Uptake and Utilization of Nitrogen Applied to Tea Plants

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Tea produced in Japan is mostly green tea. Its nitrogen content is quite high showing 5–6% on dry weight basis in the first crop of good quality. Although the recommended rate of nitrogenous fertilizer is about 600 kg N/ha/year, higher rates than that are often practiced to increase contents of nitrogenous compounds in the harvested crop. However, excessive application of nitrogen is not desirable because it causes not only damage to plant growth but also energy wasting and environmental deterioration.

The author employed ^{15}N tracer method[4,7] to make clear the uptake and utilization of nitrogenous fertilizer applied to tea plants. The use of that method for tea research has rapidly increased since 1970, probably as a result of development of the ^{15}N emission spectrometry which was established by Kumazawa et al.[4,5].

The present paper describes uptake rates of nitrogen of different forms, foliar absorption and metabolism of urea, nitrogen uptake and translocation during the growth period, utilization of applied nitrogen in the field, and reabsorption of the nitrogen contained in organic matters of tea plants. All of them were determined by the ^{15}N tracer method.

Comparative uptake of ammonium- and nitrate-nitrogen

To increase uptake and utilization of applied nitrogen, it is needed to clarify absorption specificity of different forms of nitrogen. Table 1 shows the result obtained by a water culture experiment[1]. It is apparent that tea plants absorbed ammonium-nitrogen as much as 2.6 times more than nitrate-nitrogen. However, no difference in the distribution to various organs of labelled nitrogen absorbed was observed between two sources of nitrogen.

Accordingly, it is clear that tea plants prefer ammonium-nitrogen to nitrate-nitrogen, so that this fact should be taken into account in fertilizer application to tea plants.

Effect of urea foliar spray on tea quality

Urea foliar spray is practiced in many areas, showing its effect in improving quality of green tea produced, particulary in the summer season. It increases amount of chlorophyll and amino acids in tea leaves, while reduces tannin content. It results in higher scores for color of made tea, and color and taste of tea liquor.

Difference in absorption and utilization of labelled nitrogen between foliar- and soil-application is shown in Table 2[2]. It is clear that the foliar application of urea increased the concentration of nitrogenous compounds in new leaves. Incorporation of applied nitrogen into amides and residual N (mostly amino acids) in water soluble nitrogen fraction was also markedly increased by the urea foliar application, while that into caffeine was rather less than the case of soil application.

Namely, it seems that the urea absorbed by leaves is rapidly incorporated into amides and amino acids, and the increased amount of these nitrogenous compounds may result in an improved green tea quality.

Table 1. Amount of ^{15}N absorbed from $^{15}NH_4^+$ or $^{15}NO_3^-$

($mg^{15}N$/plant)

Nitrogen source	New leaf	Mature leaf	Old leaf	Stem	Rootlet	Medium root	Sum
$^{15}NH_4^+$	227	205	266	80	523	220	1521
	(15)	(14)	(17)	(5)	(34)	(15)	(100)
$^{15}NH_3^-$	81	75	118	27	200	83	584
	(14)	(13)	(20)	(5)	(34)	(14)	(100)

Figures in parenthesis indicate the percentage to the total amount of absorbed ^{15}N.

Table 2. Incorporation of ^{15}N applied by foliar- or soil-application into nitrogenous compounds in new leaves

(gN/100 g dry wt.)

Nitrogen application	Total-N	Water sol.-N	Amide-N	Caffeine-N	Res.-N in water sol.-N
Foliar-application	4.64	1.49	0.26	0.77	0.46
	(28.6)	(35.9)	(66.4)	(22.0)	(41.9)
Soil-application	4.48	1.31	0.25	0.77	0.29
	(31.0)	(32.5)	(34.2)	(33.5)	(28.4)

Figures in parenthesis indicate ^{15}N atom % excess of each fraction, shown by taking ^{15}N atom % excess of the fertilizer applied as 100.

Uptake and translocation to new leaves of nitrogen during a growing period

Tea is an arbor crop, and its growth is largely determined by reserve substances. Nitrogenous nutrients may be translocated into harvesting organ from storage organ. Elucidation of this physiological problem is necessary to make clear the role of various organs for tea production.

Nitrogen uptake pattern during a growing period of a tea plant is shown in Fig. 1[1]. Active uptake observed immediately after the plucking was declined with the growth of new shoots, but by the time of the opening of the first leaf, 70% of the total nitrogen absorbed in a whole growing period was uptaken. Absorption of nitrogen after the leaf opening was less, but it was translocated into new shoots to a considerable extent.

Fig. 2 indicates sources of nitrogen contained in a new shoot[1]. ^{15}N which had been applied before the leaf opening of the new shoot, ^{15}N applied after the leaf opening, and ^{14}N which already existed in the plant accounted for 36%, 23% and 41%, respectively, of the total nitrogen in the new shoot. Furthermore, of the total amount of ^{14}N which was already contained in the plant and translocated into the new shoot, 56% of it was derived from old leaves, and 29% was from medium roots. Of the fraction originated from ^{15}N applied before the leaf opening, 50% of it was derived from rootlets, and 25% was from old leaves. Particularly, protein-N in old leaves, and water-soluble N in the root-

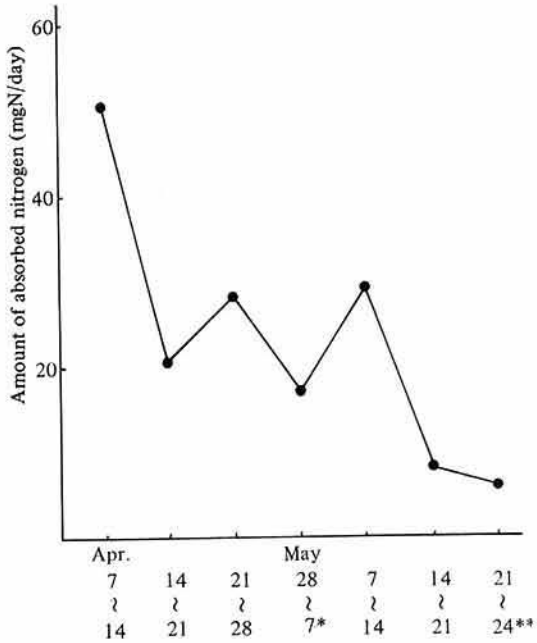

Fig. 1. Nitrogen uptake by tea plant during a growing period
* Opening time of the 1st leaf
** Plucking time of the 2nd crop

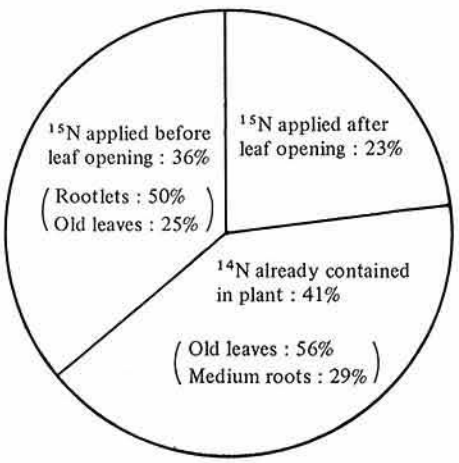

Fig. 2. Origin of nitrogen in a new shoot
Figures in parenthesis indicate the percentage of translocated nitrogen from different organs

lets played an important role in the nitrogen translocation to new shoots.

Accordingly, it may be necessary in practice to apply nitrogen before the initiation of new shoot growth in order to ensure sufficient old leaves and roots for the full function of nitrogen translocation to new shoots.

Utilization of nitrogenous fertilizer by tea plants in the field

Large scaled field experiments are needed to know the actual picture of absorption of fertilizer nitrogen. Several field experiments using ^{15}N were carried out for that purpose, and the result shown in Table 3 was obtained in a part of the experiments[6].

Fertilizer nitrogen applied in the spring was largely absorbed by the first crop, but less absorbed by the second and third crops. Leaves of tea plants uprooted in late August still contained a large amount of ^{15}N. Fallen leaves examined during the experimental period also showed a fairy large amount of ^{15}N contained in them. Rate of absorption of fertilizer nitrogen applied in the spring was 38%, and a considerable amount of the fertilizer nitrogen remained in the soil. Seasons of fertilizer application caused only a small variation in the rate of nitrogen absorption, but apparent difference in nitrogen distribution among various organs, including

Table 3. Uptake rate of fertilizer nitrogen (^{15}N) applied in the spring by tea plants growing in the field

Crop & Organ		Uptake rate (%)
1st crop		8.0
2nd crop		3.8
3rd crop		2.3
Plant*	Leaves	11.8
	Stems	4.5
	Roots	3.4
Defoliated leaves**		4.2
Sum		38.0

* Uprooted in late August
** Examined during the experimental period

Table 4. Mineralization of nitrogen in tea organic residues

Sample	T-N (%)	C/N	Inorganic N (mgN)					
			0	1	2	4	8	16 weeks
New leaf	6.05	7.4	1.88	2.16	8.38	17.33	17.70	18.44
Old leaf	2.76	17.5	1.14	0.11	0.11	0.12	0.44	1.83
Trunk	0.70	65.2	1.20	0.08	0.07	0.10	0.10	—
Rootlet	2.07	21.9	2.68	5.68	6.85	7.21	7.50	8.31

Table 5. Reabsorption of nitrogen (^{15}N) contained in tea organic residues by tea plants

Sample	T-N (%)	C/N	Water sol.-N / Total-N	Uptake rate (%)
Old leaf	3.19	14.9	23.8	13.0
Stem	1.20	39.3	32.5	20.9
Rootlet	2.90	15.9	55.2	28.5

harvesting portion. Fertilizer nitrogen applied in the spring and summer seasons was distributed more in leaves, while that of the autumn season in roots and stems.

These experimental results offer an important suggestion to the fertilizer application and crop management for growing tea in the field.

Decomposition of tea organic residues and reabsorption of their nitrogen by tea plants

Although the tea is an evergreen tree, defoliation occurs to a considerable extent. In addition, branches and leaves pruned for the purpose of regeneration are returned to tea garden soils. For saving resources, it is required to know nutrient cycles of these organic residues.

Table 4 shows mineralization of nitrogen in the tea organic residues[3]. New leaves with low C/N ratios show a rapid mineralization, while trunks with high C/N ratios give an extremely slow mineralization. However, rootlets having high C/N ratios are faster than old leaves in mineralization. This fact suggests that the mineralization is influenced not only by C/N ratio, but also by property of nitrogen contained in the organic residues and ratio of water-soluble N/total N, as observed in Table 5.

Reabsorption of nitrogen of the tea organic residues is given in Table 5[3], which shows that the tea organic residues are decomposed and nitrogen contained in them is mineralized. The rate of reabsorption was high for rootlets and low for old leaves. Amount of nitrogen returned to tea garden soil from fallen leaves and skiffed materials was estimated at 150–320 kg N/ha/year by the author's survey.

For an efficient re-utilization of these tea organic residues, it is expedient to mix them thoroughly with soil, after making clear their properties.

Conclusion

These results obtained by using the ^{15}N tracer method will be able to contribute to the improvement of fertilizer application technology in tea production. This method will be useful to other kinds of crops, too. In the future, metabolism of nitrogenous comounds in tea leaves, and nitrogen cycle in tea garden soils will be studied.

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