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The productivity and residual soil fertility status under different of rice based cropping systems in scarce rain fall zone of Andhra Pradesh, India

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ABSTRACT
A field experiment was conducted on sandy loam soils of Reddipalli, Anantapur district during 2000-2002 to evaluate the productivity and residual soil fertility status in different cropping systems in undisturbed layout in the farm. The rice equivalent yield was highest with greengram-rice-rice during first year and greengram-rice-groundnut during second year of study. Soil organic carbon, soil available phosphorus, soil available potassium were found increased by the end of two years of experimentation compared to initial status. The highest soil available nitrogen balance was recorded with greengram-rice-groundnut after first year and fallow-rice-groundnut after second year. Negative soil available nitrogen balance was registered with sesame-rice-sunflower system, during both the years of study. Phosphorus buildup in soil was observed with sunhemp-rice-rice and the lowest balanced was recorded with sesame-rice-sunflower system, during first year and with fallow-rice-fallow system during second year of study. The negative balance of soil available phosphorus was registered with fallow-rice-sunflower, sesame-rice-sunflower, sesame-rice-groundnut and fallow-rice-groundnut systems at the end of first year while phosphorus balance was positive with all the cropping systems tried at the end of second year. The highest positive balance of soil available potassium, was noticed with sunhemp-rice-rice during both the years of investigation.

Key words : Residual soil fertility, Cropping system, Soil nutrient, Nutrient balance.

INTRODUCITON

Nutrient depletion studies restricted to individual crops. The high yielding varieties grown in multiple crops sequences with recommended package of practices remove considerable amount of nutrients from soil and thus information is needed to understand the mining of soil nutrients and to work out the nutrient balance over a period of time. An effort was made to workout balance sheet of N, P and K of different cropping systems.

MATERIALS AND METHODS

Field experiments were conducted during 2000-02 at Agricultural Research Station, Reddipalli, Anantapur district; Andhra Pradesh to develop a sustainable cropping system for Tunga Bhadra Project high level canal irrigated areas of Scarce Rainfall zone of Andhra Pradesh. The experiment was laid out in randomized block design, replicated thrice with twelve cropping system. The cropping systems tried were Fallow - Rice – Fallow, Sunhemp - Rice – Fallow, Sunhemp - Rice –Rice, Fallow - Rice – Rice, Fallow - Rice – Groundnut, Fallow - Rice - Sunflower, Sesame - Rice – Rice, Sesame - Rice – Groundnut, Sesame - Rice – Sunflower, Greengram – Rice – Rice, Greengram - Rice – Groundnut, Greengram - Rice - Sunflower. Sunhemp, greengram , sesame crops during *prekharif*, rice during *kharif* and groundnut rice and sunflower during *rabi* were tested. All the crops were given recommended dose of fertilizers. Soil samples were drawn from 0-30 cm depth in each treatment prior to experimentation and after harvest of each crop in the cropping systems. Nutrient balance in the cropping systems for available N, $P_2 0_5$ and K_2O in soil was computed for different cropping systems as per the procedure suggested by Sadanandan and Mahapatra (1973 a), Sadanandan and Mahapatra (1973b) Yadav(1981) and Sandanandan Mahapatra (1974).

RESULTS AND DISCUSSION

Cropping systems productivity

The rice equivalent yield in cropping system having 300% cropping intensity was more than two crops in a year. The rice equivalent yield was the highest with Greengram – Rice – Rice system which was comparable both Sesame – Rice - Rice and Greengram - Rice – Groundnut systems during first year and Greengram - Rice – Groundnut during second year of study. The lowest rice equivalent yield was recorded with single cropped rice during both the years of study (Table. 1). The improvement in Greengram – Rice – Rice or Greengram - Rice – Groundnut or Sesame – Rice - Rice system can be attributed to substantial increase in the economic yield of all the three component crops in cropping system. The

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Table 1:Rice equivalent yield (kg ha^{-1}) of different cropping systems

Cropping system	Rice equivalent yield	
	2000	2001
F – R – F	4599	5547
Sh – R – F	5170	6477
Sh – R – R	10274	11676
F – R – R	9472	11146
F – R – G	8932	10373
F – R – Sf	6900	8298
Se – R – R	10850	12690
Se – R – G	10251	11942
Se – R – Sf	8298	9531
Gg – R – R	11192	13426
Gg – R – G	10790	12776
Gg – R – Sf	8844	10628
SE.m±	224	260
CD 5%	650	730

F-fallow ; Sh-sunhemp ; Se-sesame ; Gg-greengram ; R-rice ;G-groundnut ;and Sf-sunflower

Table 2 : Organic carbon (%) in soil as influenced by different cropping systems

Cropping system	Organic carbon (%)	
	After first year cropping cycle	After second year cropping cycle
F – R – F	0.38	0.46
Sh – R – F	0.51	0.58
Sh – R – R	0.52	0.70
F – R – R	0.40	0.58
F – R – G	0.46	0.60
F – R – Sf	0.39	0.53
Se – R – R	0.43	0.62
Se – R – G	0.45	0.58
Se – R – Sf	0.39	0.55
Gg – R – R	0.49	0.67
Gg – R – G	0.48	0.63
Gg – R – Sf	0.48	0.62
SE.m±	0.02	0.01
CD 5%	0.06	0.04

The initial value of organic carbon was 0.25%.
F-fallow ; Sh-sunhemp ; Se-sesame ; Gg-greengram ; R-rice ;G-groundnut ;and Sf-sunflower

findings are in concurrence with results of Kumar and Reddy (1991) and Sharanappa (1992).

Soil organic carbon

The initial organic carbon of the experimental field was 0.25%. The highest organic carbon content (0.52%) was recorded in cropping system of Sunhemp – Rice- Rice, which was comparable with that of Sunhemp - Rice – Fallow, Greengram - Rice – Rice, Greengram – Rice- Groundnut, Greengram - Rice - Sunflower and Fallow – Rice – Groundnut systems. The highest organic carbon content of 0.7% was recorded with Sunhemp – Rice- Rice systems, which was comparable with Greengram - Rice – Rice system (0.67%). The lowest soil organic carbon was registered with single crop of rice during both of years of study. Soil organic carbon was found improved, when compared to initial status with all cropping systems tried (Table 2).

This might be due to incorporation of sunhemp greenmanure and greengram haulms and also addition of roots, stubbles and leaf fall during crop growth period. The present findings are in agreement with those of Dhiman *et al* (2000) and Hemalatha *et al*. (2000).

Soil available Nitrogen

Post harvest soil available nitrogen due to different rice based cropping systems varied, with the highest value being recorded with Greengram – Rice – Groundnut system which was significantly superior to all other cropping systems tried during both the years of study. . The lowest with Sesame – Rice - Sunflower cropping system during both instances of study. Soil available nitrogen was more with greenmanure/ greengram haulms incorporated rice-rice system than other systems tried. In general, soil available N in Sunhemp - Rice – Fallow, Sunhemp - Rice – Rice and Greengram – Rice -Rice systems is parabolic ie., after *Kharif* season reached peak stage and N availability was reduced after *rabi* (Fig.1) during both the years of study. The findings are in agreement with those of Chandra and Pareek (1998) and Mohanty *et al*. (1998). This might be due to higher root biomass addition by growing green manure crops pre*kharif* season.

Soil available Phosphorus

The highest available phosphorus was recorded with Sunhemp – Rice – Rice during both the years of study. Increased phosphorus status of the soil was recorded with Sunhemp – Rice – Rice which was comparable with greengram-rice-rice (Table 3). Soil phosphorus increased the build up of available phosphorus in soil was due to

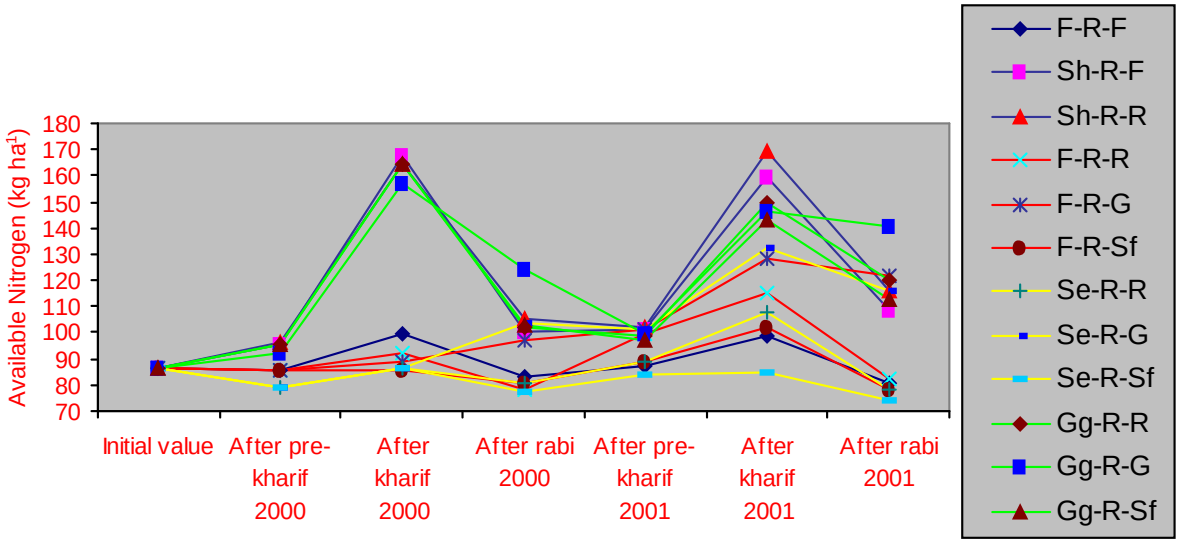

Fig. 1: Dynamics of soil available nitrogen as influenced by different cropping system

Table 3 : Dynamics of soil available nitrogen , phosphorus, and potassium (kg ha^{-1}) as influenced by different cropping systems

Cropping systems	N		P_2O_5		K_2O	
	A	B	A	B	A	B
F – R – F	82.9	80.3	11.18	12.9	70.6	102.6
Sh – R – F	100.3	108.4	12.69	15.4	159.4	200.9
Sh – R – R	105.2	116.2	13.76	19.4	194.2	253.2
F – R – R	78.0	82.6	12.00	15.9	182.6	233.2
F – R – G	97.3	121.4	9.68	12.9	137.0	170.2
F – R – Sf	80.6	78.4	9.03	13.7	149.0	185.9
Se – R – R	80.5	78.5	11.44	16.7	183.0	237.4
Se – R – G	103.9	115.6	8.99	12.9	140.0	175.1
Se – R – Sf	77.6	73.9	8.60	12.5	149.0	186.8
Gg – R – R	101.8	119.9	13.33	18.3	188.0	247.3
Gg – R – G	124.2	140.2	12.73	17.1	149.0	189.2
Gg – R – Sf	103.0	112.5	12.69	15.1	179.0	204.2
SE.m±	0.02	0.01	0.40	0.30	0.10	0.83
CD 5%	0.06	0.04	1.20	0.82	NS	2.50

A: After first cropping cycle; B: After second cropping cycle, F-fallow ; Sh-sunhemp ; Se-sesame ; Gg-greengram ;R-rice ;G-groundnut ;and Sf-sunflower

release of organic acids during microbial decomposition of greenmanure or greengram haulms which help in the solubility of native phosphorus in soil (Khan *et al.*, 1984). As the phosphorus requirement of rice was meagre and organic and inorganic additions increased the soil phosphorus content, the availability of phosphorus has been increased. These findings are in accordance with those of Dhiman *et al.* (2000). The final phosphorus status of soil at the end of two year cropping cycle was higher than initial status (Fig.2).

Soil available Potassium

Soil potassium availability was not differed with different cropping systems at the end of first year of study,

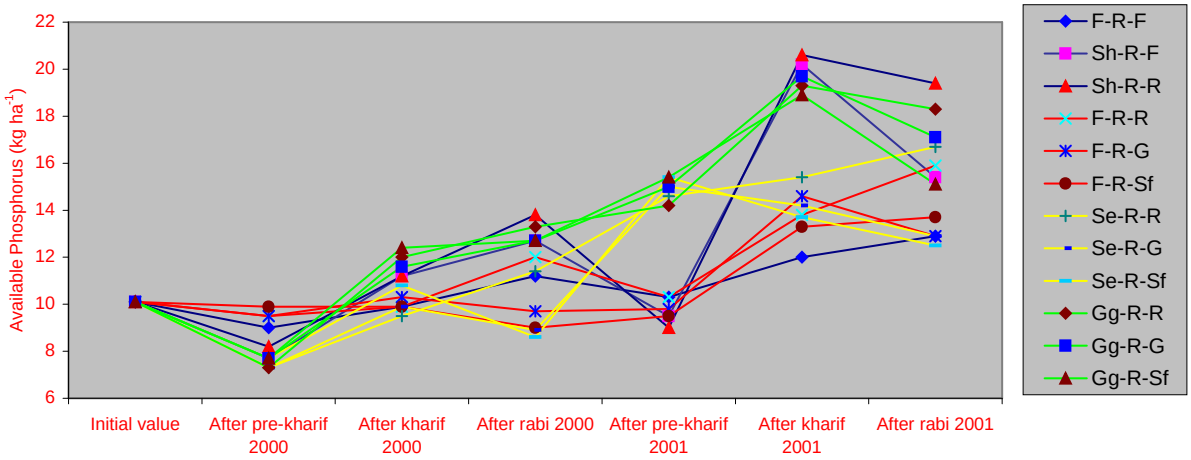

Fig 2 : Dynamics of soil available phosphorus (P_2O_5) as influenced by different cropping systems

while it was the highest with Sunhemp – Rice - Rice at the end of second year. The potassium status of the soil increased with rice and decreased with groundnut or sunflower (Table3 and Fig.3). The soil potassium was found improved by the end of two years of experimentation compared to initial status. Green manuring in situ or addition of green gram haulms on decomposition, released organic acids, which might have

Sesame – Rice - Rice, Fallow – Rice - Sunflower and single cropped rice (Table. 4). This might be due to higher uptake of nitrogen by these cropping systems, which resulted in low level left over in the soil. The highest nitrogen balance was associated with Greengram – Rice – Groundnut after first year and Fallow – Rice – Groundnut system after second year. Inclusion of greenmanure and or groundnut in the cropping systems

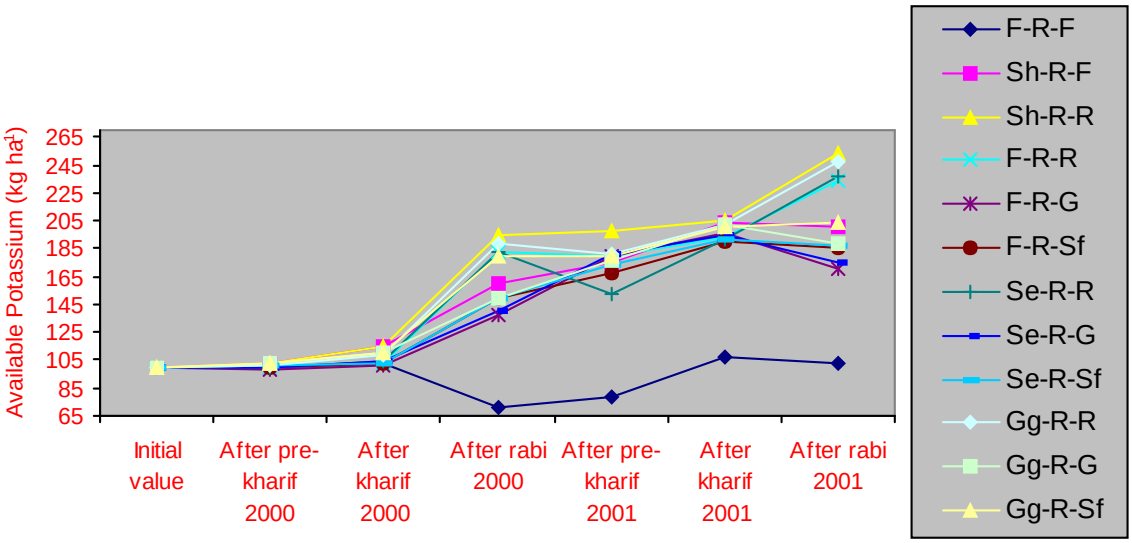

Fig 3 : Dynamics of soil available potassium (K_2O) as influenced by different cropping systems

enhanced the availability of potassium by reducing its fixation in the soil. These findings corroborate with those of Wani and Umarani (1992), Devi and Thakur (1994), Setty and Gowda (1997) and Hemalatha *et al.*, (2000).

Balance of Nitrogen

Nitrogen balance in soil was positive in all the cropping systems except Sesame - Rice - Sunflower, might have maintained nitrogen balance. The results are in conformity with Sharanappa (1992), Devi and Thakur (1994) and Mohanty *et al.* (1998).

Balance of Phosphorus

The highest soil available phosphorus was registered with Sunhemp – Rice - Rice, while the lowest phosphorus balance was recorded with Sesame – Rice - Sunflower,

Table 4 : Balance sheet of soil available nitrogen (kg ha^{-1}) in different cropping systems

Cropping system	2000					2001				
	Pre-experimental soil nitrogen	Nitrogen applied through fertilizer	Total N uptake by the system	Post-harvest N in soil	Change in available N status of soil net gain/loss	Pre-experimental soil Nitrogen	Nitrogen applied through fertilizer	Total N uptake by the system	Post-harvest N in soil	Change in available N status of soil net gain/loss
F – R – F	86.7	160	90.3	82.9	-3.8	82.9	160	98.5	80.3	-2.6
Sh – R – F	86.7	180	131.5	100.3	+13.6	100.3	180	143.1	108.4	+8.1
Sh – R – R	86.7	340	298.4	105.2	+18.5	105.2	340	278.4	116.2	+11.0
F – R – R	86.7	320	230.0	78.0	-8.7	78.0	320	230.5	82.6	+4.6
F – R – G	86.7	190	130.5	97.3	+10.6	97.3	190	154.9	121.4	+24.1
F – R – Sf	86.7	240	140.9	80.6	-6.1	80.6	240	165.8	78.4	-2.2
Se – R – R	86.7	340	293.8	80.5	-6.2	80.5	340	271.6	78.5	-2.0
Se – R – G	86.7	210	209.1	103.9	+17.2	103.9	210	211.2	115.6	+11.7
Se – R – Sf	86.7	260	220.9	77.6	-9.1	77.6	260	223.9	73.9	-3.7
Gg – R – R	86.7	340	275.4	101.8	+15.1	101.8	340	257.7	119.9	+18.1
Gg – R – G	86.7	210	179.6	124.2	+37.5	124.2	210	183.7	140.2	+16.0
Gg – R – Sf	86.7	260	186.2	103.0	+16.3	103.0	260	210.6	112.5	+9.5

F-fallow ; Sh-sunhemp ; Se-sesame ; Gg-greengram ;R-rice ;G-groundnut ;and Sf-sunflower

Table 5 : Balance sheet of soil available P_2O_5 (kg ha^{-1}) in different cropping systems

Cropping system	2000					2001				
	Pre-experimental soil P_2O_5	P_2O_5 applied through fertilizer	Total uptake by the system	Post-harvest P_2O_5 in soil	Change in available P_2O_5 status of soil net gain/loss	Pre-experimental soil P_2O_5	P_2O_5 applied through fertilizer	Total uptake by the system	Post-harvest P_2O_5 in soil	Change in available P_2O_5 status of soil net gain/loss
F – R – F	10.10	80	22.0	11.18	+1.08	11.2	80	25.0	12.9	+1.7
Sh – R – F	10.10	80	38.9	12.69	+2.59	12.7	80	40.9	15.4	+2.7
Sh – R – R	10.10	160	62.9	13.76	+3.66	13.8	160	70.6	19.4	+5.6
F – R – R	10.10	160	45.0	12.00	+1.9	12.0	160	52.6	15.9	+3.9
F – R – G	10.10	120	58.0	9.68	-0.42	9.7	120	59.2	12.9	+3.2
F – R – Sf	10.10	130	53.0	9.03	-1.07	9.0	130	56.7	13.7	+4.7
Se – R – R	10.10	180	63.6	11.44	+1.34	11.4	180	75.8	16.7	+5.3
Se – R – G	10.10	140	76.0	8.99	-1.11	9.0	140	83.0	12.9	+3.9
Se – R – Sf	10.10	150	74.8	8.60	-1.5	8.6	150	80.3	12.5	+3.9
Gg – R – R	10.10	210	79.2	13.33	+3.23	13.3	210	88.6	18.3	+5.0
Gg – R – G	10.10	170	90.3	12.73	+2.63	12.7	170	94.7	17.1	+5.4
Gg – R – Sf	10.10	180	86.0	12.69	+2.59	12.7	180	92.6	15.1	+2.4

F-fallow ; Sh-sunhemp ; Se-sesame ; Gg-greengram ;R-rice ;G-groundnut ;and Sf-sunflower

after first year and with single cropped rice after second year(Table. 5). This might be due to continuous supply of fertilizers and contribution of increased root mass for higher phosphorus uptake. The results of the present study finds credence with those of Narang *et al*, (1990) and Dhiman *et al.*, (2000).

Balance of Potassium

Soil available potassium was found to be positive with all the cropping systems tried. Continuous addition of recommended dose of fertilizers, crop residues as well as organic forms of nutrient sources (greenmanure/ greengram haulms incorporation) in continuous cropping systems might have lead to the build up of the soil

Table 6 : Balance sheet of soil available K_2O (kg ha^{-1}) in different cropping system

Cropping system	2000					2001				
	Pre-experimental soil K_2O	K_2O applied through fertilizer	Total uptake by the system	Post-harvest K_2O in soil	Change in available K_2O status of soil net gain/loss	Pre-experimental soil K_2O	K_2O applied through fertilizer	Total uptake by the system	Post-harvest K_2O in soil	Change in available K_2O status of soil net gain/loss
F – R – F	99.6	80	89.7	70.6	-29.0	70.6	80	97.3	102.6	+32
Sh – R – F	99.6	80	132.5	159.4	+59.8	159.4	80	152.6	200.9	+41.5
Sh – R – R	99.6	160	239.9	194.2	+94.6	194.2	160	270.3	253.2	+59.0
F – R – R	99.6	160	201.8	182.6	+83.0	182.6	160	225.2	233.2	+50.6
F – R – G	99.6	130	126.7	137.0	+37.4	137.0	130	151.1	170.2	+33.2
F – R – Sf	99.6	110	179.3	149.0	+49.4	149.0	110	188.4	185.9	+37.3
Se – R – R	99.6	180	225.7	183.0	+83.4	183.0	180	252.8	237.4	+54.0
Se – R – G	99.6	150	148.9	140.0	+40.4	140.0	150	175.7	175.1	+34.8
Se – R – Sf	99.6	130	200.0	149.0	+49.4	149.0	130	209.5	186.8	+37.4
Gg – R – R	99.6	160	264.8	188.0	+88.4	188.0	160	272.8	247.3	+58.9
Gg – R – G	99.6	130	187.6	149.0	+49.4	149.0	130	211.9	189.2	+39.8
Gg – R – Sf	99.6	110	241.3	179.0	+79.4	179.0	110	253.1	204.2	+24.9

F-fallow ; Sh-sunhemp ; Se-sesame ; Gg-greengram ;R-rice ;G-groundnut ;and Sf-sunflower

potassium. These results are in agreement with those of Narang *et al*., (1990), Vinod Kumar Gosh *et al*. (1999) and Hemalatha *et al*. (2000).

From this study it is clear that greengram/ greenmanure as well as groundnut included cropping systems showed positive balance of nitrogen in soil after two years of cropping cycle (Table 6). Phosphorus build up in Greenmanure – Rice – Rice system was more in the soil. Potassium build up recorded in soil after two years of cropping. Nutrient build up due to different crops in cropping systems enables us to plan the fertilizer management to reduce cost of cultivation of crops.

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