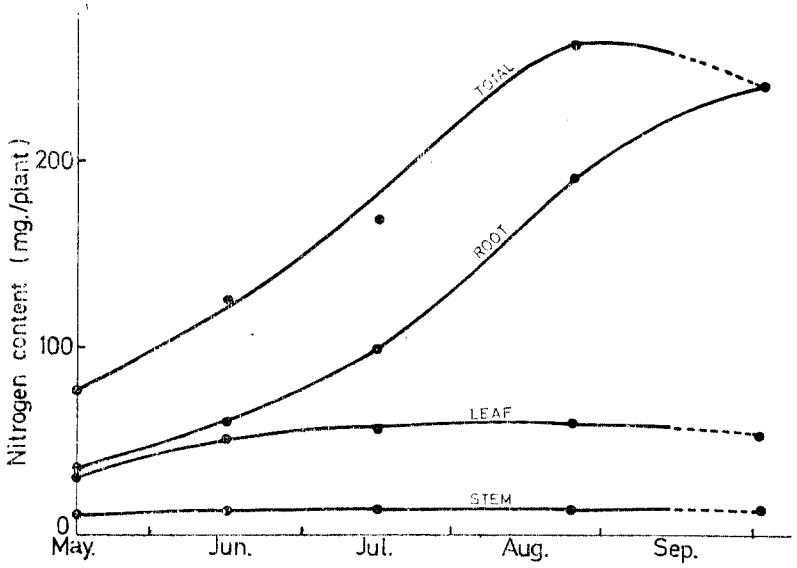

Fig. 9. Seasonal changes of total nitrogen content in each organ and a plant on the basis of dry weight. Dotted lines indicate the result obtained after the litter shedded.

pattern, especially it rapidly increased from July to September, because not only contents of T-N, P and K in root increased with time elapsed but also the growth in dry weight was rapid and the mineral nutrients were translocated from the shoot into the root at the defoliation period. The absorption of T-N, P and K in total plant were similar to the pattern of root. They contained 262 mg of T-N, 36 mg of

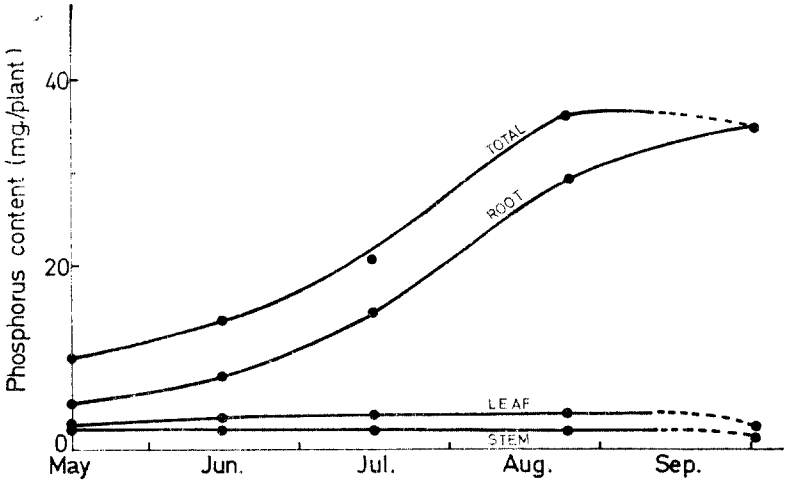

Fig. 10. Seasonal changes of available phosphorus content in each organ and a plant on the basis of dry weight. Dotted lines indicate the result obtained after the litter shedded.

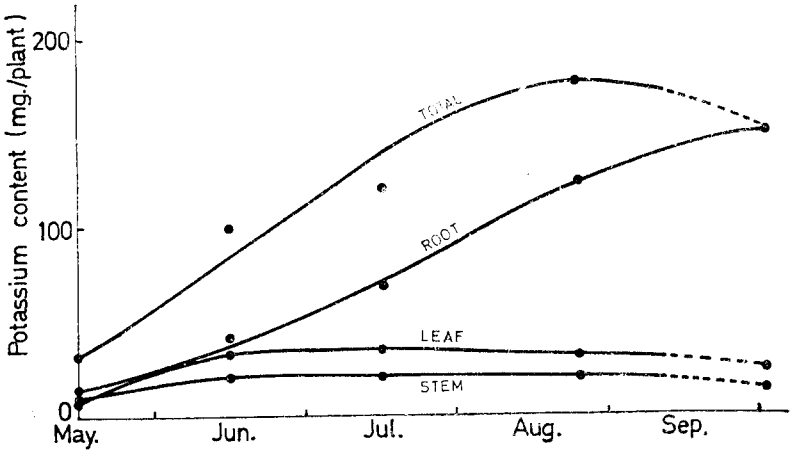

Fig. 11. Seasonal changes of potassium content in each organ and a plant on the basis of dry weight. Dotted lines indicate the result obtained after the litter shedded.

P and 176mg of K per four-year-old plant at the late of August.

The absorption rate of inorganic nutrients obtained in four-year-old ginseng plant could be applied to the ginseng plant of all ages provided that the following assumption were accomplished:

(1) The content of inorganic nutrients per unit of dry weight in each organ is no difference in all the ages of ginseng plant.

(2) The seasonal growth curve of ginseng plant is no difference in all the ages of ginseng plant.

Here, first assumption approved that the amounts of chemical components per unit of dry weight of two- to six-year-old ginsengs had been equal, except one-year-old ginseng, by Nam *et al.*[35], and second assumption was also clarified that seasonal growth were similar from two- to six-year-old-ginseng by Kim.[18] Therefore the amounts of mineral nutrients absorbed by ginseng plants in each age could be calculated by multiply each value of contents of T-N, P and K per unit of dry weight obtained at the of the maximum content(Figs. 9, 10 and 11) of four-year-old plant by dry weight of each age(Fig. 5). Fig. 12 indicates the amounts of T-N, P and K absorption calculated by the above means for the organs in each age.

Ginseng plants were usually planted 32 or 40 individuals per kan(1.6m^2) in standard culture, hence they could absorb the minerals as much as the dotted area in Fig. 12 with time elapsed. The amounts of absorbed nutrients were calculated as follows: mineral contents in 2-, 3-, 4-, 5- and 6-year-old ginseng plants were 0.8, 5.0, 8.4, 15.8, and 20.3g in T-N ; 0.1, 0.8, 1.3, 2.5 and 3.2g in P ; 0.6, 3.7,

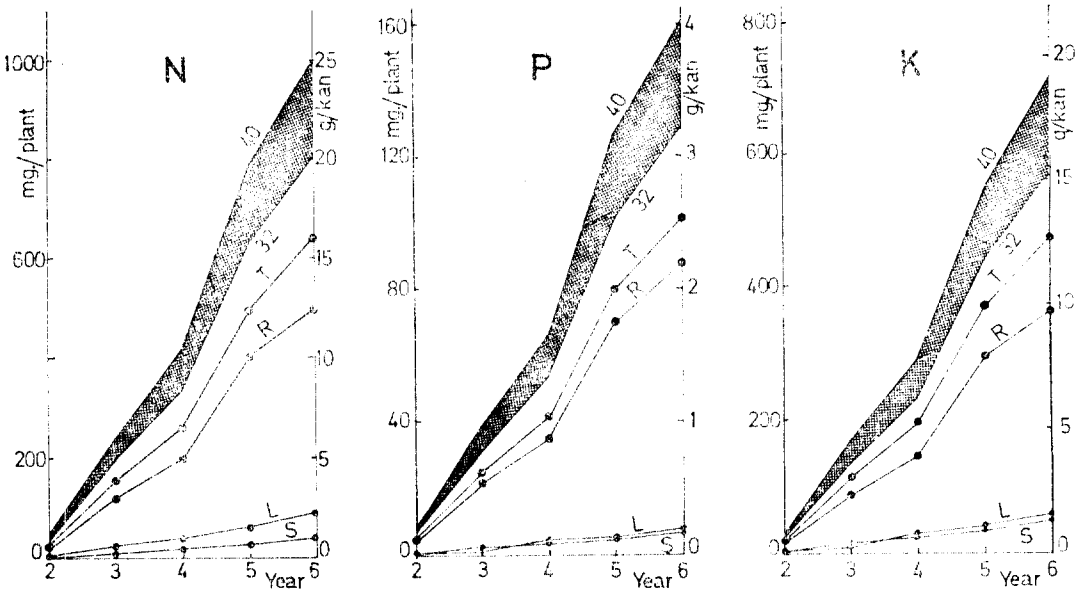

Fig. 12. The amounts of nitrogen(N), phosphorus(P) and potassium(K) absorbed perennially per organ, a plant and one Kan, in which 32 to 40 plants are planted.
S: Stem, L: leaf, R: root, T: total plant.

6.4, 11.9 and 15.3g in K on the basis of 32 individuals per Kan, respectively. Total amounts of absorption for 5 years from two- to six-year-old ginseng were 26.4, 33.0 for T-N, 3.8~4.8 for P and 20.3~25.4 for K per Kan in 32~40 individuals per Kan, respectively. Furthermore the absorbed amounts per 10 a for 5 years came to 8.3~9.9 kg for T-N, 1.2~1.5 kg for P and 6.4~7.9 kg for K in 32~40 individuals.

Nam *et al.*[35] reported that the required amounts of chemical nutrients for 6 years in ginseng plants were 10.24 kg of T-N, 2.37 kg of P_2O_5, and 14.86 kg of K_2O per 10 a. Other reports[29,33] assumed that 28 kg of T-N, 7 kg of P and 31 kg of K per 10 a were necessity for the 6 years growth period. Therefore, the results obtained in this study were lass than those of Nam *et al.* and others.

5. Absorption Ratios of Inorganic Nutrients in Ginseng Plants

The absorption ratios of N to P(N/P) and to K(N/K) by four-year-old ginseng plants were shown in each organ with seasonal growth on Fig 13. The ratio of N/P indicated 11.0~15.0 in leaves, 5.0~7.0 in root and stems, and 6.5~9.0 in total plant. While the ratio of N/K was high at the early growth stage, thereafter it was constantly maintained 1.6~1.8 in leaf, 0.6~0.7 in stem and 1.4-1.6 in root, respectively.

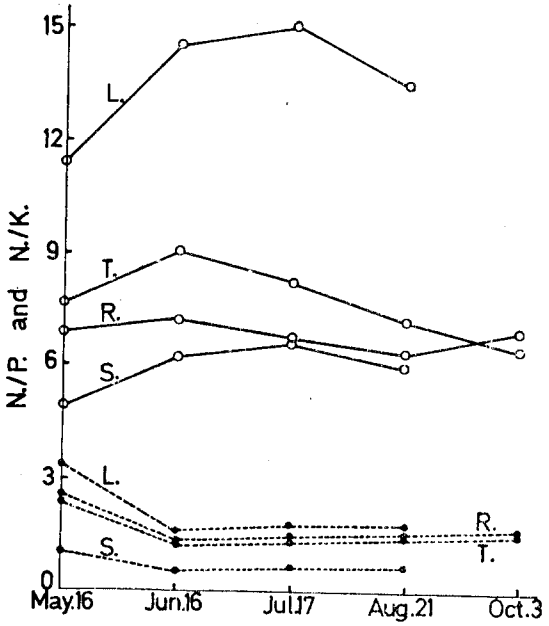

Fig. 13. Seasonal changes of ratios of nitrogen to phosphorus(N/P) and of nitrogen to potassium(N/K). Solid lines: N/P, dotted lines: N/K, L : leaf, S : stem, R : root, T : Total plant.

Although the absorption of P was low, and the that of K was higher than the absorption of T-N. Practically, in the stem, K content showed higher than T-N content.

6. Relationship of Received Light Intensity and Uptake of Inorganic Nutrients

The relationship between received light intensity and uptake of the nutrients was shown in Table XII. The contents of T-N, P and K of leaf decreased with increase the light intensity. The T-N contents of root, howerer, increased to be propotional to the intensity of light. The contents of P decreased rather and of K showed a different tendency with growth stage. While leaf dry matter index (leaf weight mg/cm^2 leaf area, LDMI) indicated to response to the received light intensity so that there was a close relationship between LDMI and the received light intensity.

Discussion

The foregoing data showed that the amounts of total N content remained in the soil of chemical plots were similar to those of Yacto plots at the late of August, in spite of the formers were supplied 2.5 folds with chemical fertilizer which was rapidly efficient more than the later with Yacto which was late efficient(Tables Ⅰ and Ⅱ).

Table XII. Relationships of the received light intensity and the content of inorganic components, and leaf dry matter index(mg/g. dry matter).

Light(%)	July 4			Aug. 21		
	5	10	20	5	10	20
Nitrogen						
Leaf	28.84	19.92	19.72	24.84	24.24	22.40
Stem	10.00	7.44	6.80	11.60	11.64	12.88
Root	11.84	11.32	12.48	23.04	23.92	24.92
Phosphorus						
Leaf	2.09	1.62	1.50	2.18	1.99	1.79
Stem	2.54	2.26	2.67	2.02	1.81	1.54
Root	2.30	1.69	1.66	3.76	2.62	2.78
Potassium						
Leaf	14.14	9.51	9.69	11.59	6.95	6.72
Stem	13.21	10.26	9.27	10.43	9.26	10.43
Root	6.26	6.72	6.03	7.65	8.11	8.34
LDMI(mg/cm)	—	—	—	2.719	3.073	3.198

Kuribayashi *et al.*[22] have indicated that the constituents of sand culture media grown the ginseng plant were not reduced in their amount. It means that ginseng plants absorbed small amounts of mineral nutrients that in this study all the decreased amount of inorganic nutrients from soil were not entirely absorbed by ginseng plants. Furthermore Yacto and chemical fertilizer did not affect the dry matter production even if it were supplied in varing amount in the current year.

The production of crops——rice, barely, wheat and pasture——increased in conjunction with the supplied amounts of N, P, and K[3,5,20,27,39] but that of ginseng plant did not show as above because the leaf area, the above ground parts or activity of photosynthesis was not affected by the amounts of manures supplied[20].

In ginseng plant, the amounts of N, P and K per unit of dry weight tended to be less than those in other crops such as tobacco and rice plant, paticularly P contents showed such tendency[22,26,39] (Fig. 13). The T-N and P contents per unit of dry weight in ginseng plant showed high levels in the begining of early growing season, but decreased rapidly up to the middle of June and thereafter showed different patterns with each organ (Tables Ⅲ, Ⅳ, Ⅵ and Ⅶ). However, the K contents of both the stem and the leaf came to the highest in the middle of June in chemical plots and in the middle of July in Yacto plots. All the inorganic nutrients in the root showed a peculiar characterstic such that they decreased up to the middle of June and increased again continuously up to Autumn (Figs. 6, 7 and 8).

The decrease of inorganic nutrients contents in stem and leaf in the middle of June may be due to the reduction of the absolute amount of protoplasm with growth development. It can be supported by the fact that the respiration rates of stem and leaf decreased with the growth of ginseng plants.[19] The rates of absorption of inorganic nutrients, N, P and K, by ginseng plants were not changed in proportion to the quantity of manures supplied, although the absorptions of N nutrients in general agricultural crop plants were directly proportional to the concentrations of fertilizer supplied[4,5,7,8,9,25,26,28]. Wheat, tomato, tobacco with increased P fertilizer[3,6,26], and rice, green gram and tomato with increased K fertilizer[1,2,26] increased several times in amounts of their absorption.[22] It was reported that, however, the large amounts of fertilizer supplied to ginseng plant did not accerelated the absorption rate but rather inhibited the growth[15,31,32,34] though in this study such effects were not shown. However, it was also reported that the growth of ginseng plant was inhibited by the complete lack of each essential element except sulfur[21,29-33]. It could be seen the trend of decreasing N contents in leaf of ginseng with the increase of the received light intensity. This may be thought to be due to the reduction of the amount of protoplasm by aging effect induced from in leaf cells. However, the N contents of root have a tendency to increase by strong light. Such results also reported by Pechenitsina[37] and Kim[15,16]. The fact that the sunny plants such as corn absorbed more N nutrient in proportion to the light intensity[4] is a good contrast with that of ginseng plant.

Acknowledgment

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인삼의 무기 영양 흡수에 관한 연구

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초 록

4년생 인삼 식물을 재료로 하여 계절에 따르는 영양 염류 흡수와 건물 생장량과의 관계를 해석하였다.

인삼포의 토양에 시비한 영양 염류는 계절에 따라 감소되었는데 약토구보다 무기비료구의 잔존량이 적었다. 당년에 시비한 비료의 시비량에 따른 차이는 건물 생장에는 영향을 미치지 않았다. 단위 건물량당 영양염류의 함량은 속효성 비료인 화학비료를 시비하면 생육 초기(5월 16일)에, 지효성 비료인 약토를 시비하면 생육 후기(8월 21일)에 함량차가 나타났다. 단위 건물량당의 질소, 인산 및 가리 함량의 계절변화는 잎, 줄기, 뿌리가 5월 중순에 많은 량을 함유하였지만 6월 중순에 급감되고 그 이후는 잎, 줄기에서는 점감하고 뿌리에서는 증가되었다. 지상부의 생육기간중에는 뿌리속의 영양 염류가 지상기관으로 전류되었지만 지상부 생육이 완료되면 흡수된 염류가 뿌리에 저장되었다. 개체당 영양 염류함량의 계절변화는 생육이 완료된 지상부 기관에서는 그 변화가 없고 뿌리에서는 S자 곡선에 따라 생육이 완료될 때까지 증가되었다. 영양염류의 종류에 따른 흡수비로서 N/P는 높았고 N/K는 낮았다. 수광량이 많을수록 잎의 질소, 인산, 가리 함량은 낮아졌고, 줄기는 염류에 따라 함량 차를 보였다.