environments except for plant height at E1 (Table 1). Superior performance of hybrids at environment E2 was observed for all the characters followed by E5 compared to other environments. The hybrids SI 861 x BS 6-1-1, IS 200 x IS 305 and SI 861 x SI 2257 recorded significantly superior seed yield (921 kg ha^{-1}, 909 kg ha^{-1} and 907 kg ha^{-1} respectively) in the pooled analysis than the general mean (747 kg ha^{-1}) (Table 3). The hybrid SI 2257 x SO 573 (852 kg ha^{-1}) closely followed these hybrids for seed yield. Hybrids SI 2257 x SO 573 and IS 200 x IS 305 combined significantly superior number of capsules per plant than the general mean over locations. The hybrid IS 200 x IS 305 combined superior number of branches per plant than general mean over locations and also at four locations. Considering the location wise performance, the hybrid IS 200 x IS 305 recorded significant superior seed yield at three locations and SI 861 x BS 6-1-1 and SI 2257 x SO 573 recorded superior seed yield at two locations. The hybrids SI 2257 x SO 573 and IS 200 x IS 305 recorded superior number of capsules per plant at three locations.

All the hybrids recorded significant standard heterosis for seed yield confirming their superiority as hybrid variety at all locations individually and pooled over all locations. Among the hybrids, SI 861 x BS 6-1-1 (78.8 %), IS 200 x IS 305 (76.5 %), SI 861 x SI 2257 (76.1%) and SI 2257 x SO 573 (65.4 %) registered maximum standard heterosis (pooled over all locations) for seed yield (Table 3). Observing the performance at individual location, hybrids SI 2257 x SO 573 and IS 200 and IS 305 combined significant standard heterosis for number of capsules per plant at all locations individually and also pooled over all locations. Hybrids SI 861 x BS 6-1-1, SI 2257 x SO 573 and IS 200 x IS 305 recorded significant standard heterosis for number of branches per plant individually at four locations and pooled over all locations. With regard to plant height and oil content, it was observed that all the hybrids failed to show such contrasting improvement over the local cultivar. Hence to conclude, the hybrids SI 861 x BS 6-1-1, SI 2257 x SO 573 and IS 200 x IS 305 may be recommended for commercial cultivation because of its high yielding in all the locations.

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Residual effects of inorganic and organic manuring on certain soil properties and yields of rice crop

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Abstract : In a Permanent Manurial Experiment (PME) conducted since 1975, pH has decreased from neutral to slightly acidic in the manured treatments. The organic carbon and cation exchange capacity have increased significantly in the manured treatments and in the treatments that received N with or without P and K. Grain, straw and total dry matter yield of rice crop in NPK, NP, NK and N treatments were on par and higher than the yields in the treatments without N. *(Key words: PME, Rice, Soil properties, Yield).*

The fertility problem cannot be solved merely by supply of plant food elements but their efficient management also has to be given a due thought. The complex problem of soil fertility management can only be studied by long-term field trials as it takes time for the crops, crop rotation, fertilizers and manures to have a measurable effect on soil fertility. Long-term field experiments can be used for precise monitoring of changes in soil properties and soil productivity.

Effects of long-term application of single nutrient and nutrient combinations with and without organic manures on soil fertility have been evaluated under the Permanent Manurial Experiment being conducted in Madurai, Tamil Nadu since 1975 and the most significant findings in respect of some important soil fertility parameters like soil reaction (pH), EC, soil organic carbon content, cation exchange capacity and crop yields are discussed in this paper.

Materials and Methods

Two field experiments were conducted in the existing long-term manurial experiment plot during *rabi* '97-'98 and *kharif* '98-99 with ADT 36 rice crop. The treatment structure consisted of eight treatments T_1 - Control, T_2 - N alone, T_3 - P alone, T_4 - K alone, T_5 - N+P, T_6 N+K, T_7 - P+K, T_8 - N+P+K replicated two times in split plot design. The organic manures *viz.*, Farm Yard Manure (FYM), Green Leaf Manure (GLM) and Urban Compost (UC) were applied at the rate of 12.5 t ha^{-1} and N, P and K were applied at the rates of 120, 60 and 60 kg ha^{-1} in the form of urea, superphosphate and muriate of potash respectively. The entire dose of P was applied basally and N and K were applied in three equal splits. Both crops were grown to maturity, harvested and the grain and straw yields were recorded. Preplanting and postharvest soil samples were drawn for analysis and the properties like pH, EC, cation exchange capacity and organic carbon content were determined following standard procedures.

Results and Discussion

Soil reaction

Soil reaction ranged between 6.6 in FYM treatment and 7.2 in unmanured control (Table 1). Soil reaction was lower in the treatments that received manures. This may be attributed to the release of organic acids from manures which inturn would have reduced the pH by releasing hydrogen ions. Soil reaction did not vary significantly due to NPK treatments and was the same at the preplanting and postharvest stages of rabi '97 and at the postharvest stage of *kharif* '98. Similar results were reported by Dekamedhi and De Datta (1995) who attributed lower pH in manurial treatments to the Co 2 and organic acids production by the organic manures during their decomposition.

Soil salinity

Soil salinity has not changed significantly due to different manure-fertilizer schedules and was almost the same at the preplanting and postharvest stages of rabi '97 and at the kharif '98 postharvest stage. Similar result was reported by Subramanian and Kumaraswamy (1989) who stated that the different treatments *viz.*, organic manures and inorganic fertilizers tried at the recommend levels in the long term experiment under garden land cultivation at Coimbatore had no significant effect on the electrical conductivity.

Cation exchange capacity

The CEC was significantly higher in the treatments that received manures (FYM-28.3, GLM-27.2 & UC-25.7 cmol (P+) kg^{-1}) and this may be attributed to the higher CEC of the humus in these treatments as evidenced by the higher organic carbon content. Similar findings were reported by Sanchez (1976) and Drake and Motto (1982). Among the NPK treatments CEC was higher in the treatments that received N with or without P and K. This may be attributed to the higher crop residues in the form of roots that would have been left in these treatments. Similar results were reported by Udayasoorian (1983) and Leinweber *et al.* (1993). The CEC has increased from 25.1 cmol (P+) kg^{-1} at the kharif'98 stage. This may also be attributed to the organic manures applied and more crop residues left in the soil.

Organic carbon

Organic carbon content was higher in the treatments that received manures(FYM-1.27, GLM-1.06 & UC-1.33%) than in unmanured control (0.75%). This may be attributed to the contribution of organic matter through humus formation. Patnaik *et al.* (1989) also reported a build-up of organic carbon in the Long Term Field Experiment (LTFE) at Bhubaneswar and Hyderabad where rice-rice crop sequence was followed.

Table 1. The basic properties of the soil as influenced by manure . fertilizer schedules - Pooled averages of 3 cropping seasons

Treatments	pH	EC (dSm^{-1})	CEC (cmol (p+) kg^{-1})	OC(%)
Main (Manures)				
M_1 - Control	7.2	0.27	24.3	0.75
M_2 - FYM	6.6	0.29	28.3	1.27
M_3 - GLM	6.8	0.30	27.2	1.06
M_4 - UC	7.0	0.31	25.7	1.33
SE_d	0.047	0.130	0.361	0.025
CD (P = 0.05)	0.2	0.04	1.2	0.08
Sub (NPK)				
F_1 - Control	6.9	0.27	23.6	0.96
F_2 - N	6.7	0.27	26.7	1.17
F_3 - p	6.8	0.30	25.7	1.06
F_4 - K	6.9	0.28	24.8	0.97
F_5 - NP	6.9	0.26	27.4	1.11
F_6 - NK	6.9	0.32	27.3	1.19
F_7 - PK	6.9	0.28	26.9	1.10
F_8 - NPK	6.9	0.33	28.6	1.26
SE_d	0.078	0.015	0.420	0.048
CD (P = 0.05)	NS	0.03	0.9	0.10
Stages				
S_1 - PP '97	6.9	0.25	25.1	1.08
S_2 - PH '97	6.9	0.33	26.6	1.03
S_3 - PH '98	6.9	0.29	27.4	1.20
SE_d	0.047	0.13	0.236	0.280
CD (P = 0.05)	NS	0.03	0.5	0.06

PP - Preplanting stage; PH - Postharvest stage

Among the fertilizer treatments, organic carbon content was higher in the treatments that received N with or without P and K due to higher crop residues left in these treatments. Udayasoorian *et al.* (1988) reported that application of NPK recorded the highest level of organic matter content compared to control and this was followed by N alone, NK and NP combinations. The organic carbon had slightly increased from 1.08% at the rabi '97 preplanting stage to 1.20% at the kharif '98 post-harvest stage. Singh *et al.* (1982) also reported a 0.92% increase in organic carbon content in soil in 8 years in Pusa farm due to long-term cultivation of sugarcane and rice. According to him the increase in organic carbon content may be attributed to continuous flooding of soil and added crop residues by rice and weeds, which are not so rapidly oxidized under water-logged conditions.

Yields of rice crop

Grain yield

The results showed that among the manurial treatments, significantly higher yields were recorded in the treatments that received one of the manures than in the unmanured control (Table 2). The higher grain yields in the treatments receiving organic manures may be attributed to the overall

Table 2. Rice yields as influenced by manure-fertilizer schedules. Pooled averages of two crops (t ha^{-1})

Treatments	Grain yield	Straw yield	Total dry matter yield
Main (Manures)			
M1 - Control	4.2	8.0	12.2
M2 - FYM	5.4	10.7	16.1
M3 - GLM	5.1	9.1	14.2
M4 - UC	4.9	9.8	14.7
SE_d	0.060	0.314	0.172
CD (P = 0.05)	0.2	1.0	0.5
Sub (NPK)			
F1 - Control	3.9	7.0	10.9
F2 - N	6.0	10.6	16.6
F3 - P	4.3	7.6	11.9
F4 - K	4.1	7.7	11.8
F5 - NP	5.7	11.8	17.5
F6 - NK	5.5	11.3	16.8
F7 - PK	4.1	7.3	11.4
F8 - NPK	6.1	12.4	18.5
SE_d	0.173	0.444	0.522
CD (P = 0.05)	0.4	0.9	1.1
Stages			
S1 Rabi '97	4.9	9.3	14.2
S2 - Kharif '98	4.9	9.6	14.5
SE_d	0.115	0.308	0.310
CD (P = 0.05)	NS	NS	NS

positive influences of the manures on the properties and fertility status of the soil. Mahimairaja *et al.* (1986) reported that the yield in the organic manure alone treatment was on par with the yield in the NPK treatment. Similar results were reported by Panda and Sahoo (1989) who observed the direct, residual and cumulative effects of 15t FYM/ha to be significant in lateritic soil in the rice-rice cropping system. The results from the experiments at the Broad balk field (Rothamsted) continuing for more than 150 years have also shown the significant positive effects of FYM on crop growth (Nambiar, 1994).

Among the fertilizer schedules the grain yield ranged from 3.9 t ha^{-1} in control to 6.1 t ha^{-1} in NPK treatment. The yields recorded in N alone, NK and NP treatments were on par with the yield in NPK treatment. The grain yields in the treatment receiving either P or K or both without N were almost on par with the grain yield in the control showing that the response of the crop to P and K without sufficient N was not appreciable. The results showing that the grain yields in the treatments receiving NPK and N alone were on par, indicates that there is a possibility to effect a saving in the inputs of P and K in soils with sufficient status of these nutrients without reduction in the rice grain yield.

Straw yield

The straw yield ranged between 8.0 t ha^{-1} in control and 10.7 t ha^{-1} in the FYM treatment among the manurial treatments and among the fertilizer schedules it ranged from 7.0 t ha^{-1} in control to 12.4 t ha^{-1} in NPK treatment. The results on the rice straw yield reflected similar trends as in the grain yield.

Straw yield was significantly higher in the treatments receiving one of the manures and N irrespective of the application of P and K. Significantly lower yields were recorded in treatments without N due to poor vegetative growth in the absence of N. Balagopalan *et al.* (1994) reported that straw yields increased with increasing levels of applications of glyricidia leaves, which he attributed to the overall improvement in soil properties such as water and nutrient retention.

Total dry matter yield

Total dry matter yields in the treatments that received either FYM, UC or GLM were significantly higher than the total dry matter yield in the unmanured control. Similar results were reported by Parihar *et al.* (1996) who stated that the rice yield was the highest with FYM application followed by green manuring. Among the fertilizer treatments total dry matter yield was significantly higher in the treatments that received N irrespective of the application of P and K. These results show the significant positive influence of organic manures and N on the growth and yields of the crops. The non-significant response of the rice crop to P and K may be attributed to the sufficient build-up of these nutrients in the soil due to the regular application of manures and respective fertilizers over the years and high residual effect of P and K.

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