Effect of Organic Manures on Quality of Vegetables

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Effect of organic manure application on quality of several kinds of vegetables and the mechanism involved in the effect are presented in this paper.

Materials and method

Of various kinds of organic manures, the rapeseed cake, which shows a high yield-increasing effect of nitrogen and is widely used as an organic manure, and the bark compost, which has a less yield-increasing effect of nitrogen, but is used as a material for improving physical properties of soils, were selected for the use in the experiment. As shown in Table 1, six

Table 1. Experimental plots and treatments

Plot No.	Treatment	Rate of application (kg/a)		
		Org. N	Inorg. N	Bark compost
1	Inorg. N +BC	0	3	400
2	Org. N(1/2) +BC	1.5	1.5	400
3	Org. N +BC	3	0	400
4	Inorg. N	0	3	0
5	Org. N(1/2)	1.5	1.5	0
6	Org. N	3	0	0

Org. N : N in rapeseed cake, Inorg. N : NH_4-N in a compound fertilizer, BC : Bark compost

different treatment plots were designed by the combination of these two organic manures and a chemical fertilizer (a compound fertilizer containing NH_4–N as an only source of N). All of them were applied as the basal dressing. As the application of the rapeseed cake, containing 5% of N, 2% of P, and 1% of K, causes a shortage of P and K, as compared with the chemical fertilizer application, a supplemental application of superphosphate and potassium chloride was made to the former.

For the culture in plastic greenhouse, eggplant, cucumber, and tomato were grown successively, and for the outdoor culture, cabbage, radish, and lettuce were grown successively.

Results and discussion

1) *Effect on physico-chemical properties of soil*

Changes in pH, EC (electric conductivity) and inorganic N content of soil during the growing season of vegetables are summarized as follows.

Application of the rapeseed cake caused an increased soil pH, which lasted until harvesting time. Soil EC and inorganic N content (NH_4–N plus NO_3–N) showed a general trend that they are high at first, but decrease toward the harvesting time, although the rate of decrease was low under a mulch or in autumn-winter season. The higher the rate of rapeseed cake application, the lower EC and inorganic N content of soil, although the effect mostly disappeared by the harvesting time (Fig. 1).

Application of the bark compost increased soil water content. On the average of 6 croppings, it was 17.4% as compared with 15.7% in plots

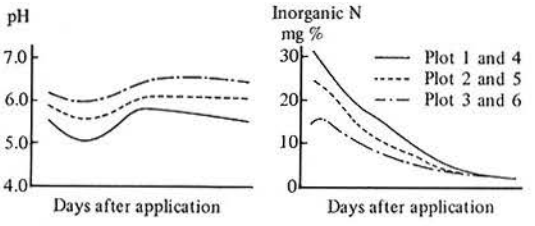

Fig. 1. Diagrammatic illustration of changes in soil pH and inorganic N (NH_4–N + NO_3–N) content of soil during the growth period

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without compost application.

2) *Effect on yields of vegetables*

Yields of vegetables, as a whole, were in the order of Inorg. N>Org. N(1/2)>Org. N plots, and of bark compost plots≤no bark compost plots (Table 2). There have been many reports showing that the yield-increasing effect of rapeseed cake is less than that of inorganic nitrogenous fertilizers. The present experiment gave the similar result. The result that the yield for Org. N(1/2) was inbetween the yields for Org. N and Inorg. N seems to indicate that yields were mainly determined by the amount of inorganic N made available for the crops. Application of bark compost showed a tendency to decrease yields of many of the vegetables used, suggesting a suppression of yield-increasing effect of N.

Table 2. Yields of harvested crops, as expressed by percentages to Inorg. N plots and to non-BC plots

Vegetable	Plots			Plots	
	Inorg. N	Org. N (1/2)	Org. N	Without BC	With BC
Eggplant	100	100	90	100	93
Cucumber	100	88	94	100	96
Tomato	100	100	74	100	97
Cabbage	100	83	88	100	113
Radish	100	87	82	100	89
Lettuce	100	126	108	100	108

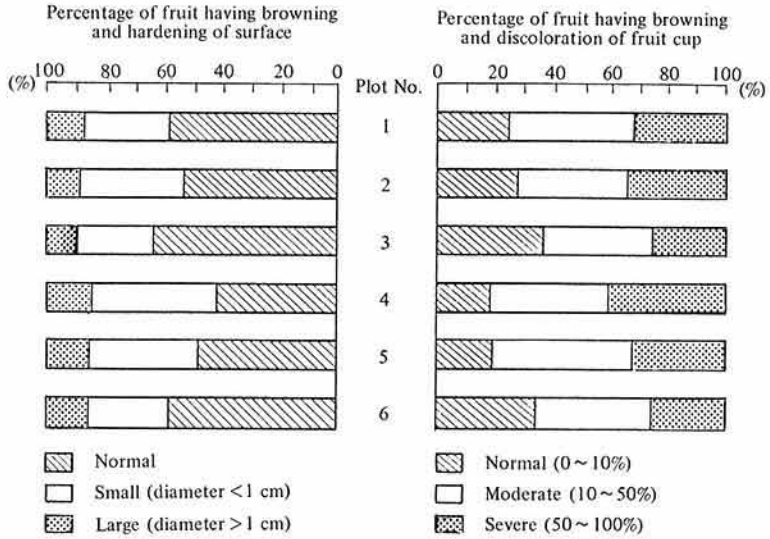

Fig. 2. Effect of rapeseed cake and bark compost applications on external appearance of eggplant fruit

3) *External appearance of vegetables harvested*

(1) Eggplant

Application of rapeseed cake and bark compost reduced the browning and hardening of fruit surface, and the browning and discoloration of fruit cups (Fig. 2). It is known that both injuries occur in summer season when the plant vigor lowers, and are accelerated by a shortage of soil moisture.[5] As their occurrence was mainly observed in the late harvesting time, and was less in the rapeseed cake plots, nitrogen is presumed to be involved in their occurrence. Namely, much of the organic N in the rapeseed cake was mineralized rapidly in about 1 month after the application, but the mineralization continued slowly for long. Even at the late harvesting time, when soil inorganic N is exhausted, the mineralized N supplied from the rapeseed cake, though it is a small amount, must be utilized by plants and exert a favorable effect on the external appearance of fruit. This presumption is supported by the fact that the total N content in fruit was higher in the Org. N plot than in other plots.

On the other hand, the bark compost, which gave no effect on the total N content of fruit, may

have been effective in reducing the fruit injuries by keeping high soil moisture contents.

(2) Cucumber

The rapeseed cake application reduced the occurrence of curved fruit and partially slender fruit, and resulted in a smooth progress of fruit enlargement, i.e., small coefficient of variation in the number of fruit daily harvested, while the bark compost application exerted opposite effects (Fig. 3).

The effects of rapeseed cake seem to be caused by the same reason as in the case of eggplant. Curved fruit are regarded to be caused by nutrient shortage during the stage from flower bud differentiation to flowering, and by plant fatigue due to fruit bearing, while malshaped fruit are caused by high temperature of day and night and by nutrient shortage.[3] Several fruit enlarge simultaneously in cucumber so that nutrient competition among them is inevitable. Nitrogen made available slowly, though in a small amount, might be effective in alleviating plant fatigue, and sustaining good fruit shape. Total N content of fruit was the higher with the higher rate of rapeseed cake application, like the case of eggplant.

On the other hand, the bark compost, whose effect was in the opposite direction to that of rapeseed cake, seems to suppress nitrogen effect, giving lower total N content of fruit than that without bark compost application.

(3) Tomato

The rapeseed cake suppressed the occurrence of large stylar scars and cat's face fruit (Fig. 4). This effect seems to be attributed to low content of inorganic N of soil in the rapeseed cake plot at the early growth period, unlike the case of eggplant or cucumber. The large stylar scars and cat's face fruit are caused by low temperature and excess of N or water at the stage of flower bud differentiation and fruit development.[6] Low inorganic N content of soil at this stage, about one month after transplanting, seems to have alleviated the occurrence of the injured fruit.

(4) Cabbage

The rapeseed cake reduced the occurrence of black heart. The black heart is caused by Ca-deficiency at the stage after head formation, and promoted by heavy application of N and soil drying.[2] As the cabbage was grown in an open field, inorganic N content of soil was low in the middle-late growth period, but only an increased soil pH was recognized in the rapeseed cake plot. The increased soil pH must have made Ca absorption by plants easy, and reduced the black heart occurrence.

(5) Radish

Occurrence of curved roots and pithiness was suppressed by the rapeseed cake ,while the pithiness was promoted by the bark compost (Fig. 5).

As a variety having a high rate of root emergence above soil surface was used in the experiment, and it was exposed to typhoon at the root-developing stage, a large number of roots curved at their basal portion were produced. However, in the rapeseed cake plot, plants were slightly

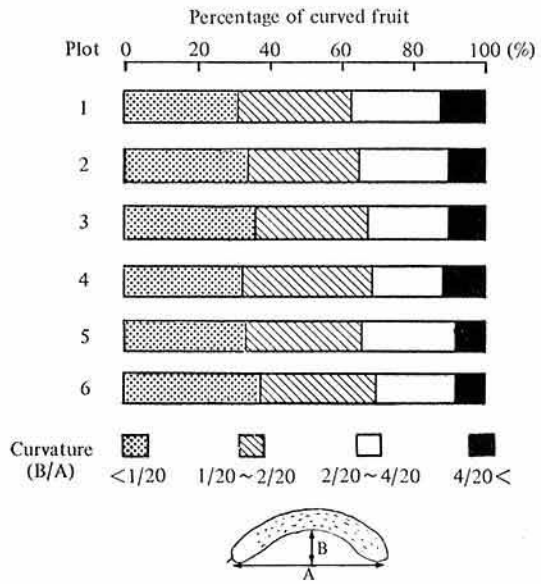

Fig. 3. Percentage of curved fruit of cucumber

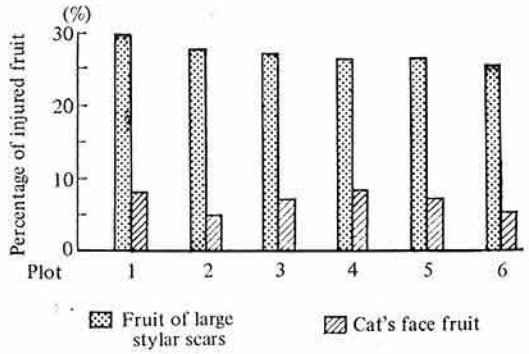

Fig. 4. Percentage of injured fruit of tomato

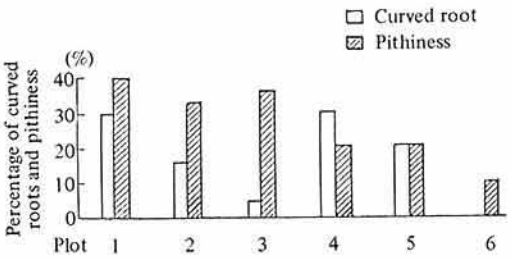

Fig. 5. Percentage of curved roots and pithiness of radish

smaller due to low inorganic N content of soil, and hence less affected by the typhoon. This may be the reason for less occurrence of curved roots in the rapeseed cake plot.

The pithiness is caused by a rapid enlargement of roots with insufficiently accumulated contents of parenchyma cells, and its occurrence is promoted by high N and high moisture conditions.[1] The rapeseed cake, which slowly supplied inorganic N to the plants, induced stable root enlargement and hence less occurrence of the pithiness. Total N content of root at the harvesting time was low.

On the other hand, the bark compost induced higher water content of soil, which seems to have promoted the occurrence of pithiness.

(6) Lettuce

The number of loosed heads was reduced by the rapeseed cake and bark compost applications. The loosed head of lettuce is caused by high temperature, strong light, long sunshine hour, and nutritional status of plants, i.e., low C/N ratio, etc.[4] The climate of the year of the experiment was not favorable for head formation, because of shortage of sunshine during the early half of the head formation period, followed by strong sunshine and long sunshine duration in the later half.

As mentioned repeatedly, the rapeseed cake kept inorganic N content in soil at a low level. Consequently, N content in plant was also kept low, causing high C/N ratio, which promotes heading formation. Regarding the bark compost, its performance of suppressing nitrogen effect may have occurred, but no difference was observed in total N of harvested crop.

4) *Contents of sugar and vitamin C in harvested crops*

In some kinds of vegetables, applications of the rapeseed cake and the bark compost showed increased sugar contents of the crops. However, it seems that this is not a direct effect, but is derived from the relation to nitrogenous compounds in the crops (Fig. 6).

As a whole, there is a negative correlation between sugar contents and total N contents. The correlation is clear for cabbage, radish, and lettuce, but not clear for eggplant, cucumber, and tomato. In the former, the development of harvested portions requires a long time, so that accumulation of photosynthate and its distribution to the harvesting portion can sufficiently be made. On the contrary, the latter is characterized by a short period of fruit development, apt to be not sufficient enough to receive full distribution of the photosynthate. It may be natural

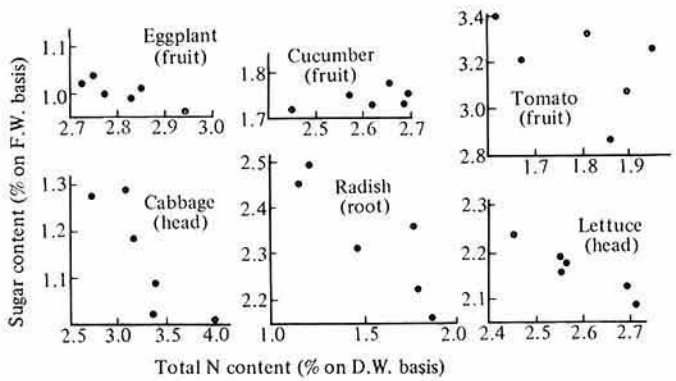

Fig. 6. Relation between sugar and total N content in fruit, heads and roots of vegetables

Table 3. Total nitrogen content in harvested crops and vitamin C content after storage of the crops

Plot No.	T-N (% on D.W. basis)						Vitamin C after storage (mg% on F.W. basis)					
	E	Cu	T	Ca	R	L	E	Cu	T	Ca	R	L
1	2.75	2.45	1.81	4.01	1.75	2.71	5.4	11.4	20.2	34.4	19.7	3.1
2	2.94	2.62	1.67	2.72	1.19	2.55	5.7	11.8	17.6	39.0	20.4	3.1
3	2.83	2.70	1.62	3.09	1.15	2.55	5.6	11.2	18.3	37.8	21.4	3.2
4	2.77	2.57	1.95	3.39	1.78	2.69	5.0	11.6	21.9	32.7	18.1	2.8
5	2.72	2.69	1.90	3.15	1.45	2.45	6.0	11.4	19.1	38.1	22.4	3.0
6	2.85	2.66	1.86	3.35	1.85	2.56	5.6	11.6	17.9	40.0	19.6	3.0

E : fruit of eggplant, Cu : fruit of cucumber, T : fruit of tomato, Ca : head of cabbage, R : root of radish, L : head of lettuce

Table 4. Effects of rapeseed cake and bark compost applications on external quality of harvested crops, and possible factors involved in each effect

Vegetable	Qualitative term	Application of rapeseed cake		Application of bark compost	
		Effect[a]	Factor[b]	Effect[a]	Factor
Eggplant	Browning and hardening of fruit surface	+	N+	+	Increased water retention
	Browning and discoloration of fruit cup	+	N+	+	do
Cucumber	Coefficient of variation of daily harvesting number	+	N+	(−)	N deficiency
	Curved fruit	+	N+	−	do
	Partially slender fruit	+	N+	−	do
Tomato	Fruit of large stylar scar	+	N−	−	?(Increased water retention)
	Cat's face fruit	+	N−	±	
Cabbage	Blackening of heart head	+	Rise of pH	±	
Radish	Curved root	+	N−	±	
	Pithiness	+	N−and +	−	Increased water retention
Lettuce	Loosed head	+	N−	+	N deficiency

a) + : Positive effect, − : Negative effect, ± : No effect observed

b) N+ : More inorganic N available in soil than the Inorg. N plot at the growth stage of producing harvested organs of crops
N− : Less inorganic N available at that stage
N−and + : Less inorganic N available at the early stage of root development and more N available at the late stage

that the harvested crop of the former is more influenced by nitrogen effect than the latter.

No consistent effect was recognized on vitamin C content in harvest. However the crops of eggplant, cabbage, radish, and lettuce, harvested from the rapeseed cake plot showed slightly higher vitamin C contents after storage (by usual packaging method at 20°C) than crops from other plots(Table 3). This result suggests an activity of inhibiting vitamin C destruction during storage, but nothing is known about its mechanism and inter-relations with other components.

Conclusion

Effects of application of rapeseed cake and bark compost on external quality and yield of harvested crops are summarized in Table 4, together with possible factors involved.

The rapeseed cake expressed favorable effects, and most of them were attributed to the slow-release of N from it. The effect of the slow-release of N is divided into two: (1) In an early growth period, N is supplied at a lower level than chemical fertilizers, and (2) after that, N supply continues for long, although in a small amount.

Due to the former effect, the occurrence of large stylar scars and cat's face fruit of tomato, and curved roots of radish was reduced, while due to the latter effect, the external appearance of eggplant fruit was improved, and the stable enlargement of cucumber fruit with a reduced number of curved or malshaped fruit was induced. The reduction of pithiness of radish roots seems to be caused by the former effect followed by the latter one.

As to the bark compost, positive and negative effects were observed by similar number. Its effective factors are considered to be N incorporation and high moisture conditions of soil (due to increased water retention).

The N incorporation into bark compost enhances the N slow-releasing effect of rapeseed cake in an early period, but reduces it in the later period. The improved heading formation in lettuce caused by bark compost was due to the former effect, while the reduced fruit enlargement and the increased number of malshaped fruit of cucumber seem to be caused by the latter effect.

Although it was not well examined to what extent the small difference of soil moisture content such as 1–3%, observed in the present experiment can influence the quality of vegetables, it is considered that the soil moisture content increased by the bark compost application might have given a positive effect on the external appearance of eggplant fruit and a negative effect on the pithiness of radish roots, depending upon the water requirement at the time of occurrence of these injuries.

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(Received for publication, April 4, 1983)