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Effect of bio-mulches on soil nutrient availability and microbial population in summer rice

S. B. Goswami* and S. K. Das

All India Co-ordinated Research Project on Water Management, Bidhan Chandra Krishi Viswavidyalaya, Gayespu, West Bengal-741234, India

ABSTRACT

A field experiment was carried out on summer rice (Oryza sativa L) during 2003 and 2004 using different organic mulches – Azolla, rice chaffy grain, saw dust, subabool (Leucaena leucocephala L.) green leaves and FYM under rotational submergence at 5 days after disappearance of ponded water against continuous submergence. The results revealed that rotational submergence reduced the uptake of N, P_2O_5 and K_2O by 40.2, 49.3 and 33.1% respectively as compared to continuous submergence. However, application of organic mulches in rotational submergence improved the uptake of nitrogen (11.1 - 51.9%), phosphorus (12.7% - 67.6%) and potassium (9.3 - 39.1%) compared to without mulching condition. Among the organic mulches, rice chaffy grain recorded maximum uptake of N and K and FYM recorded maximum uptake of P_2O_5. Rotational submergence (cyclic stress) reduced the nutrient availability to the extent of 23.8, 17.2 and 2.0% of N, P_2O_5 and K_2O respectively. Organic mulches under rotational submergence significantly improved the nutrient availability to the extent of nitrogen 33.8 - 59.7%, phosphate 28.2 - 61.8% and potash 1.65 - 9.1% and it was even higher than continuous submergence. Soil water stress reduced the oxidisable soil organic carbon status by 5.13% as compared to continuous submergence, whereas, mulching improved the carbon status by 9.5% to 18.2% and increased the grain yield by 20.5-50.7%. Water supply situation and organic mulches significantly influenced microbial population. Among the mulches saw-dust and FYM increased the microbial population by 37-192% over stress control.

Key words: *Rice organic mulches, rotational stress, nutrient availability, microbial population*

The use of organic mulches in summer rice under soil water stress is a new dimension of water saving, soil physical, chemical and microbial health improvement. Soil microbial population acts as a sink for nutrients including N and can be used as an index of soil fertility. As the soil harbours a dynamic population of microorganisms, their abundance in nature gives an indication of their possible role in decomposition of organic matter, phosphate solubilization, transformation of nitrogen and humification of organic materials. Organic mulching have been reported to increase the microbial population and there by improves the soil fertility as reported by Black and Miller (1998). Baverly *et al*. (2000) reported higher P content of soil due to chopped maize straw and grass mulch application. Medcalf (1956) reported increased availability of K and P content of soil due to mulching. Tindall *et al*. (1991) reported significant increase of organic matter content of soil (2.26 %) after two years due to straw mulching @ 2.6 Mg ha^{-1} over bare soil condition (0.99 %). Sekour *et al*. (1987) also reported similarly. Keeping the above research findings in view the objective of the present investigation was to study the impact of various locally available organic mulches on nutrient availability and microbial population of soil in summer rice under limited water supply situation.

MATERIALS AND METHODS

Field experiments were carried out during January to May 2004 at the experimental farm of the Regional Research Station, Gayespur for New Alluvial Zone of Bidhan Chandra Krishi Viswavidyalaya. The soil was sandy clay loam (5.13% coarse sand, 43.82% fine sand, 26.1% silt and 24.95% clay), mixed hyperthermic family of typic ustochrept with surface (0-0.15 m), bulk density value 1.46 Mg m^{-3} and percolation rate 10.6 mm day^{-1}. The major chemical properties of the soil were pH 6.9, organic carbon 0.78%; available nitrogen, P_2O_5 and K_2O were 0.058%, 16.06 kg ha^{-1} and 128.05 kg ha^{-1} respectively. There were two irrigation scheduling viz. continuous submergence, (CS) T_1 and rotational submergence, (RS) at 5 days after disappearance of ponded water. Five types of bio-mulches namely *Azolla, AZ* (T_3) @ 1 Mg ha^{-1}, Rice chaffy grain, (RC) @ 2.5 Mg ha^{-1}, Saw dust, (SD) @ 2.5 Mg ha^{-1}, Subabool green leaf, (GL) @ 2.5 Mg ha^{-1}, and FYM @ 5 Mg ha^{-1} were applied under rotational submergence (RS) at 15 days after transplanting. The quantity of bio-mulches applied was fixed on the N-equivalent basis and these were broadcast over the zero standing water in the plot. Irrigation scheduling was started from 15 days after transplanting. Under continuous submergence 5 cm depth of water was maintained but for rotational submergence the depth of irrigation was 5 cm. The treatments were arranged in randomized block design with three replications in 5m x 6m plots. The crop received NPK fertilizers @ 120, 60 and 60 kg ha^{-1} respectively. Twenty five percent of total N, total P and total K were applied at transplanting. Fifty percent of total N was top dressed at 20 days after transplanting (DAT)) and rest twenty five percent of total N was top dressed at 42 DAT at panicle initiation stage. Rice variety 'Shatabdi' (IET 4786) was taken as a test crop. Rice seedlings of 35 days were transplanted at a spacing of 15 cm x 15 cm during 1st week of February every year. Under continuous submergence, number of irrigations was 24 and 33 and under rotational submergence it was 11 and 14 during 2003 and 2004 respectively. Crop was harvested at 94 days during both the cropping seasons and yield was recorded from net plot harvest.

The N, P and K content of grain and straw of rice were determined by modified micro-Kjeldahl, colorimetrically after acid digestion and by flame photometer after tri acid digestion methods (Piper, 1942) respectively. The total N, available P and K, oxidizable organic carbon content of soil were determined by modified macro-Kjeldahl, Olsen's, flame photometer and Walkley and Black methods (Jackson 1967) respectively. For counting microbial population, the rhizosphere soil samples were stored in a refrigerator and microbial count was done following Baruah and Bartthakur (1997). The data were subjected to statistical analysis to ascertain significant differences among the treatments.

RESULTS AND DISCUSSION

Soil nutrient availability was significantly influenced by water availability and organic mulches (Table 1). Rotational submergence reduced the nutrient availability to the extent of 23.8, 17.2 and 2.0% nitrogen, phosphate and potassium respectively. However, organic mulches under rotational submergence largely improved the nutrient availability to the extent of nitrogen 33.8 - 59.7%, phosphate 28.2 - 61.8% and potash 1.65 - 9.1% and it was even higher than continuous ponding. The highest total N content was recorded with FYM followed by RC, SD and AZ though they were statistically at par.

The highest available P_2O_5 (20.52 kg ha^{-1}) was recorded with RC, which was closely followed by FYM, SD, AZ and GL. Similar trend was observed in case of available K_2O (kg ha^{-1}). Oxidizable soil organic carbon (SOC) status was very much influenced by water supply and mulching. Water stress (RS) reduced

Table 1. Soil nutrient availability as influenced by different organic mulches under limited water supply condition

Treatment	SOC(%)	Total N (%)	Available P(kg ha^{-1})	Available K(kg ha^{-1})
CS	0.78	0.051	15.32	128.81
RS	0.74	0.039	12.68	126.17
RS + AZ	0.84	0.059	16.30	128.26
RS + RC	0.87	0.061	20.52	137.65
RS + SD	0.82	0.060	16.59	133.95
RS + GL	0.81	0.052	16.26	129.04
RS + FYM	0.88	0.062	16.99	135.64
CD (P=0.05)	0.04	0.004	1.11	0.99
Initial	0.79	0.058	16.11	128.55

the SOC status by 5.1% as compared to continuous submergence (CS), whereas, mulching had an additive effect in maintaining higher soil OC status by 9.45% - 18.24% due to high rates of carbon mineralization immediately following addition of mulches (Sridevi *et al*. 2003). The highest SOC content (0.88%) was recorded under FYM mulching followed by rice chaffy grain mulching (0.87%). Mulching increased the soil C and soil N in post harvest soil (Mandal and Ghosh 1984 and Sodaniappan *et al.* 1999). Similarly, organic mulching increased the available K, P and organic matter content of soil after it's decomposition as reported by Ghorai (2004). The association of oxidisable SOC with total N, available P and K revealed (Fig 1) that relationship was much stronger with N (R^2 = 0.8675*) followed by P (R^2 = 0.7153) and K (R^2 = 0.6678).

Water supply situation and organic mulches significantly influenced nutrient uptake in rice crop. The highest uptake of N, P_2O_5 and K_2O (120.5 kg N ha^{-1}, 27.4 kg P_2O_5 ha^{-1} and 114.6 kg K_2O ha^{-1}) were recorded under continuous submergence condition, which was the resultant of higher grain yield (Table 2). Rotational submergence at 5 DADPW without mulching reduced the uptake of N, P_2O_5 and K_2O by 40.2, 49.3 and 33.1% respectively. However, application of organic mulches at 15 DAT improved the uptake of nitrogen (11.1 - 51.9%), phosphorus (12.7 - 67.6%) and potassium (9.3 - 39.1%) compared to rotational submergence without mulching condition. Among the organic mulches

Table 2. Mean nutrient uptake and yield of summer rice as influenced by different organic mulches under limited water supply condition (pooled)

Treatment	Nutrient uptake (kg ha^{-1})			Grain yield (t ha^{-1})	Soil N-use (kg kg N^{-1})
	N	P	K		
CS	120.5	27.4	114.6	5.21	43.2
RS	72.1	14.2	76.7	3.17	43.9
RS + AZ	86.6	19.3	87.1	4.14	47.8
RS + RC	109.5	23.8	106.7	4.88	44.5
RS + SD	107.3	22.7	102.5	4.84	45.1
RS + GL	80.1	16.0	83.8	3.80	47.4
RS + FYM	107.3	24.1	104.2	4.77	44.4
CD(P=0.05)	3.5	1.1	5.3	0.20	0.54

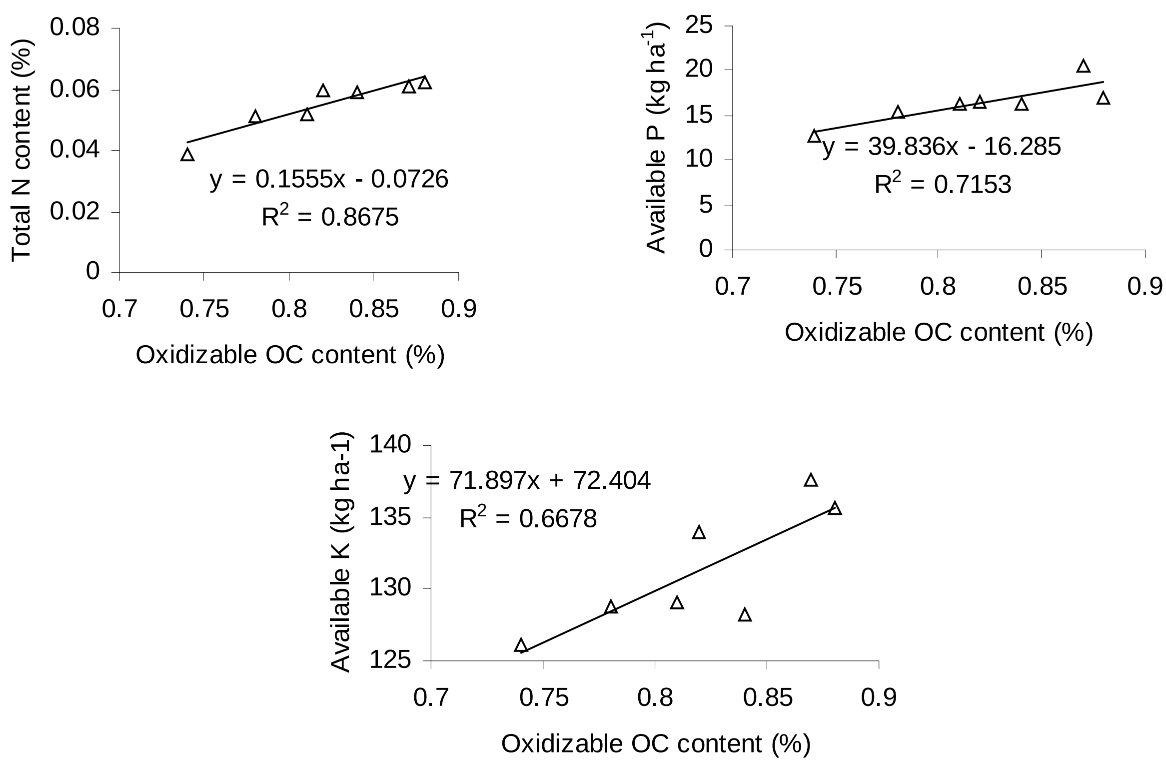

Fig. 1. Total nitrogen and release pattern of available P and K as influenced by SOC under varying water supply situation

maximum uptake of N and K were recorded under rice chaffy grain mulch and maximum uptake of P_2O_5 was recorded under FYM mulch, however the organic mulches like rice chaffs, FYM and saw-dust were found more or less equally effective and were statistically at par. Similar observation was also reported by Kalita and Sarmah (1992). Kumar *et al*. (2005) also reported that grass mulch and black polythene mulch favoured the nutrient uptake by strawberry due to a favourable soil environment.

The highest grain yield (5.21 t ha^{-1}) of summer rice was obtained with maintaining continuous submergence situation, whereas, rotational submergence at 5 DADPW decreased the yield by 37.8 to 40.4%. However, use of bio-mulches under rotational submergence restricted yield reduction by 6.3 to 25.1 and 6.2 to 29.1% over two years of study. The soil N-use efficiency was significantly increased up to 8.9% with the use of mulches in rotation submergence. The highest N-use rate was noted in *Azolla* (47.8 kg kg N^{-1}) followed by subabool green leaf mulch might faster mineralization as compared to sawdust and rice chaffs. The N-use rate was at lower scale in rotational submergence as well as in continuous submergence. Microbial population was significantly influenced by water supply situation and organic mulches (Table 3). The total microbial population increased with intermittent irrigation (rotational submergence) and mulch application. Among the mulches saw-dust and FYM increased the microbial population by 37-192% over

Table 3. Mean microbial population in rhizosphere of summer rice as influenced by different organic mulches under rotational stress.

Treatment	Microbial population			
	B	F	TMP	*Azotobacter*
CS	10.0	14.8	24.8	—
RS	40.3	9.7	50.0	—
RS + AZ	41.2	7.6	48.8	13.7
RS + RC	50.3	17.4	67.7	68.7
RS + SD	126.3	13.7	140.0	110.3
RS + GL	58.7	12.1	70.8	9.3
RS + FYM	113.3	16.7	130.0	21.2
CD(P=0.05)	16.8	6.9	19.7	38.6

B: Bacteria; F: Fungi ; TMP: Total Microbial Population (B- x $10^6 g^{-1}$ soil; F- x $10^6 g^{-1}$ soil ; *Azotobacter*- x $10^4 g^{-1}$ soil)

stress control. Jain *et al*.(2003) also reported that application of FYM helped in maintaining the soil biological health. Under continuous submergence the bacterial population was found very scanty (10 x 10^6 g^{-1} soil) and fungi that were observed mostly saprophytic in nature. Under rotational stress with out mulching condition the overall total population was not very high but bacterial population was dominating over fungal population. Among the fungal colonies *Trichoderma viridi* was observed which formed inhibitory zone. *Azolla* supported good growth of bacteria mostly *Bacillus* types which might be due to *Azolla* fixing atmospheric nitrogen that raised the population of N – eating bacteria and also few colonies of *Azotobacter* were also noticed. Application of rice chaffy grain as organic mulch registered a good number of bacterial (50.3 x 10^6 g^{-1} soil) colonies of which *Bacillus* and *Pseudomonas* were dominant as well as fungal (17.4 x 10^6 g^{-1} soil) colonies of which maximum were *Penicillium* and *Aspergillus.* The highest total microbial population was found with sawdust mulching (140 x 10^6 g^{-1} soil) which also recorded the presence of maximum population of *Azotobacter* (110.3 x 10^4 g^{-1} soil) and it was significantly higher than all other treatments, might be due to increased porosity and aeration and it also acted as a good source of organic matter. Black and Miller (1998) opined similarly. Subabool green leaf mulch enhanced the population of fast growing saprophytic bacteria of which saprophytic sterile hyphae were more. FYM mulch recorded significantly higher number of bacterial and fungal colonies. Among the fungi *Penicillium, Aspergillus,* and *Gliocladium* sp. were dominant. Thus, it was evident that application of organic mulches particularly saw dust, FYM, and rice chaffy grain raised the microbial population significantly over continuous submergence and rotational stress with out mulching. Organic mulching significantly raised the microbial population of soil due to maintenance of favourable hydro-physical environment for their growth (Prasad *et al*. 2000). The increased microbial population due to organic mulching resulted into increase in the fertility status of the soil. The highest available P_2O_5 (20.52 kg ha^{-1}) content was recorded with rice chaffy grain mulch which might be the resultant of highest number of fungal colonies (17.4 x 10^6 g^{-1} soil) of which mostly were *Penicillium* and *Aspergillus* and good number of *Bacillus* and *Pseudomonas* colonies which were phosphate solubilizing micro organisms.

The present investigation indicated that rotational submergence in puddle rice soil of summer rice reduced the nutrient availability and uptake from 33.1 to 49.3% as compared to continuous submergence. However, application of organic mulches under rotational submergence improved the uptake of nitrogen (11.1 - 51.9%), phosphorus (12.7% - 67.6%) and potassium (9.3 - 39.1%) compared to without mulching condition. Among the organic mulches, rice chaffy grain recorded maximum uptake of N and K, whereas, FYM recorded maximum uptake of P_2O_5. Soil water stress reduced the organic carbon (SOC) status as compared to continuous submergence, whereas, mulching improved soil organic carbon status. Organic mulches significantly raised the microbial population of the rice soil. Performances of organic mulches in maintaining soil health were in the order of rice chaffy grain > FYM > saw dust >*Azolla* > Subabool green leaves.

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