2) *Effect of Upland Crops and their Growing Seasons (1976)*

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In crop rotation consisting of upland crops and rice in paddy field, the growth of rice is affected by the preceding upland crops and their growing practices. The experiment was conducted to clarify the effect of the upland crops and their growing seasons on the succeeding rice crop.

Materials and method

1. Preceding upland crop
   Maize (C_1) : Thai DMR No.6
   Soybean (C_2) : SJ 2
   Peanut (C_3) : Tainan No.6
2. Growing season of the upland crops (days before transplanting of rice)
   Early (T_1) : Jan. 9 — Apr. 27 (92 days)
   Medium (T_2) : Feb. 21 — Jun. 2 (56 days)
   Late (T_3) : Apr. 8 — Jul. 14 (14 days) ..... C_1
   Jul. 22 (6 days) ..... C_2, C_3

   Additionally, plot (T_0) laid fallow in dry season was provided. Number of days in parentheses shows the duration from harvesting of the upland crops to transplanting of rice.
3. Nitrogen application for rice (Kg/ha)

Plot	Basal	Top	Supplement for top dressing (out of statistical analysis)	Total
Control (F_1)	0	0		0
			+ 10 (F_{1+1})	10
Reduced (F_2)	10	10		20
			+ 10 (F_{2+1})	30
Standard (F_1)	20	20		40
			+ 10 (F_{3+1})	50

4. Design and plot size
   Split plot design with one replication. L27 (3^{13}) orthogonal table was employed for the statistical analysis of data. The size of sub-sub-plot was 60 m^2 (7.5 m × 8 m).
5. Cultivation of preceding upland crops
   1) Fertilizer application (Kg/ha):

Crop	N	P_2O_5	K_2O
maize	100	75	37.5
leguminous	20	75	37.5

One half of nitrogen was applied for basal dressing and the rest for top dressing.

2) Spacing: maize: 75 cm × 25 cm (1 plant/hill)
leguminous: 75 cm × 20 cm (2 plants/hill)

3) Harvesting: For maize, only ears were harvested and the rest of plant was plowed into soil. For soybean, top part of plant was harvested and taken out of the field. For peanut, whole plant with pods was pulled out.

6. cultivation of rice
   1) Variety used: RD 7
   2) Transplanting time: July 28, 1976
   3) Fertilizer application: N: as mentioned above
      P_2O_5: 20 Kg/ha
      K_2O: 0
   4) Spacing: 25 cm × 25 cm, 3 seedlings/hill
   5) Harvesting time: Nov. 11, 1976

Result

1. Growth and yield of preceding upland crops.

Growth and yield of the preceding upland crops were shown in Table 2-3. All the crops tested grew less vigorously in T_1 plot than T_2 and T_3 plots in the initial growth stage. Such a trend seemed to be caused by the abnormally low temperature in January in that year.

Maize plant of T_1 plot grew fairy well in the reproductive growth stage and yielded 2.8 ton/ha, highest among the plots of 3 growing seasons. In T_2 and T_3 plots, especially in T_2 plot, the growth in the reproductive stage and the yield were poor probably affected by leaching and/or gasification of the top-dressed nitrogenous fertilizer by rainfall.

Soybean and peanut also yielded fairy well in T_1 plot and poorly in T_2 and T_3 plots. Among them peanut of T_3 plot yielded extremely poor due to poor germination and rainy weather condition in May.

2. Growth and yield of rice

The growth in terms of plant height, tiller number, leaf area index (LAI) and dry weight was shown in Fig. 2-4, 5, 6 and 7; yield and yield components were shown in Fig. 2-8 and 9.

1) There was seen an interaction effect on the growth and yield of rice between C treatment (kind of the preceding upland crops) and T tretment (growing season of the preceding upland crops) as follows:

In the plot succeeding to maize, rice obviously grew better up to the panicle formation stage in T_1 plot as compared with T_2 and T_3 plots. Afterwards, the rice growth became vigorous in T_3 plot, which resulted in the highest yield among 3 plots of T treatment of maize.

In case of the plots succeeding to soybean and peanut, the growth and yield of rice were in the order of $T_2 > T_3 > T_1$.

The rice growth in T_0 plot (fallow in dry season) tended similarly to that in T_3 C_1 plot (succeeding to maize of late sowing).

2) Among the yield components, number of panicles and number of spikelets per panicle well coincided with the yield.

3) Changes of the content of ammonium nitrogen in the soil, as shown in Fig. 2-10, was in agreement with the trend of the growth and yield of rice.

4) There was seen the significant linear effect of the rate of fertilizer application on rice yield; that is, the higher the rate of fertilizer was the better crop was obtained irrespective of C and T treatments. However, as seen in Fig. 2-9, the difference of yeild among F treatment was bigger in C_1 plot (succeeding to maize) and less in C_2 and C_3 plots (succeeding to leguminous crops).

   There seemed to be a trend that the rate of basal dressing affected the number of panicles while the increased rate of top dressing affected the number of spikelets per panicle.

Discussion and Summary

The factors which originated from the preceding crop to affect the succeeding crop will be classified into following categories; ① effect of applied fertilizer (relationship between application of fertilizer and its absorption by plants), ② plant residue (quantity and quality), ③ physical effect of root penetration into subsoil, ④ chemical substance (effective or toxic), and ⑤ changes of biological environment. In the present experiment, the discussion focuses on the matters concerned with the categories ① and ②.

Ordinally, maize plant absorbs much amount of nutrients from soils, by taking out more than the applied ones. Therefore, the plant residues except ears were turned back to the field after harvesting in this experiment similarly as the customary method. The progress of decomposition of plant residues varies with the duration after incorporation of them into the soil; it may induce the different growth of the rice by supplying with different amount of inorganic nutrients in each growth stage of rice. Thus, rice plant of T_1 plot could take much nutrients originating from the decomposed plant residues in the initial growth stage but insufficient ones in the later growth stage; on the other hand the nutrients became available to rice plant only in later growth stage in T_3 plot where maize yielded the highest. There will be a possibility, however, to raise high yield of rice in T_1 plot if accompanied with appropriate fertilizer application in the reproductive growth stage.

In case of leguminous crops such as soybean and peanut, the quantity of the plant residues was quite less as the plants were reaped or pulled out of the field. Since leguminous crops can fix nitrogen by themselves through bacterial nodules, the soil generally becomes fertile. However, those fixed nitrogen would possibly be leached and/or gasified away when the duration from harvesting those leguminous crops to rice tranplanting was so long as 3 months like in T_1 plot. On the other hand, the fixed nitrogen was quite effective on the succeeding rice crop when the duration was less than two months. The inferior growth of rice plant of T_3 plot could probably be explained by less fixation of nitrogen because of poor stands of the preceding leguminous crops.

The rice growth in T_0 plot showed the similar trend to that in T_3 C_1 plot. It is assumed that the weeds, which happened to emerge during the fallow time in dry season, played the similar role as maize plant of T_3 plot.

Thus, the results are summarized as follows:

1) When maize was grown as a preceding crop, about 3 months of the duration from harvesting of maize to transplanting of rice was favorable to the rice growth in the early growth stage up to the panicle formation stange. Although the plot of 2 weeks of the duration yielded highest in the experiment, a higher yield will be expected from 3 months of the duration accompanied with the appropriate fertilizer

application in the later growth stage of rice.

2) When leguminous crops such as soybean or peanut were grown as the preceding crops, the rice growth was fairy well when rice was transplanted within 2 months after harvesting the preceding crop.
3) Changes of MH_4-N content of soil, which varied depending upon the balance of supply and absorption of fertilizer by the preceding crops and the decomposition of the plant residues, was in agreement with the rice growth.

Table 2-3. Growth, yield and yield component of preceding upland crops

		Culm length	Tassel length	Cob length	Plant population	No. of ears	No. of grains	Weight of 100 grains	Grain yield	Dry wt. of whole top
Maize		cm	cm	cm	plant/m^2	/m^2	/ear	g	Kg/ha	g/m^2
	T_1	172.8	29.4	13.4	4.33	4.33	294	22.2	2,826	777
	T_2	144.5	32.1	7.9	4.35	3.38	145	18.4	903	297
	T_3	155.7	29.1	12.4	4.41	4.36	232	22.4	2.264	561

		Stem length	No. of branches	Thickness of stem	Actual plant population	No. of full pods	No. of grains	Weight of 100 grains	Grain yield	Dry Wt. of whole top
Soybean		cm	/plant	mm	hills/m^2 plant/hill	/hill	/pod	g	Kg/ha	g/m^2
	T_1	47.0	3.4	5.4	5.46 × 2.00	143.1	1.99	15.5	2.412	459
	T_2	46.0	3.1	7.0	6.24 × 2.17	161.4	1.46	12.2	1,792	389
	T_3	54.5	5.6	7.6	5.61 × 2.40	206.1	1.47	11.2	1,890	380

		Stem length	Length of longest branch	No. of branches	Actual plant population	No. of pods	No. of grains	Weight of 100 grains	Grain yield	Dry Wt. of whole plant
Peanut		cm	cm	/plant	hills/m^2 plants/hill	/hill	/pod	g	Kg/ha	g/m^2
	T_1	37.7	53.9	5.1	5.30 × 2.81	49.1	1.80	42.0	1,970	775
	T_2	55.9	64.7	5.6	5.77 × —	21.5	1.75	32.8	711	463
	T_3	40.3	50.2	6.0	4.54 × 1.37	11.0	1.61	35.2	270	317

Moisture content of grain yield was 13% in maize and soybean, and 9% in peanut.

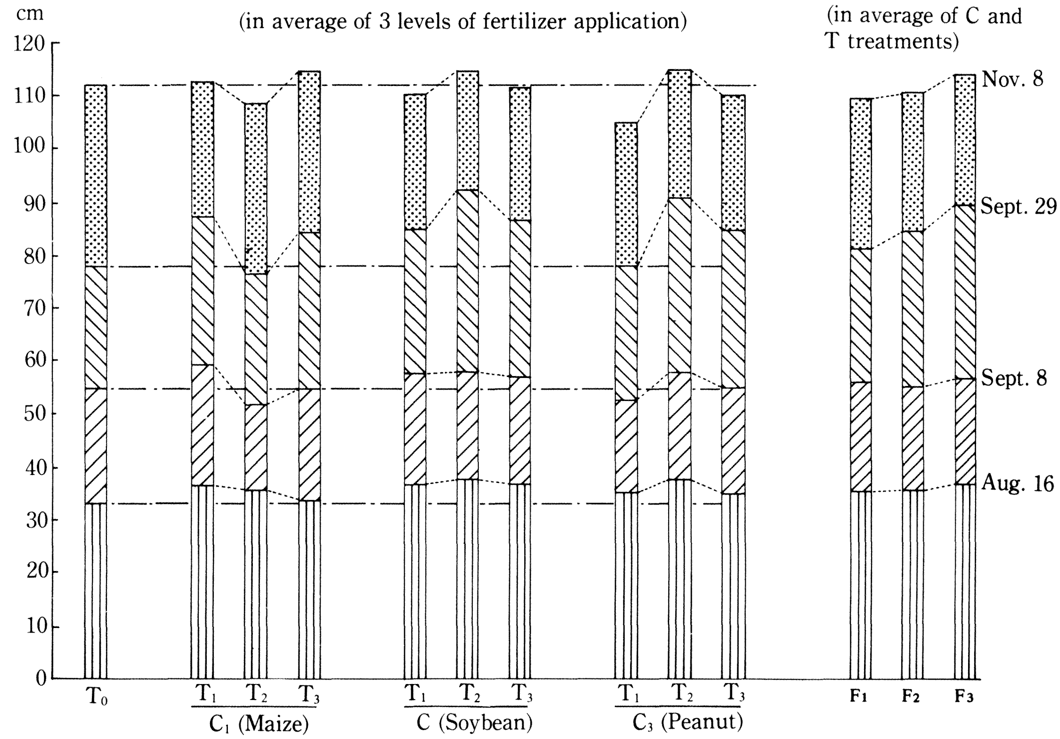

Fig. 2-4. Plant height of rice in relation to preceding upland crops

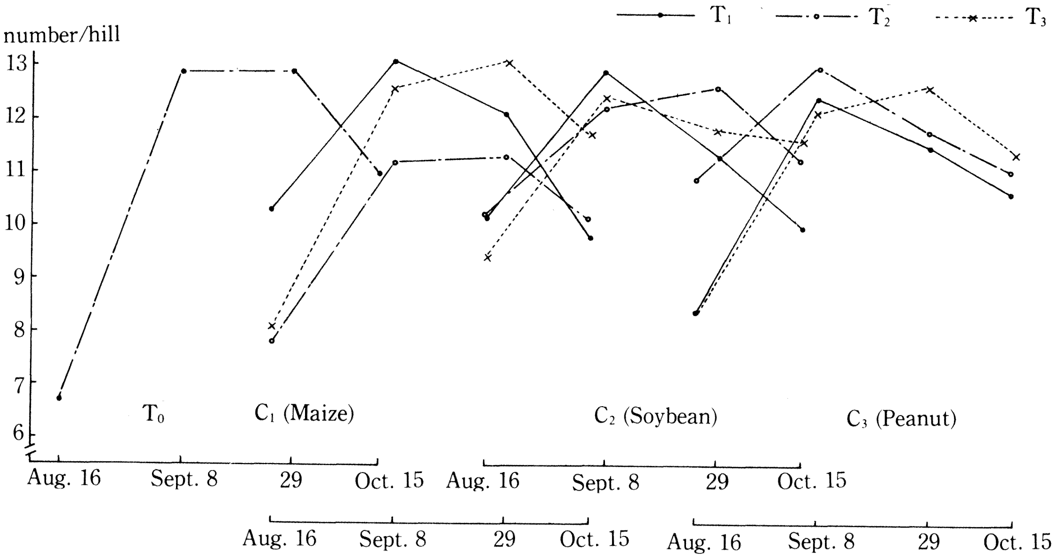

Fig. 2-5. Number of tillers of rice plant in relation to preceding upland crops

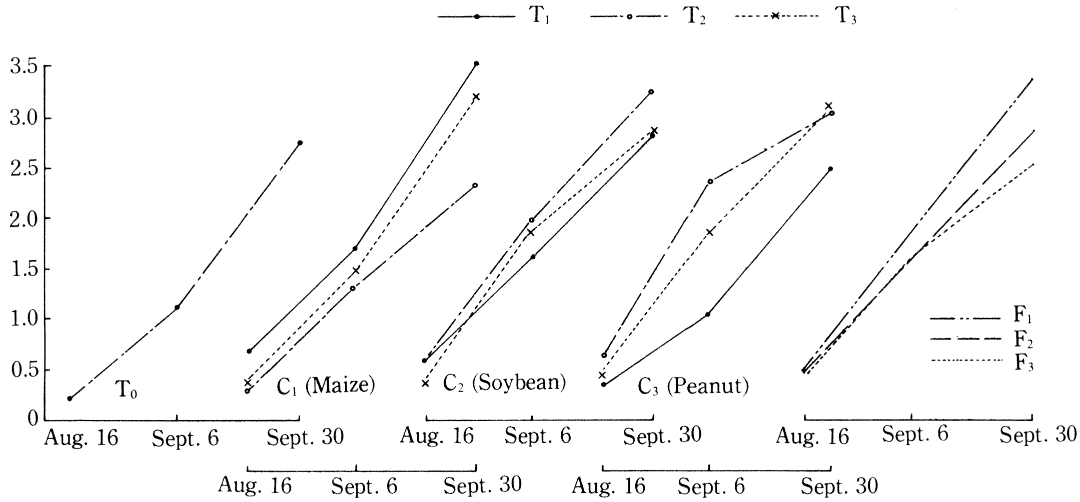

Fig. 2-6. Leaf are index (LAI) of rice plant in relation to preceding upland crops

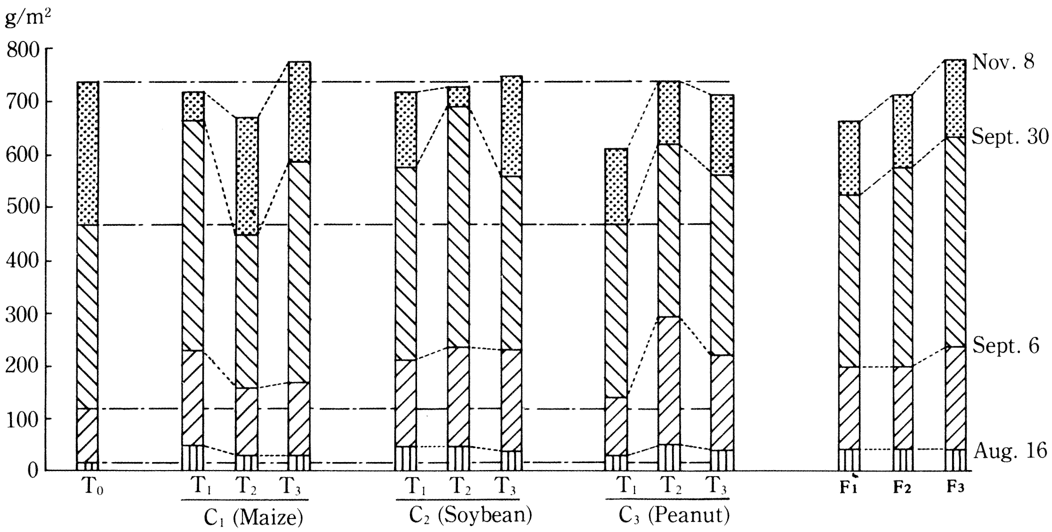

Fig. 2-7. Dry weight of rice plant in relation to preceding upland crops

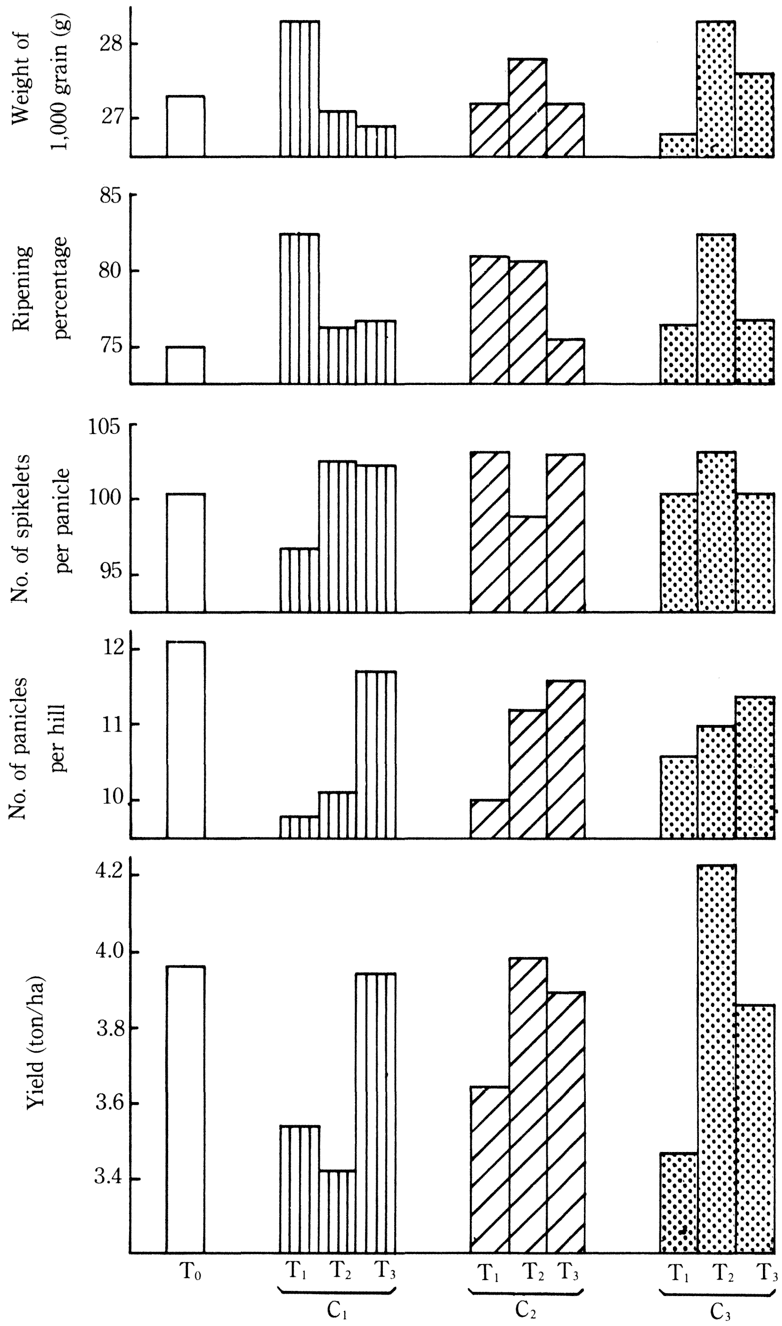

Fig. 2-8. Yield and its component of rice in relation to preceding upland crops (in average of 3 levels of fertilizer application)

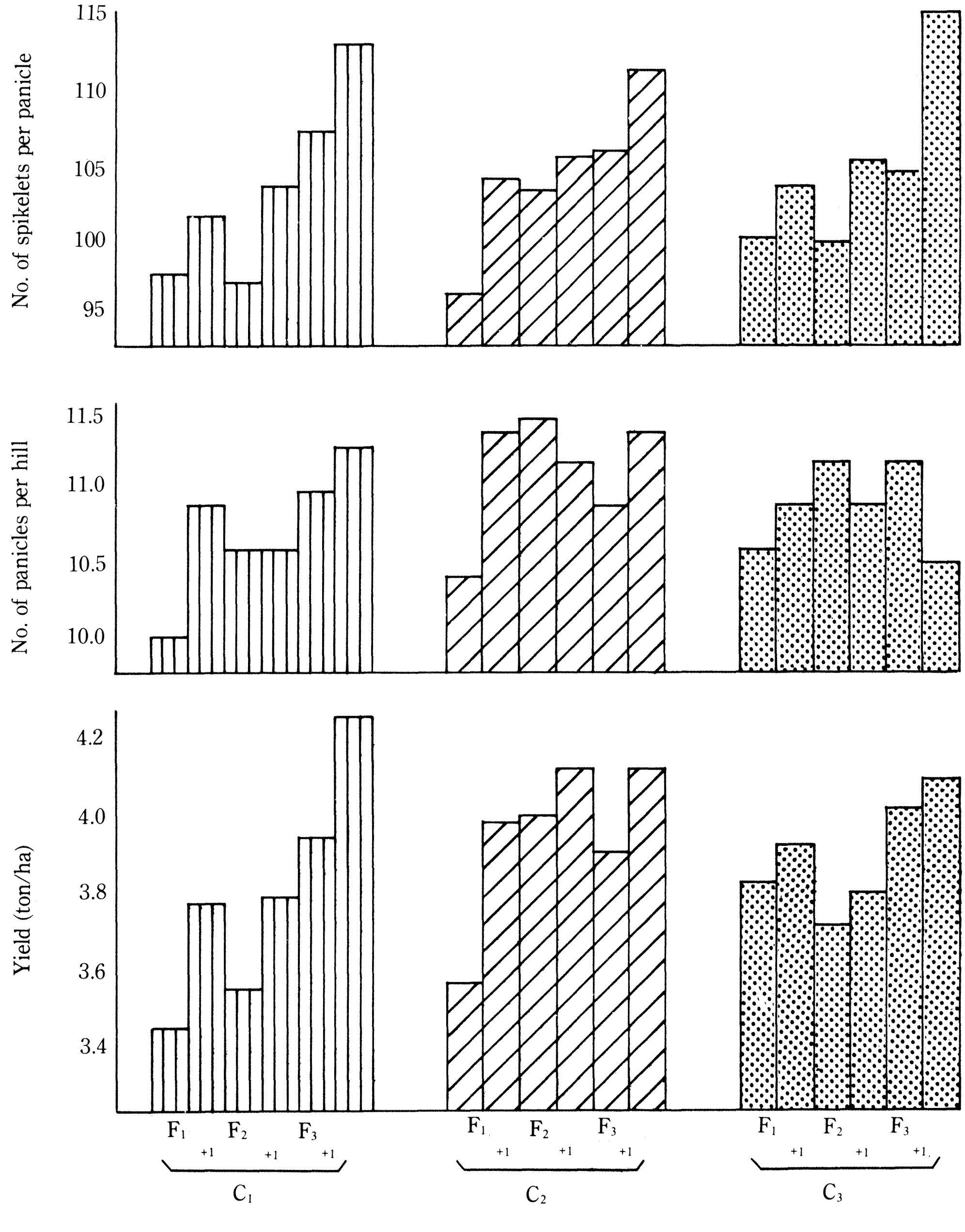

Fig. 2-9. Yield and its component in relation to rate of fertilization and preceding upland crops (in average of 3 levels of growing season of preceding crops)

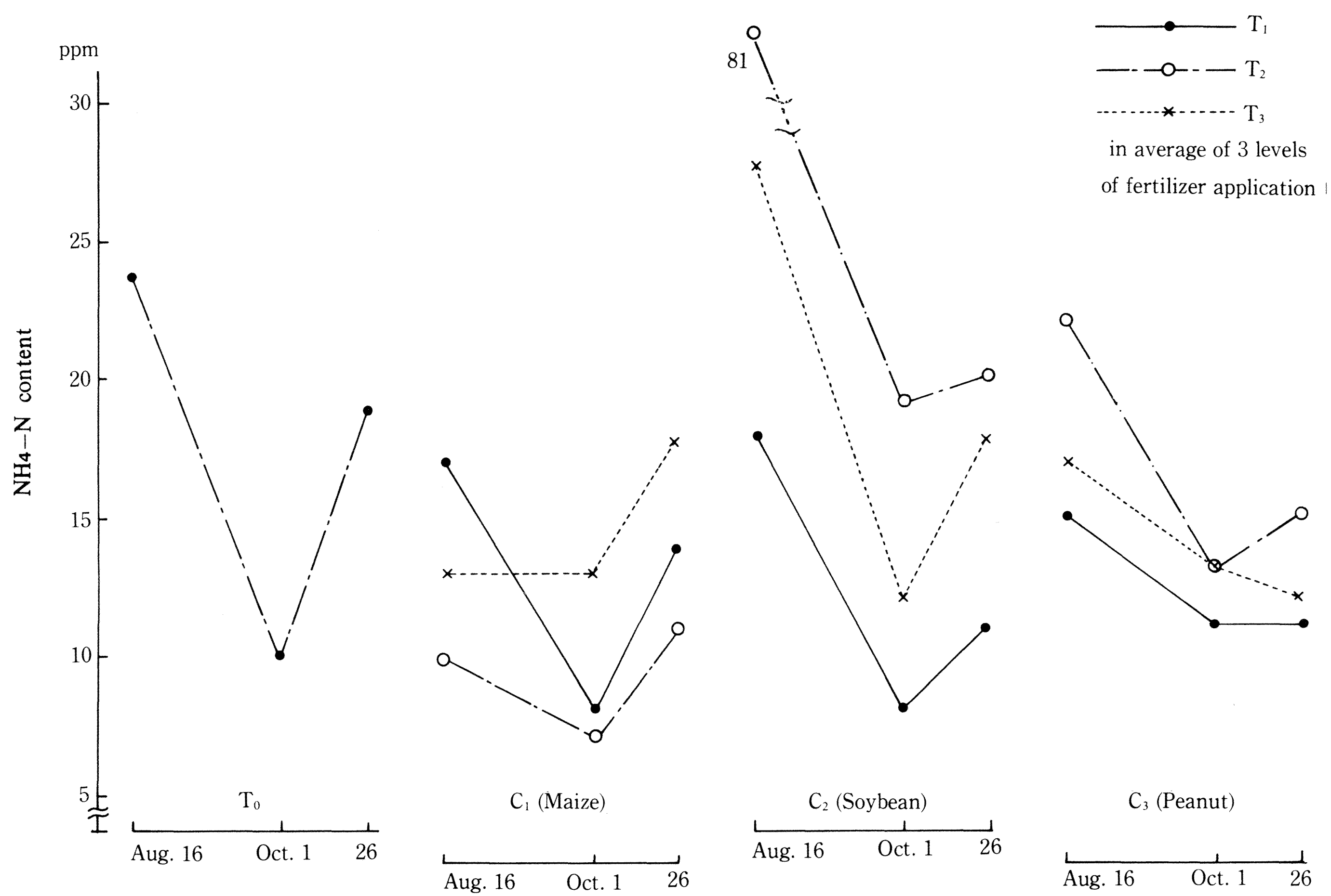

Fig. 2-10. Changes of nitrogen (NH_4-N) content of soil in relation to preceding upland crops