Influence of weeds of fallow rice fields on subsequent growth of rice *

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INTRODUCTION

MOST rice fields when in fallow are covered abundantly with weeds which are incorporated into the soil in the course of land preparation for cultivation. The quantity of weed matter thus incorporated varies considerably depending on a number of factors, the more important of which are cropping pattern; climatic, edaphic, and biotic influences; and ecological characteristics of species constituting the weed population.

Application of fresh green matter to rice soils of the dry zone has been reported to be beneficial (2) and is practised in these areas to some extent, but such a practice is almost unknown in the wet-zone particularly in areas with ill-drained soils. Whether green matter is applied or not, during land preparation considerable amounts of fresh green material in the form of weed growth are incorporated into the soil and this is generally left to decompose under anarobic conditions. Planting of rice usually follows 3 to 4 weeks after, but this interval may even be shorter at times.

The ill-effects of organic manuring on rice grown under submerged, ill-drained soil conditions have been reported by many workers (3, 5, 6, 7, 8, 11). However no recognition has been made of the importance of the weed component that is incorporated into the soil, particularly in relation to harmful anaerobic decomposition products that are liberated into the soil milieu.

MATERIALS AND METHODS

Experiment I: The effects of added fresh organic matter, duration of submergence of soil before planting, and degree of soil drainage on growth of rice were studied under green-house conditions. The soils

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used were from the rice research stations at Bombuwela (humic and sandy soils), Panagoda and Pussellawa. Freshly harvested vegetative material of the weed *Isachne globosa O. Ktze* was used as the source of organic matter. The levels of added organic matter were 0 and 5 percent by weight of air dry soil. Duration of submergence before planting ranged from 0 to 3 weeks through one week intervals. Drainage treatments were no drainage and vertical drainage at the rate of 0.2 in. per day from the day of planting. The organic matter, drainage and duration of submergence treatments were combined factorially and replicated 4 times. Two replicates were used for determination of root growth while the other two were used to determine growth.

Four litre capacity glazed earthenware posts containing 3 kg air dry soil with provision for drainage in appropriate treatments were used. All posts received fertilizer at the rate of 1.5 gm each of concentrated superphosphate, sulphate of ammonia and muriate of potash per pot. Except for concentrated superphosphate which was given all at planting, the other fertilizers were applied in three equal doses at planting, tillering (2 weeks after planting), and primordium initiation (six weeks after planting). Twenty one day old seedlings of *Oryza sativa* L. var. H-4 and Murungakayan 302 were used for transplanting. Each pot was planted with one hill of 3 seedilngs per hill.

Experiment II : The effect of increasing levels of fresh organic matter on growth of *O. sativa* L. var. Murungakayan 302 was studied. The organic matter used was fresh material of *I. globosa*. The levels of added fresh organic matter ranged through 0 to 4 percent by weight of air dry soil. Twenty one day old rice seedlings were transplanted in 4 litre capacity earthenware pots each containing 3 kg (air dry) Bombuwela humic soil. Fertilizers were added to the soil in all pots as in Experiment I. Each pot was planted with one hill of 3 plants per hill. Organic matter additions were done one week before planting. Four replicates were planted of which two were sacrificed for sampling at the primordium initiation stage. From these 100ml of sold percolate were collected per pot and ferrous iron was determined by the O-phenanthroline method of Fortune and Mellon (4).

Experiment III : Soil percolates were collected from Bombuwela humic soil contained in earthware pots to which o. 5 and 10% fresh organic matter had been added three weeks before and the effects of the soluble decomposition products of fresh organic matter on production of new roots in 3 week old Murungakayan 302 seedlings were tested. Part of each of the percolates was distilled and each distillate was compared with the respective percolate at equivalent volumes in respect of the effect on root production. The distillate from the 10% organic maettr treatment was treated with $NaHCO_3$ concentrated by drying under reduced pressure and chromatographed using n-butanol and 3.0 N aqueous ammonia 50/50 VV as the solvent. A o. 04% aqueous solution of Bromothymol Blue adjusted to pH 7.5 with dilute sodium hydroxide was used for colour development of the chromatogram.

RESULTS AND DISCUSSION

Effects of added fresh organic matter, duration of submergence and drainage on root development in rice

The effect of various treatments on production of new roots within a week after transplanting in H-4 and Murungakayan 302 is shown in tables 1 and 2, respectively. Added fresh organic matter drastically reduced root production in H-4 and Mrungakayan 302 and in its presence neither drainage nor period of submergence prior to planting had any beneficial effects. In the absence of added organic matter considerably more roots were produced, but drainage had hardly any effect except in Bombuwela humic soil where in the absence of drainage root production was markedly reduced, particularly in Murungakayan 302 (Table II).

Data on tiller production in Murungakayan 302 at three stages of growth—tillering phase, primordium initiation stage and two weeeks after heading—are presented in tables 3, 4 and 5. The amount of new roots produced one week after transplanting and tiller production at the three growth stages were significantly positively correlated (Table VI).

The results of this experiment revealed the deleterious effects of freshly added organic matter on growth of rice in submerged soils.

Effects of incorporation of various levels of fresh organic matter in soil on growth of rice

Incorporation of increasing levels of fresh organic matter into Bombuwela Humic soil resulted in reduced tillering in the variety Murungakayan 302 (Table VII). In treatments receiving 3 percent fresh organic matter, tillering was considerably reduced and in the 2 percent organic matter treatment tiller production was appreciably delayed. Late tillers are invariably non-productive, and as tillers form an important component of the yield constituting factors any inflence affecting the rate of tiller production adversely will necessarily lead to a reduction in yield.

Root production was found to be reduced at levels of added organic matter of 2 per cent or more. Ferrous iron in the soil percolates was observed to increase with increase in amount of added organic matter (Table VIII).

Effects of anaerobic decomposition products of I. globosa *on root growth of rice.*

Soil percolates collected from Bombuwela Humic soil to which 0, 5 and 10 per cent fresh organic matter had been added 21 days before and left submerged were tested to determine effects on root production. With increase in amount of added organic matter root production decreased and was completely inhibited in percolates originating from the 10 per cent organic matter tratment. Distillates obtained from the respective percolates were found to have about the same ill-effects on root production as the original percolates, thus indicating that solubilised iron and other inorganic substances in the percolates were of little or no importance in retarding root production (Table IX).

The distillate obtained from the 10 per cent organic matter treatment was treated with sodium bicarbonate to convert any organic acids to their sodium salts and n-butyric acid was isolated by paper chromatography.

A number of invetigators have studied the decomposition of organic matter under anaerobic conditions. Exhaustive investigations have been carried out by Harrison and Aiyer (5, 6) on the composition of gases of swamp rice soils. The decomposition of carbohydrates in water logged soils under laboratory conditions has been studied by Subrahmanyan (10) where he noted that lactic acid was the first acid to appear but that it decomposed rapidly to form acetic and butyric acids. Acetic acid, butyric acid, Co_2 methane and small quantities of hydrogen were reported by Aachrya (1) to be the products of anaerobic decomposition of diverse plant materials inoculated with soil. This worker also noted that organic acids were produced during the first phase of decomposition and that these were subsequently decomposed. Numerous other compounds are known to be produced during anaerobic decomposition. Ammonia, carboxylic acids, amines, mercaptans and hydrogen sulphides are some of these compounds. Of these, methane is non-toxic (12) but the harmful effects of green manures on rice have been attributed to the abundant production of butyric acid under conditions of impeded drainage. Of the organic acids produced during anaerobic decomposition of organic matter, butyric acid is stated to be the most important. It is toxic to the plant and persists in the soil under ill-drained acid conditions. Sufficient evidence is now available to prove the toxicity of butyric acid and butyrates to the rice plant (8).

Besides the production of toxic organic compounds, actively decomposing organic matter has a considerable influence in lowering the redox potentials of soils. A low redox potential *per se* may not have an adverse effect on the rice plant but such a condition may influence considerably the liberation of iron and manganese into the soil solution in concentrations toxic to rice plants (9). Addition of increasing levels of organic matter had the effect of liberating large quantities of ferrous iron (Table VIII) and root production was strikingly affected with increase in added organic matter. However, comparison of root production in the distilled and undistilled percolates showed no appreciable difference, suggesting that the organic compounds liberated are of considerably greater importance in inhibiting root development than substances of inorganic nature liberated into the soil solution during anaerobic decomposition of organic matter.

Butyric acid was isolated chromatographically as one of the products of anaerobic decomposition. This compound is a known respiratory inhibitor and could adversely affect the mechanisms of selective on absorption in roots and thereby lead to a nutritionally impoverished plant resulting from a physiologically inactive root system. Tests carried out with authentic butyric acid at concentrations found in the soil solution did not have such drastic effects on root production as the soil solution. This suggests the presence of other substances liberated during anaerobic decomposition of organic matter which are possibly more toxic to root development and root activity than n-butyric acid.

Easily decomposable organic matter in soils under ill-drained conditions appears to be responsible for bringing about unfavourable conditions for rice growth. Weed growth incorporated in the soil during land preparatio nprior to cultivation constitutes an important source of easily decomposable organic matter. A considerable improvement in rice growth under ill-drained submerged soil conditions should be possible if the incorporation of weeds in an easily decomposable form could be avoided at the time of cultivation. The use of pre-plant applications of total weedkilers may have application in minimizing the deleterious effects of weeds incorporated into ill-drained soils.

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Table 1.—Effect of added fresh organic matter, drainage, and duration of soil submergence on root production in H4[1]

Soil	*Panagoda*				*Pussellawa*				*Bombuwela Humic*				*Bomubuwela Sandy*			
Duration of submergence before planting	+OM[2]2		-OM		+OM		-OM		+OM		-OM		+OM		-OM	
	+D[3]3	-D	+D	-D	+D	-D	+D	-D	+D	-D	+D	-D	+D	-D	+D	-D
0 days ..	0.1	0	9.2	3.7	4.4	0.5	18.0	7.6	0	0	6.4	4.5	0	0	5.5	5.3
7 days ..	0	0	0.1	8.2	0	0	22.4	34.7	0	0	4.3	3.4	0	0	2.3	4.2
14 days ..	0.1	0	2.5	2.2	0	0	13.6	24.7	0	0	6.3	0.6	0	0	3.8	7.6
21 days ..	3.6	0	3.3	0.8	0	0	13.2	9.7	0	0	4.6	7.9	0	1.0	3.7	12.0

(1) Values reported are mean dry weights of roots produced per hill of 3 seedlings in mg.

(2) +OM and −OM are 5 per cent fresh organic matter added to air dry soil and none added, respectively.

(3) +D and −D are drained and undrained, respectively.

Table II.—Effect of added fresh organic matter, drainage, and duration of soil submergence on root production in Murungakayan 302[1]

Soil	Panagoda				Pussellawa				Bombuwela Humic				Bombuwela Sandy			
Duration of submergence before planting	+OM[2]		—OM		+OM		—OM		+OM		—OM		+OM		—OM	
	+D[3]	—D	+D	—D	+D	—D	+D	—D	+D	—D	+D	—D	+D	—D	+D	—D
0 days ..	2.0	0	5.8	11.3	4.3	0.9	12.7	6.7	0	0	5.6	3.3	2.0	0.4	6.5	5.3
7 days ..	0	0	6.9	7.5	0	0	8.7	9.0	0	0	7.7	0.8	0.3	0	4.4	3.3
14 days ..	0.6	0.4	10.5	4.1	0.4	0.9	11.1	9.8	0	0	5.2	0.7	1.8	0	4.4	4.8
21 days ..	2.5	0	12.1	8.8	3.7	1.8	5.1	12.1	4.8	0	3.1	0.9	0	2.3	5.4	12.3

(1) Values reported are mean dry weights of roots produced per hill of 3 seedlings in mg.

(2) +OM and —OM are 5 percent fresh organic matter added to air dry soil and none added, respectively.

(3) +D and —D are drained and undrained, respectively.

Table III.—Effect of added fresh organic matter, drainage, and duration of soil submergence on the number of tillers per hill at tillering phase in Murungakayan 302[1]

Soil	*Panagoda*				*Pusse.llawa*				*Bombuwela Humic*				*Bombuwela Sandy*			
Duration of submergence before planting	+OM[2]		—OM		+OM		—OM		+OM		—OM		+OM		—OM	
	+D[3]	—D	+D	—D	—D	—D	+D	—D	+D	—D	+D	—D	+D	—D	+D	—D
0 days ..	1.5	0	13.0	11.5	5.5	2.0	7.0	6.5	1.5	0	11.0	9.5	3.0	0	13.5	10.0
7days ..	0	0	15.5	14.0	0	0	6.5	6.5	0	0	12.0	10.0	0	0	16.5	9.5
14 days ..	4.0	1.5	14.0	11.5	0	0	9.0	6.0	0	0	13.5	5.0	0.5	0	14.5	12.0
21 days ..	8.5	0	15.0	12.5	4.0	2.5	7.0	7.0	10.0	0	10.5	9.0	3.5	0.5	11.5	9.5

(1) Mean of two replicates.

(2) and (3) same same as in table I.

Table IV.—Effect of added fresh organic matter, drainage, and duration of soil submergence on the number of tillers per hill at primordium iniation stage in Murungakayan 302[1]

Soil	*Panagoda*				*pussellawa*				*Bombuwela Humic*				*Bombuwela Sandy*			
Duration of submergence before planting	+OM[2]		—OM		+OM		—OM		+OM		—OM		+OM		—OM	
	+D[3]	—D	+D	—D	+D	—D	+D	—D	+D	—D	+D	—D	+D	—D	+D	—D
0 days ..	6.5	0	20.0	19.0	13.5	1.0	11.5	10.5	6.0	0	17.5	17.0	8.5	0	19.0	17.5
7 days ..	0	0	23.0	25.0	0	0	10.0	11.0	0	0	20.0	13.5	0	0	18.0	19.5
14 days ..	7.5	7.5	22.0	23.5	0	0	10.0	11.0	0	0	21.5	9.5	0	0	16.5	21.0
21 days ..	18.5	0	21.0	23.0	8.0	4.0	13.5	10.0	22.5	0	18.0	12.5	9.0	3.5	17.5	18.0

([1]) Mean of two replicates.

([2]) and ([3]) same as in table I.

Table V.—Effect of added fresh organic matter, drainage, and duration of soil submergence on the number of tillers per hill two weeks after heading in Murungakayan 302[1]

Soil	*Panagoda*				*Pussellawa*				*Bombuwela Humic*				*Bombuwela Sandy*			
Duration of submergence before planting	+OM[2]		—OM		+OM		—OM		+OM		—OM		+OM		—OM	
	+D[3]	—D	+D	—D	+D	—D	+D	—D	+D	—D	+D	—D	+D	—D	+D	—D
0 days ..	7.5	0	14.0	14.0	13.5	1.5	9.0	11.0	4.5	0	12.0	12.0	7.0	12.5	12.5	9.5
7 days ..	0	0	13.0	17.5	0	0	9.5	11.0	0	0	11.5	8.5	0	0	11.5	7.0
14 days ..	5.0	6.0	13.5	16.5	0	0	9.0	10.5	0	0	11.5	7.0	0	0	11.0	7.5
21 days ..	12.0	0	12.0	17.0	8	4	9.5	10.0	13.5	0	11.0	7.0	8.0	4	10.0	8.5

([1]) Mean of two replicates.

([2]) and ([3]) same as in table I.

TABLE VI.—Correlation between dry weight of roots produced one week after transplanting and tiller production at different growth stages in Murungakayan 302

Growth Stage / *Soil Type*	*Tillering phase*	*Primordium Initiation stage*	*Two weeks after heading*
Panagoda	0·899 xxx	0.839 xxx	0·805 xxx
Pussellawa ..	0·883 xxx	0·765 xxx	0·763 xxx
Bombuwela Humic ..	0·833 xxx	0·863 xxx	0·839 xxx
Bombuwela Sandy ..	0·685 xx	0·741 xx	0·661 xx

xx, xxx Significant at 1 % and 0.1 % level of probability, respectively.

TABLE VII.—Effect of different levels of added organic matter on tiller production in Murungakayan 302[1]

Added organic matter (%)	*Tillers produced per hill*		
	Three weeks after planting	*Five weeks after planting*	*Six weeks after planting (P.I. stage)*
0·0	5·5	11·0	11·0
0·5	3·5	10·0	10·0
1·0	4·5	11·0	11·0
2·0	3·0	8·0	12·0
3·0	3·5	7·0	9·0

[1] Mean of two replicates.

TABLE VIII—Effect of different levels of added organic matter on root production in Murungakayan 302 and ferrous iron content in soil solution

Added organic matter (%)	*Six weeks after planting (P.I. stage)*	
	Dry weight of roots (mg/hill)	*Ferrous iron in soil solution (ppm)*
0·0	75·2	185
0·5	88·6	270
1·0	86·8	370
2·0	62·4	480
3·0	47·7	555
4·0	39·5	540

TABLE IX.—Comparison of the effects of soil percolates and distilled percolates from different organic matter levels on root production in Murungakayan 302

Added organic matter (%)	*Dry weight of roots in mg*	
	Soil percolate	*Distilled soil percolate*
0·0	8·7	8·2
5·0	3·6	3·4
10·0	0·0	0·0