

2. Effects of Application of Fresh Materials of Upland Crops into Heavy Clay Paddy soil (1976—1977)

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The experiment was carried out to examine the effect of incorporation of fresh materials of some upland crops into paddy soil of heavy clay, on the succeeding crops.

1) Experiment in 1976

Materials and Method

Design of experiment

1. 1st crop

The following crops were grown on paddy field from late January to mid March and plowed into soil at their flowering stages.

- 1) Fallow during the period
- 2) Soybean (New Pelican)
- 3) Crotalaria
- 4) Maize (Thai DMR6)
- 5) Sorghum

2. 2nd crop

Maize and peanut were grown from April to July in order to examine the effect of the incorporation of the fresh materials of the 1st crop.

3. 3rd crop

Rice was grown under flood condition from August to November for the same purpose.

Cultural practices

1. 1st crop

Seeding time: January 23, 1976

Fertilizer application

	N	P ₂ O ₅	K ₂ O
Soybean and crotalaria:	10	75	37.5 kg/ha
Maize and sorghum:	100	75	37.5 kg/ha

Spacing

Soybean:	75 cm × 20 cm	(2 plants/hill)
Crotalaria:	75 cm × drill	(30 kg/ of seed/ha)
Maize:	75 × 25 cm	(2 plants/hill)
Sorghum:	75 cm × drill	(30 kg of seed/ha)

Size of plot

15 m (75 cm × 20 ridges) × 14 m = 210 m² with 2 replications.

Irrigation

Furrow irrigation was made at the average rate of 5.6 mm/day.

Time of incorporation into soil: March 19, 1976

2. 2nd crop

Variety

Maize: Suwan No.1

Peanut: Tainan No.6

Seeding time: April 9, 1976

Fertilizer application

	N	P ₂ O ₅	K ₂ O
Maize:	100	75	37.5 kg/ha
Peanut:	10	75	37.5 kg/ha

Non-fertilizer treatments for each plot of both the crops were preliminarily tried in border rows with one replication.

Spacing

Maize: 75 cm × 25 cm (1 plant/hill)

Peanut: 75 cm × 20 cm (2 plants/hill)

Design and size of plot

Each plot of the 1st crop was equally divided into two plots, for maize and peanut, with each size of 7.5 m (75 cm × 10 ridges) × 14 m = 105 m²

Irrigation

Furrow irrigation was made at the average rate of 6.5 mm/day.

Harvesting time

Maize: July 13, 1976

Peanut: July 26, 1976

3. 3rd crop

Variety: RD7

Transplanting time: August 17, 1976

Fertilizer application

Basal: N: 20 and P₂O₅: 25 kg/ha were applied on August 24.

Top dress: N: 17.5 kg/ha was applied on September 28.

Spacing: 25 cm × 25 cm (3 seedlings/hill)

Design and size of plot

Same as in the 2nd crop

Harvesting time: November 24, 1976

Results

1. The amount of the fresh materials of the crops plowed into the soil at their flowering stages is shown in Table 2-1.
2. The yields of maize and peanut (2nd crop) as affected by the incorporation of those fresh materials are shown in Table 2-2 and 3. There was not found a significant difference in the yields of both the crops among the plots, however the yields and the dry weight of top parts of the crops seemed best in the plot where soybean was grown and incorporated, and worst in the plot where maize was.
3. Non-fertilizer treatment for 2nd crop was preliminary tried. The results obtained were not reliable because of the limited number of the samples, but the following can be assumed. Maize needs chemical fertilizers, even though the fresh materials of any preceding crops were incorporated into the soil.
4. The bulk density of the soil of each plot during the growth period of 2nd crop is shown in Table 2-4. The bulk density of surface soil at the end of the period was lower in the plot where sorghum was incorporated than in others.
5. The yield of rice (3rd crop) was shown in Table 2-5. There was not a significant difference among the yields of the plots.

Table 2-1. Fresh materials plowed into the soil

Crop	Plant height	Fresh weight	Dry weight	Dry matter percent
	cm	t/ha	t/ha	%
Soybean	64.8	6.6	1.16	17.6
Crotalaria	146.9	13.9	2.58	18.6
Maize	134.2	10.4	1.71	16.4
Sorghum	171.6	16.5	3.59	21.8

Note: Those materials were plowed in on March 19, 1976.

Table 2-2. Yield and yield components of maize

Plot	Grain weight*	No. of plants	No. of ears	No. of grains	Weight of* 100 grains
	kg/ha	/m ²	/m ²	/ear	g
Fallow	2452	5.0	4.6	215	23.2
" NF	235	4.5	4.1	46	12.4
Soybean	3014	5.0	4.5	272	24.1
" NF	295	5.4	3.7	40	19.7
Crotalaria	2376	4.4	4.1	228	24.1
" NF	340	4.7	2.8	62	19.3
Maize	1895	4.3	4.3	218	21.5
" NF	24	4.1	1.6	13	10.9
Sorghum	2216	4.7	4.6	247	22.6
" NF	617	5.1	4.6	76	17.6

Remarks: NF means non-fertilizer treatment.

* 13% of moisture content.

Table 2-3. Yield and yield components of peanut

Plot	Grain weight*	No. of hills	No. of pods	No. of grains	Weight of* 100 grains
	kg/ha	/m ²	/hill	/pod	g
Fallow	814	4.7	29.8	1.6	38.8
" NF	746	4.7	30.6	1.5	37.8
Soybean	951	5.4	27.0	1.6	36.7
" NF	1170	5.3	31.8	1.7	43.2
Crotalaria	765	4.7	23.8	2.0	38.9
" NF	845	4.8	29.5	1.6	40.8
Maize	697	4.7	24.9	1.6	36.4
" NF	871	4.4	32.5	1.6	40.9
Sorghum	847	4.9	29.6	2.0	36.3
" NF	1084	5.6	32.7	1.6	39.1

* 9% of moisture content

Table 2-4. Bulk density of surface soil in 2nd crop

Plot	Maize			Peanut		
	2*	9*	16*	2*	9*	16*
Fallow	1.21	1.35	1.34	1.26	1.32	1.38
Soybean	1.27	1.34	1.36	1.20	1.33	1.44
Crotalaria	1.18	1.32	1.42	1.18	1.35	1.40
Maize	1.25	1.41	1.43	1.18	1.38	1.42
Sorghum	1.23	1.31	1.23	1.25	1.27	1.35

- Remarks: 1) The soil samples were taken at the depth of 5 to 10 cm from the surface of ridges.
 2) Each value is the average of three samples.
 3) * Weeks after seeding.

Table 2-5. Yield and yield components of rice

Plot 2nd crop/1st crop	Weight of full grain	Number of panicles	Number of spikelets	Ripening percentage	Wt. of 1,000 full grains
	kg/ha	/m ²	/panicle	%	g
Maize/Fallow	3189	159.4	111.0	68.4	26.2
" /Soybean	3643	160.1	115.0	73.3	27.0
" /Crotalaria	3870	163.0	113.7	75.2	27.8
" /Maize	3472	154.0	113.8	74.5	26.7
" /Sorghum	3390	161.2	113.7	70.4	26.2
Mean	3513	159.5	113.4	72.3	26.8
Peanut/Fallow	2902	133.4	111.6	71.6	27.3
" /Soybean	3112	145.0	114.3	70.5	26.2
" /Crotalaria	3299	139.7	114.1	74.7	27.6
" /Maize	3321	152.8	108.9	72.7	27.5
" /Sorghum	3160	143.5	110.0	72.0	27.7
Mean	3159	142.9	111.8	72.3	27.3

Remarks: Grain weight is expressed on the basis of 14% of moisture content.

2) Experiment in 1977

Materials and methods

Crotalaria and sorghum (1st crop) were grown from January to March 1977 and applied to soil at their flowering stage. Maize (2nd crop) was grown from April to July to examine the effects of the application. Rice (3rd crop) was planted from August to November under flood condition with uniform cultural practices.

1. Design of experiment (for maize, 2nd crop):

- 1) Application of fresh materials (main plot)
 - (a) Mulching with fresh materials of crotalaria (Cr-M)
 - (b) Incorporation of fresh materials of crotalaria (Cr-P)
 - (c) Mulching with fresh materials of sorghum (Sr-M)
 - (d) Incorporation of fresh materials of sorghum (Sr-P)
 - (e) Fallow during the growing period of these crops (F1)

2) Irrigation (sub plot)

- (a) Approximately once per 2 weeks (I₁)
- (b) Approximately once a week (I₂)

3) Fertilizer application (sub-sub plot)

- (a) Low (F₁) N: 50 kg/ha
- (b) High (F₂) N: 50, P₂O₅: 75, K₂O: 50 kg/ha

4) Layout

Randomized design was applied for main plot with two replications; each plot was equally divided into sub-plot and then into sub-sub plot. The size of sub-sub plot was 7 m × 7.5 m.

2. Cultural practices:

1) 1st Crop (crotalaria and sorghum)

Seeding time: January 19, 1977

Fertilizer application:

	N	P ₂ O ₅	K ₂
Crotalaria	20	37.5	25kg/ha
Sorghum	75	37.5	25kg/ha

Spacing:

Crotalaria: 75 cm × drill (33 kg of seed/ha)

Sorghum: 75 cm × drill (8.5 kg of seed/ha)

The amount of seed sown is calculated on the basis of germination test.

Irrigation:

Furrow irrigation was made approximately once a week.

Application to soil:

(1) Incorporation plots (Cr-P, Sr-P)

Fresh materials of the crops were plowed into soil by rotary tiller on March 28.

(2) Mulching plots (Cr-M, Sr-M)

Those fresh materials were reaped on the same day, kept outside the field until April 11 and mulched on the field after seeding of maize.

2) 2nd Crop (maize — Suwan No.1)

Seeding time: April 11, 1977

Spacing: 75 cm × 25 cm (1 plant/hill)

Harvesting: July 7, 1977. Plant residues of maize after harvesting ears

were plowed into soil.

- 3) 3rd Crop (rice — RD 7)
Transplanting time: August 8, 1977
Fertilizer application:
N: 40 kg/ha (one half was applied for top-dressing)
P₂O₅: 25 kg/ha
Spacing: 25 cm × 25 cm (3 seedlings/hill)
Harvesting: November 15, 1977.

Result

1. Amount of fresh materials applied to soil.
The growth of sorghum was rather delayed owing to poor germination but crotalaria grew well (table 2-6 and 7). Dry weight of fresh materials applied to soil was about 40% more in crotalaria, but 30% less in sorghum as compared with those of last year.
2. Effects of application of fresh materials on maize (2nd crop)
 - 1) Rainfall during the growth period of maize (88 days) was only 80 mm in total. Irrigation was made 6 times for I₁, and 11 times for I₂ plots during the period. Uneven germination of maize brought about lower yield on the whole.
 - 2) Effects of the application was clearly observed on growth of maize. The effects of three factors, C (crotalaria or sorghum), T (mulch or incorporation) and F, on plant height were significant on 1% level.
 - 3) Yield of maize and its analysis are shown in Table 2-10 and 11. The effects of main plot (Cr-M, Cr-P, Sr-M, Sr-p and F1), I and F on maize yield were significant (Table 2-11-a). When analysis was made simplifying into four factors (C, T, I and F) by excluding 'F1 treatment' as shown in Table 2-11-b, effects of C, I, F and C × T × F were significant; effect of T was not observed significantly.
 - 4) These analytical results suggest the following:
 - (a) Sufficient irrigation and fertilizer application is essential to raise high yield of maize in paddy field of heavy clay, as often observed in the previous experiments.
 - (b) Application of fresh materials, especially those of crotalaria is effective, and mulching resulted better than incorporation. The fact is also observed by comparing maize yield of I₁ and F₁ plots of both Cr-M and F1 treatments (Fig. 2-1).
 - 5) Higher content of total nitrogen in surface soil of Cr-M plot also proves the effect of crotalaria mulch (Table 2-9).
 - 6) When maize was harvested, the residues of mulched fresh materials were still on the field. The ratio of the residues to the applied amount on dry matter basis was estimated at 44% for crotalaria and 35% for sorghum. In the plots of incorporation, only trace of sorghum residues were found in the soil.
3. Effects on rice (3rd crop):
Rice yields were not so different among all the plots (Table 2-12). Effects of I and T on rice yield were significant. That is I₂ and incorporation treatment to maize positively affected rice yield to some extent.

Table 2-6. Amount of fresh materials applied to soil

Plot	Plant height	Fresh weight	Dry weight	Dry matter %
	cm	t/ha	t/ha	
Cr—M	178.6	18.1	3.69	20.4
Cr—P	162.2	16.9	3.48	20.6
Sr—M	131.8	13.7	2.18	15.9
Sr—P	152.0	16.4	2.59	15.8

— Average of two replications

Table 2-7. Chemical analysis of fresh materials

Crop	N	P	K	Na	Ca	Mg
	%	%	%	%	%	%
Crotalaria	2.12	0.25	1.41	0.07	0.81	0.24
Sorghum	0.72	0.23	2.12	0.04	0.28	0.19

Remarks: 1) Percentage to dry matter.
2) Average of two replications.

Table 2-8. Bulk density of surface soil

Plot	Cr-M	Cr-P	Sr-M	Sr-P	Fl
Bulk density	1.12	1.14	1.14	1.20	1.10

Remarks: 1) Soil samples were taken at the depth of 5 to 10 cm from surface of ridges of I₁F₁ plot on May 27 (2 months after application of fresh materials or 1.5 months after sowing of maize).
2) Each value is average of three samples.

Table 2-9. Chemical analysis of surface soil

	Available N	Exchangeable K
	ppm	mg/100g of dry soil
Cr-M	42.5	19.2
Cr-P	22.5	13.3
Sr-M	27.0	17.3
Sr-P	29.5	15.3
Fl	20.5	15.5

Remarks: 1) Soil samples were taken from the furrows of I₂ treatment of each plot on May 26 (one and a half month after seeding.)
2) The figures are the average of F₁ and F₂ treatment.

Table 2-10. Yield and related factors of maize

Plot		Dry weight	LAI	Grain yield	No. of plant	No. of ear	No. of grain	100 Grain weight
		g/m ²		kg/ha	/m ²	/m ²	/ear	g
Cr-M	I ₁ F ₁	439	1.26	834	4.5	3.7	110	18.3
	2	451	1.50	1182	4.3	3.9	152	18.7
	2 1	490	1.75	1213	4.7	4.3	151	18.6
	2	584	2.18	1469	4.7	4.1	181	19.4
Cr-P	1 1	298	1.02	441	4.5	3.8	78	15.2
	2	422	1.82	1277	4.6	4.0	184	17.8
	2 1	283	1.21	545	4.5	3.4	93	17.3
	2	666	1.98	2186	4.6	4.3	247	20.9
Sr-M	1 1	212	0.90	385	4.2	3.3	60	15.0
	2	419	1.23	945	4.5	3.9	125	17.3
	2 1	311	1.26	456	4.6	3.8	74	16.0
	2	609	1.88	1563	4.6	4.4	182	19.4
Sr-P	1 1	171	0.89	194	4.3	2.9	42	13.3
	2	279	0.91	420	4.4	3.2	80	15.7
	2 1	193	1.03	251	4.5	3.5	49	14.8
	2	429	1.51	1165	4.3	3.6	169	18.6
Fl	1 1	225	1.15	237	4.5	3.0	52	14.7
	2	360	1.13	615	4.7	3.9	99	16.6
	2 1	343	1.04	688	4.4	3.8	107	16.8
	2	601	1.52	1918	4.6	4.5	216	19.7
Cr-M		491	1.67	1175	4.6	4.0	149	18.8
Cr-P		417	1.51	1112	4.6	3.9	151	17.8
Sr-M		388	1.31	837	4.5	3.9	110	16.9
Sr-P		268	1.09	508	4.4	3.3	85	15.6
Fl		382	1.21	865	4.6	3.8	119	17.0
I ₁		328	1.18	653	4.5	3.6	98	16.3
I ₂		451	1.54	1145	4.6	4.0	147	18.2
F ₁		297	1.15	524	4.5	3.6	82	16.0
F ₂		482	1.57	1274	4.5	4.0	164	18.4
Mean		389	1.36	899	4.5	3.8	123	17.2

Remarks: Grain yield was expressed on the basis of 13% of moisture content.

Table 2-11. Analysis of variance of maize yield

(a)	Factor	ϕ	S	V	F
	B	1	1225700	1225700	31.08**
	I	1	2424578	2424578	61.48**
	e ₁	1	39438	39438	
	T	4	2238419	559605	4.37*
	F	1	5592048	5592048	43.67**
	I × T	4	407724	101931	0.80
	I × F	1	810393	810393	6.33*
	T × F	4	981183	245296	1.92
	I × T × F	4	277026	69257	0.54
	e ₂	18	2305127	128062	

Remarks: T: Cr-M, Cr-P, Sr-M, Sr-P, Fl.
 * : Significant at 5% level. **Same at 1% level.

(b)	Factor	ϕ	S	V	F
	B	1	1089288		130.90*
	I	1	1256112		150.95*
	e ₁	1	8320		
	C	1	1775670		11.55**
	T	1	307328		2.00
	F	1	4332096		28.18**
	I × C	1	4465		0.03
	I × T	1	26680	equal to S	0.17
	I × F	1	473851		3.08
	C × T	1	143380		0.93
	C × F	1	9384		0.06
	T × F	1	226801		1.48
	I × C × T	1	6786		0.04
	I × C × F	1	34060		0.22
	I × T × F	1	134421		0.87
	C × T × F	1	721200		4.69*
	e ₂	15	2306295	153753	

Remarks: Analysis was made simplifying into four factors (C, T, I, F) by excluding Fl plot.

C : Kind of crop for fresh materials (crotalaria & sorghum)

T : Application of fresh materials (mulch & plow in)

Table 2-12 Yield and yield components of rice

		Full grain wt.	Unripened grain wt.	Straw weight	Grain Dry wt. ratio	Top
		kg/ha	kg/ha	kg/ha		kg/ha
Cr-M	I ₁ F ₁	3659	277	3856	1.03	6798
	2	3489	272	3640	1.04	6463
	2 1	3568	272	3745	1.03	6621
	2	3659	246	3856	1.02	6773
Cr-P	1 1	3620	250	3726	1.04	6630
	2	3785	277	3922	1.04	6966
	2 1	3929	299	4066	1.04	7233
	2	3829	277	3894	1.06	6978
Sr-M	1 1	3603	268	3640	1.07	6556
	2	3611	272	3745	1.04	6658
	2 1	3633	281	3693	1.06	6640
	2	3502	303	3659	1.04	6516
Sr-P	1 1	3581	299	3755	1.06	6663
	2	3620	272	3698	1.06	6623
	2 1	3737	281	3860	1.04	6873
	2	3964	321	4186	1.02	7387
fl	1 1	3481	299	3540	1.07	6389
	2	3550	321	3794	1.02	6689
	2 1	3716	286	3736	1.07	6751
	2	3728	303	3813	1.06	6845
Cr-M		3594	267	3774	1.03	6664
Cr-P		3791	276	3902	1.05	6952
Sr-M		3587	281	3684	1.05	6593
Sr-P		3725	293	3875	1.05	6887
Fl		3619	302	3721	1.06	6669
I ₁		3600	281	3732	1.05	6644
I ₂		3727	287	3851	1.04	6862
F ₁		3653	281	3762	1.05	6715
F ₂		3674	286	3821	1.04	6790
Mean		3663	284	3791	1.05	6753

Remarks: Grain yield was expressed on the basis of 14% of moisture content.

Fig.2-1. Yield of Maize

