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RESEARCH PAPER

Balance sheet of nitrogen, phosphorus and potassium in rice–groundnut cropping system

C. RADHA KUMARI* AND D. SRINIVASULU REDDY[1]
Department of Agronomy, District Agricultrual Advisory and Transfer of Technology Centre, ANANTAPUR (A.P.) INDIA

Abstract **:** Field experiments were conducted in the wetland farm of S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Andhra Pradesh for two consecutive years 2002 – 2003 and 2003 – 2004 to investigate the effect of crop residues, organics and inorganics in rice based cropping system. Highest rice grain equivalent yield of the rice-groundnut cropping system was recorded with the incorporation of fieldbean crop residues along with the supply of recommended nitrogen through FYM to rice. Substitution of N through FYM led to build up of soil fertility status after the entire cropping system.

Key Words **:** Rice, Groundnut, Nitrogen, Phosphorus, Potassium

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INTRODUCTION

Currently used crop management practices based on chemical fertilizers do not provide a balanced approach between soil nutrient supply and crop requirements. Rather these practices deteriorate the sustainable soil fertility and health in the long run basis. An integrated nutrient management approach seems appropriate for sustained crop production. The *in situ* crop residue incorporation is beneficial in areas, where fallow of a short duration is available preceding the transplanted low land rice. Crops like greengram, cluster bean, field bean and cowpea could be raised in that time. After the harvest the residues can be incorporated prior to transplanting of rice, which is reported to contribute about 50 to 60 kg N ha^{-1} to the succeeding rice crop (Dixit and Gupta , 2000). Organic manures are the viable components of nitrogen management, which can supplement and successfully replace costly fertilizer nitrogen. Research efforts to maximize the productivity and soil fertility status of the rice-groundnut cropping system, by developing appropriate and viable nitrogen management practices, without any compromise on soil health are long due in the Southern Agro-Climatic Zone of Andhra Pradesh. The present experiment was, therefore, conducted to study the effect of crop residues, organics and inorganics on rice equivalent yield and soil fertility status of rice – groundnut cropping system.

MATERIALS AND METHODS

Field investigations were conducted during 2002-03 and 2003-04 at wetland farm of S.V. Agricultural College, Tirupati. The soil was sandy clay loam in texture, slightly alkaline in reaction (pH7.6), low in organic carbon (0.27 %) and available nitrogen (160.8 kg N ha^{-1}), medium in available phosphorus (25.6 kg P_2O_5 ha^{-1}) and available potassium (175.4 kg K_2O ha^{-1}).

The experiment was laid out in factorial RBD with five replications. There were four treatments comprising of preceding crops to rice raised during *Kharif* season *viz.*, greengram, clusterbean, fieldbean and cowpea. Their residues were incorporated prior to transplanting of rice crop. Samples of all the crop residues were taken to estimate the nutrient

*** Author for correspondence.**
[1]Department of Agronomy, S.V. Agricultural College, TIRUPATI (A.P.) INDIA

content (Table A) before incorporation into soil . The N, P and K content of crop residues were analysed by standard procedures outlined by Jackson (1973). The varieties of greengram, clusterbean, fieldbean, cowpea were LGG-407, Pusa Navabahar, HA-3 and CO-4, respectively.

Table A : Quantity of crop residues (kg ha^{-1}) and nutrient content (%) of crop residues and FYM, incorporated before planting of rice (mean of 2 years data)

Source	Quantity of crop residues incorporated (kg ha^{-1})	N	P_2O_5	K_2O
FYM	--	0.50	0.20	0.51
Greengram residue*	7100	0.82	0.205	0.63
Clusterbean residue*	13460	0.53	0.13	0.50
Fieldbean residue*	17050	0.655	0.155	0.445
Cowpea residue*	15320	0.605	0.145	0.495

*On fresh weight basis

Rice crop was raised during the *Rabi* season in four sub-plots, to which four nitrogen management practices were assigned. Rice was taken up in a split plot design with incorporation of crop residues of four preceding crops to rice as main plot treatments and four nitrogen management practices imposed on *Rabi* rice as sub-plot treatments *viz*., No nitrogen, 100 per cent recommended nitrogen through fertilizer, 50 per cent recommended nitrogen through fertilizer + 50 per cent recommended nitrogen through farm yard manure and 100 per cent recommended nitrogen through farm yard manure. The recommended dose of nutrients was 120 kg N, 80 kg P_2O_5 and 40 kg K_2O ha^{-1}. The N content in FYM (Table A) was taken into consideration for incorporation in to the plots 10 days before transplanting of rice. Nitrogen in the form of urea was applied in three split doses of 50 per cent as basal, 25 per cent at active tillering and 25 per cent at panicle initiation stages. A uniform dose of 80 kg P_2O_5 and 40 kg K_2O ha^{-1} was applied basally to all the treatments except in control. Test variety of rice was NLR 33359.

Groundnut (cv. K- 134)was raised during summer season after the harvest of *Rabi* rice in the same undisturbed layout of split plot design, to find out the residual and cumulative effect of incorporation of crop residues of preceding crops to rice and N management practices imposed on *Rabi* rice crop. The layout of *Rabi* rice crop was undisturbed, in which groundnut crop was sown. No treatments were imposed to groundnut crop. Plant samples collected for dry matter estimation at different growth stages of rice and groundnut were oven dried, ground into fine powder and used for nutrient analysis. The uptake of N, P and K in Kg ha^{-1} at different stages of crop growth was calculated by multiplying the nutrient content with the respective drymatter weights. Soil samples were collected from the individual plots of the treatments immediately after harvesting of rice and groundnut, analysed for organic carbon (Walkley and Black, 1934), available nitrogen (Subbiah and Asija, 1956), available phosphorus (Olsen *et al.,* 1954) and available potassium (Jackson, 1973). Pod yield of groundnut was converted into rice grain equivalent (RGE) on the basis of the prevailing market price, using the following formula and expressed in kg ha^{-1}.

$$\text{RGE} = \frac{\text{Pod yield of groundnut (kg ha}^{-1}\text{)} \times \text{Price of groundnut pods (Rs kg}^{-1}\text{)}}{\text{Price of rice grain (Rs kg}^{-1}\text{)}}$$

RESULTS AND DISCUSSION

The results of the present study alongwith relevant discussion have been presented as under:

Grain yield of rice:

The interaction effect (crop residue incorporation and nitrogen management practices) of incorporation of fieldbean crop residues along with the supply of 100 per cent nitrogen through fertilizer resulted in the highest grain yield of rice (Table 1).

Pod yield of groundnut:

The interaction effect (cumulative and residual effect of crop residue incorporation and nitrogen management practices to rice) incorporation of fieldbean crop residues along with the supply of 100 per cent nitrogen through FYM resulted in the highest pod yield of groundnut.

Economic yield of rice-groundnut cropping system:

Economic yield of the cropping system was altered to a noticeable extent by incorporation of crop residues and nitrogen management practices imposed to rice. Economic yield of the cropping system was expressed in terms of rice grain equivalent yield. The highest total economic yield (rice grain equivalent) of the rice-groundnut cropping system was recorded with the incorporation of fieldbean crop residues along with the supply of 100 per cent nitrogen through FYM to rice, which was however, statistically similar to supply of 50per cent nitrogen each through fertilizer and FYM, while it was the lowest with the incorporation of greengram crop residues and non supply of nitrogen to rice. This indicated that for the entire cropping system the economic yield realized with recommended nitrogen application through any source could meet the nutritional demand of the entire system equally. The lower yields of rice with supply of 100 per cent nitrogen through FYM has been compensated with higher yields of the succeeding groundnut by supply of 100 per cent nitrogen through FYM thus resulting in comparable realization of economic yield of the cropping system with different nitrogen management practices to rice.

Nutrient removal of rice-groundnut cropping system:

Incorporation of fieldbean crop residues and supply of 100 per cent nitrogen through fertilizer increased the highest nutrient uptake. The nutrient uptake with incorporation of fieldbean crop residues in combination with supply of 100 per cent nitrogen through fertilizer was highest among all combinations, while it was the lowest with incorporation of greengram crop residues without any nitrogen supply. Incorporation of fieldbean crop residues was superior to any other crop residue with regard to growth and yield as well as nutrient uptake, during both the years. This beneficial effect of incorporation of fieldbean crop residues in rice may be ascribed to higher quantity of nutrients addition due to incorporation of higher quantity of field bean (17050 kg ha^{-1}) crop residues compared to greengram crop residues (7100 kg ha^{-1}). Availability of adequate quantity of nutrients in the soil, obviously promotes the performance of rice crop. Comfortable level of absorbed and assimilated nitrogen in the plants has manifested elevated level of growth and yield structure, resulting in superior performance of rice crop (Dixit and Gupta, 2000). Increased uptake of N with the incorporation of fieldbean crop residues was the result of higher dry matter production and enhanced absorption of N, while that of P and K might be due to better foraging of soil, due to vigorous root growth, thus accumulating more phosphorus and potassium in plant in addition to enhanced dry matter production (Table 1).

The beneficial effect of incorporation of fieldbean crop residues after pod harvest might be due to adequate decomposition of green parts of fieldbean, which might have enabled the rice plant to get almost an ensured and continuous nitrogen supply distributed over the entire period of crop growth. Crop residues undergo decomposition at a slower rate under submerged conditions, releasing ammonical nitrogen in reasonable quantities over a long period of time. Thus, the rhizo-ecosystem of low land gets enriched with less leachable form of available nitrogen. Superior performance of rice crop with incorporation of fieldbean crop residues as observed in the present study corroborates the findings of John *et al.* (1992). Though green gram residue contains highest N (0.82 %) compared to field bean residue (0.655 %) the rice grain equivalent yield, N, P and K removal of rice – groundnut cropping system and balance sheet of N in soil was not in favour with the incorporation of green gram crop residues. This might be due to release of lesser quantity of readily available nitrogen in soil solution due to incorporation lower quantity of greengram residues (7100 kg ha^{-1}) compared to field bean residues (17050 kg ha^{-1}).

Higher nutrient removal with the with application of 100 per cent nitrogen through FYM to preceding rice crop might be due to higher availability of nitrogen in the soil and enhanced dry matter production. The higher removal of phosphorus and potassium with the same treatment of supply of 100 per cent nitrogen through FYM to preceding rice might be due to better foraging of soil, due to vigorous root growth, thus accumulating more phosphorus and potassium in plant in addition to enhanced dry matter accumulation under the influence of higher amount of residual N. Slowly mineralizing organic fractions under anaerobic lowland conditions would leave behind enriched status of soil fertility, even after sufficient uptake of nutrients by rice crop.

Balance sheet of nutrients:

Regardless of the preceding crops tried for incorporation of crop residues prior to rice, nitrogen management practice of substituting 100 per cent of recommended dose of nitrogen through FYM to rice has resulted in build up of soil fertility status (in terms of organic carbon, available N, P and K) after the entire cropping system.

Table 1 : Grain yield of rice, pod yield of groundnut and rice grain equivalent yield (kg ha^{-1}) of rice-groundnut cropping system as influenced by crop residue incorporation and nitrogen management practices to rice (mean of 2 years data)

Treatments	Grain yield of rice					Pod yield of groundnut					Rice grain equivalent yield				
	Incorporation of crop residues														
Nitrogen management practices	C_1	C_2	C_3	C_4	Mean	C_1	C_2	C_3	C_4	Mean	C_1	C_2	C_3	C_4	Mean
N_1	2547	3148	4127	3777	3400	1449	1614	1944	1779	1696	5051	5973	7686	6825	6383
N_2	4813	5222	6049	5734	5454	1664	1829	2159	1994	1911	7534	8359	10043	9249	8796
N_3	4468	4717	5743	5431	5090	2132	2297	2627	2462	2379	8012	8752	10539	9748	9232
N_4	3916	4340	5449	5137	4710	2347	2512	2842	2677	2597	7946	8774	10603	9811	9264
Mean	3936	4357	5342	5020		1898	2063	2393	2228		7135	7965	9718	8908	
	S.E. ±		C.D. (P=0.05)			S.E. ±		C.D. (P=0.05)			S.E. ±		C.D. (P=0.05)		
C	101		248			75		185			148		364		
N	143		296			106		220			210		434		
C at N	268		296			200		424			393		835		
N at C	286		592			213		441			420		868		

The nitrogen balance of cropping cycle tried has indicated a firm increase of soil available nitrogen in the soil after the cropping system with different combinations of crop residues and nitrogen management practices tried, except that

Table 2 : Nutrient removal (kg ha^{-1}) in rice-groundnut cropping system as influenced by crop residue incorporation and nitrogen management practices to rice (mean of 2 years data)

Treatments	Nutrient removal (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
Incorporation of crop residues			
C_1 : Greengram	150.0	39.0	239
C_2 : Clusterbean	171.5	44.5	269
C_3 : Fieldbean	215.0	54.5	321
C_4 : Cowpea	193.0	49.5	294
S.E.±	5.4	0.6	18.3
C.D. (P=0.05)	13.2	1.6	37
Nitrogen management practices			
N_1 : No nitrogen	148.0	36.5	218
N_2 : 100% recommended nitrogen through fertilizer	183.0	45.0	278
N_3 : 50% recommended nitrogen through fertilizer + 50% recommended nitrogen through FYM	196.0	50.5	306
N_4 : 100% recommended nitrogen through FYM	203.5	55.0	320
S.E.±	7.6	0.9	21.4
C.D. (P=0.05)	15.7	1.9	42

Table 3 : Balance sheet of soil available nitrogen (kg ha^{-1}) in rice-groundnut cropping system as influenced by crop residue incorporation and nitrogen management practices to rice (mean of 2 years data)

Treatments	Intial soil available N (kg ha^{-1})	Nitrogen applied through crop residues (kg ha^{-1})	Nitrogen applied through fertilizers (kg ha^{-1})		Total nitrogen applied through crop residues + fertilizers (kg ha^{-1})	Nitrogen uptake (kg ha^{-1})			Soil available N after 2 cycles of cropping system (kg ha^{-1})	Net gain or loss (kg ha^{-1})
			Rice	Groundnut		Rice	Groundnut	Total		
Incorporation of crop residues										
C_1 : Greengram	160.8	58.2	120	--	178.2	72.2	78.5	150.7	183.3	22.5
C_2 : Clusterbean	160.8	71.3	120	--	191.3	86.4	85.1	171.5	192.1	31.3
C_3 : Fieldbean	160.8	111.6	120	--	231.6	117.9	97.8	215.7	209.7	48.8
C_4 : Cowpea	160.8	92.7	120	--	212.7	101.8	91.4	193.2	201.1	40.2
S.E.±	--	1.2	--	--	3.1	1.4	1.5	3.2	2.7	--
C.D. (P=0.05)	--	2.9	--	--	8.2	3.6	3.6	8.2	6.8	--
Nitrogen management practices										
N_1 : No nitrogen	160.8	83.4	0	--	83.4	68.3	80.5	148.8	166.6	5.8
N_2 : 100% recommended nitrogen through fertilizer	160.8	83.4	120	--	203.4	86.3	96.2	182.5	191.4	30.6
N_3 : 50% recommended nitrogen through fertilizer + 50% recommended nitrogen through FYM	160.8	83.4	120	--	203.4	103.2	93.2	196.4	208.4	47.5
N_4 : 100% recommended nitrogen through FYM	160.8	83.4	120	--	203.4	120.6	82.8	203.4	219.8	58.9
S.E.±	--	1.7	--	--	4.2	2.1	2.0	4.0	3.9	--
C.D. (P=0.05)	--	3.5	--	--	8.7	4.3	4.1	8.5	6.1	--

$$\text{Nitrogen supplied through crop residues} = \frac{\text{Qty. of crop residues incorporated (kg ha}^{-1}\text{) x Nutrient content (\%)}}{100}$$

a marginal decline in the soil N was noticed with the incorporation of greengram crop residues and non supply of N to rice. However, the decline was very low, even as that could be lesser than analytical error.

The budgeting of soil available N, P and K after 2 cycles of rice – groundnut cropping system showed considerable variation both due to the source of residue incorporation and the nitrogen management. The incorporation of residues in the *Kharif* season without external input of nutrients to rice in *Rabi* or groundnut in summer sustained the initial levels of available 160.8kg N ha^{-1}. The cumulative influence of residual effect due to crop residues and fertilizer applied at recommended level of 120 N kg ha^{-1} substantially increased the availability of this nutrient. Incorporating the crop residues of field bean before planting of rice and supply 120 kg N ha^{-1} through FYM was found best. The soil available N was maximized to 233 kg ha^{-1} with a net gain of 72.2 kg N ha^{-1} after 2 cycles of rice- groundnut cropping system. The application of 120 kg N ha^{-1} to rice through FYM maintained higher level of soil available N through fertilizer or their combined application. This trend was similar with other sources of residue incorporation (Table 3).

The soil available P was depleted to low value after 2 cycles of rice – groundnut cropping system by the incorporation of greengram residue before the planting of rice (Table 4). There was net negative balance of this nutrient even with the application of 120 kg N ha^{-1} to rice through fertilizer, FYM or their combined application. But the crop residue of cluster bean or cowpea sustained the initial level of soil available P. The application of 120 kg N ha^{-1} through fertilizer, FYM or their combined application slighty improved the soil available P. The best crop residue was fieldbean. The soil had relatively more P in the available from than due to the effect of other crop residues irrespective of the source of nitrogen applied to rice.

The soil available potassium was more after 2 cycles of rice – groundnut cropping system in all the treatments compared to the initial value (Table 5). There was a net gain of 21.3 to 90.7 kg K_2O ha^{-1}. This improvement was more due to the integrated supply of 50 per cent N each through inorganic and organic source irrespective of the crop residue source. The most distinct response was due to the incorporation of crop residue of field bean before planting of rice and application of 120 kg N ha^{-1} to rice through FYM. The soil had 266.1 kg

Table 4 : Balance sheet of soil available phosphorus (kg ha^{-1}) in rice-groundnut cropping system as influenced by crop residue incorporation and nitrogen management practices to rice (mean of 2 years data)

Treatments	Intial soil available P (kg ha^{-1})	phosphorus applied through crop residues (kg ha^{-1})	phosphorus applied through fertilizers (kg ha^{-1})		Total phosphorus applied through crop residues + fertilizers (kg ha^{-1})	Phosphorus uptake (kg ha^{-1})			Soil available P after 2 cycles of cropping system (kg ha^{-1})	Net gain or loss (kg ha^{-1})
			Rice	Groundnut		Rice	Groundnut	Total		
Incorporation of crop residues										
C_1 : Greengram	25.6	14.6	80	--	94.6	28.9	10.5	39.4	24.5	-1.1
C_2 : Clusterbean	25.6	17.4	80	--	97.4	33.4	10.9	44.3	26.8	1.27
C_3 : Fieldbean	25.6	26.4	80	--	106.4	42.2	11.9	54.1	28.6	3.07
C_4 : Cowpea	25.6	22.2	80	--	102.2	37.7	11.4	49.1	27.8	2.22
S.E.$\pm$	--	0.2	--	--	0.9	0.7	0.09	0.5	1.1	--
C.D. (P=0.05)	--	0.6	--	--	2.1	1.8	0.2	1.4	2.7	--
Nitrogen management practices										
N_1 : No nitrogen	25.6	20.1	80	--	20.1	25.7	10.7	36.4	25.9	0.35
N_2 : 100% recommended nitrogen through fertilizer	25.6	20.1	80	--	100.1	33.4	11.7	45.1	26.8	1.22
N_3 : 50% recommended nitrogen through fertilizer + 50% recommended nitrogen through FYM	25.6	20.1	80	--	100.1	40.2	11.5	51.7	27.1	1.52
N_4 : 100% recommended nitrogen through FYM	25.6	20.1	80	--	100.1	44.0	10.9	54.9	27.9	2.3
S.E.$\pm$	--	0.3	--	--	1.2	1.0	0.24	0.8	1.5	--
C.D. (P=0.05)	--	0.75	--	--	2.5	2.1	0.3	1.7	3.2	--

$$\text{Phosphorus supplied through crop residues} = \frac{\text{Qty. of crop residues incorporated (kg ha}^{-1}\text{) X Nutrient content (\%)}}{100}$$

Table 5 : Balance sheet of soil available potassium (kg ha^{-1}) in rice-groundnut cropping system as influenced by crop residue incorporation and nitrogen management practices to rice (mean of 2 years data)

Treatments	Intial soil available K (kg ha^{-1})	potassium applied through crop residues (kg ha^{-1})	potassium applied through fertilizers (kg ha^{-1})		Total potassium applied through crop residues + fertilizers (kg ha^{-1})	potassium uptake (kg ha^{-1})			Soil available K after 2 cycles of cropping system (kg ha^{-1})	Net gain or loss (kg ha^{-1})
			Rice	Groundnut		Rice	Groundnut	Total		
Incorporation of crop residues										
C_1 : Greengram	175.4	44.7	40	--	84.7	169.3	70.6	239.9	218.2	42.7
C_2 : Clusterbean	175.4	67.2	40	--	107.2	196.6	74.5	271.1	226.1	50.7
C_3 : Fieldbean	175.4	75.8	40	--	115.8	239.1	82.2	321.3	241.9	66.5
C_4 : Cowpea	175.4	75.8	40	--	115.8	216.7	78.4	295.1	234.0	58.6
S.E.±	--	1.14	--	--	1.3	3.4	1.3	2.7	3.1	--
C.D. (P=0.05)	--	2.8	--	--	3.2	8.3	3.2	6.8	7.6	--
Nitrogen management practices										
N_1 : No nitrogen	175.4	65.8	40	--	65.8	152.3	65.1	220.4	208.5	33.1
N_2 : 100% recommended nitrogen through fertilizer	175.4	65.8	40	--	105.8	194.5	84.1	278.6	219.9	44.5
N_3 : 50% recommended nitrogen through fertilizer + 50% recommended nitrogen through FYM	175.4	65.8	40	--	105.8	225.9	81.0	306.9	241.6	62.0
N_4 : 100% recommended nitrogen through FYM	175.4	65.8	40	--	105.8	248.9	72.3	321.2	254.3	78.8
S.E.±	--	1.6	--	--	1.8	4.8	1.8	3.9	4.4	--
C.D. (P=0.05)	--	3.3	--	--	3.8	9.9	3.6	8.1	9.0	--

$$\text{Potassium supplied through crop residues} = \frac{\text{Qty. of crop residues incorporated (kg ha}^{-1}\text{) x Nutrient content (\%)}}{100}$$

K_2o ha $^{-1}$ with a net gain of 90.7 kg K_2O ha $^{-1}$ over the initial value. Slow decomposition and mineralisation of crop residues and farm yard manure added in large quantities to preceding rice crop would have enriched the organic carbon, available nitrogen, phosphorus and potassium status of soil after the harvest of groundnut. These results are in agreement with those of Rajendra Prasad (1985) and Buresh and De Datta (1991).

Thus raising a reasonably short duration leguminous crop (either a pulse crop or vegetable crop) preceding to rice and incorporation of the crop residues after picking the economic yield and supply of 50 per cent recommended dose of nitrogen each through fertilizer and FYM to rice followed by raising groundnut as residual crop, to utilize the residual fertility was found the best integrated nitrogen management package for rice-groundnut cropping system not only in terms of higher productivity, but also for sustaining the soil fertility.

REFERENCES

Buersh, R. J. and De Datta, S. K. (1991). Nitrogen dynamics and management in rice legume cropping systems. *Adv. Agro.*, **45** : 1-59.

Dixit, S. and Gupta, B.R. (2000). Effect of farm yard manure, chemical and biofertilizers on yield and quality of rice (*Oryza sativa*) and soil properties. *J. Indian Soc. Soil Sci.*, **48**: 773-780.

Jackson, M.L. (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., Bew Delhi, pp.134-204.

John, P.S., Pandey, R.K., Buresh, R.J. and Prasad, R. (1992). Nitrogen contribution of cowpea green manure and residue to upland rice. *Plant & Soil,* **142** : 53-61.

Olsen, S.R., Cole, C.L., Watanabe, F. S. and Dean, D. A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate, USDA Cir. No.939.

Rajendra Prasad, T. V. P. (1985). Management of pulses in rice - based cropping system. M.Sc.(Ag.) Thesis, Tamil Nadu Agricultural University, COIMBATORE, T.N. (India).

Subbaiah, B.V. and Asija, G.L. (1956). A rapid procedure for determination of available nitrogen in soils. *Cur. Sci.,* **25** : 259-260.

Walkey, A. and Black, C. A. (1934). An examination of degtiaroff method for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Sci.,* **37**:29-34.

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