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NUTRIENT STATUS OF SOILS UNDER MAJOR CROPPING SYSTEMS OF CHITTOOR DISTRICT, ANDHRA PRADESH

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ABSTRACT

Assessment of soil properties and nutrient status is essential for addressing issues of soil health through which one can guide for maintaining sustainable crop productivity. In view of this, soil samples were collected from selected villages under different mandals of Chittoor district to assess macronutrients and micro nutrients status in the year of 2022-23. A total of 225 soil samples (0-15 cm depth) were collected from groundnut-groundnut cropping system, groundnut-red gram cropping system, paddy-groundnut cropping system, fallow-paddy cropping system, paddy-paddy cropping system, sugarcane-sugarcane cropping system, perennial fodder system, tomato mono cropping system and mango orchards. The results revealed that highest available nitrogen, phosphorus, potassium and sulphur was found in the groundnut- red gram cropping system, paddy-paddy cropping system, perennial fodder system and groundnut-groundnut cropping system, respectively, whereas the lowest nitrogen, potassium and sulphur was recorded in fallow-paddy cropping system. The available phosphorus was found to be low in groundnut-groundnut cropping system. The highest available calcium, magnesium and DTPA extractable Zn, Cu, Fe and Mn was found in perennial fodder system whereas, lowest Ca and Mg were noticed in groundnut-groundnut cropping system, while, lower DTPA extractable micronutrients *viz*., Zn, Cu, Fe and Mn were observed under fallow paddy cropping system. The soils of perennial fodder system followed by groundnut-red gram cropping system were found to be more sustainable when compared to other cropping systems. The soils were deficient in some nutrients while others were very high due to imbalanced fertilization coupled with intensive cultivation of nutritive exhaustive crops. To achieve the desired crop production without harming the soil's health, adoption of soil tests based fertilizer recommendations are absolutely necessary.

(Keywords: Cropping system, soil health, DTPA extractable nutrients and production)

INTRODUCTION

Soil testing is often employed to determine the available nutrient status and nutrient supplying power of soil, which aids in the development of cost-effective nutrient management practices that serves as a foundation for amendments and sound fertilizer recommendations, leading to long-term agriculture production through the adoption of good agronomic management practices by farmers in the study area. Macronutrients (N, P, K, S, Ca and Mg) and micronutrients (Zn, Fe, Cu, Mn) are very important soil elements that controls fertility and productivity of a particular soil. Soil fertility is one of the important factors controlling crop yields and soil characterization in relation to evaluation of soil fertility of an area or a region is an important aspect in the text of sustainable production (Prasad *et al*., 2020). In present context, maintaining soil fertility is a key problem in Indian agriculture, especially under the country's rapidly growing population in recent decades. According to recent population growth estimates the world's population will reach 8.6 billion people by 2030 and 9.8 billion by 2050 and impose greater pressure on the available natural resources (Anonymous, 2017). Knowing crop nutrition demand and soil nutrient supplying power determines the amount of fertilizer supplementation (Chalwade *et al*., 2006). Inadequate fertilizer management resulted in the formation of multinutrient deficits in Indian soils. It is difficult to increase agricultural productivity and feed the world's rapidly growing population without maintaining soil fertility. Soil analysis and the investigation of macro and micronutrient levels have been key research topics in recent decades. Soil nutrient status information is required for advising individual farmers on fertiliser scheduling and monitoring changes in soil fertility over a period.

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MATERIALS AND METHODS

Chittoor district is a part of Rayalaseema region of Andhra Pradesh. Chittoor district lies extreme South of Andhra Pradesh state approximately between 12°37' to 14°08' North latitude and 78°03' to 79°55' East longitude. The district occupies an area of 15,359 km^2. The soils in the district constitute red loamy (57%), red sandy (34%) and the remaining 9% is covered by black clay, black loamy, black sandy and red clay. Of the total geographical area of 14.98 lakh ha, nearly 30 per cent (3.9 lakh ha) of the area is under cultivation. Chittoor is at 309 m above sea level with a tropical climate. The district is characterized under Southern agro climatic zone of Andhra Pradesh based on soil type, rainfall and altitude. Chittoor district receives an annual rainfall of 918.1 mm. The district has the benefit of receiving rainfall during both the South-West and North-East monsoon periods. While the normal rainfall of the district for the South-West monsoon period is 438.00 mm and for the North-East monsoon period is 396.00 mm. The average annual temperature in Chittoor is 26.5°C (79.8°F). The temperatures are highest on average in May, at around 30.9°C (87.7°F). The lowest average temperature in the year occurs in December, it is around 22°C (71.9°F).

Survey was conducted in nine major cropping systems growing area of Chittoor district covering 7 mandals and 225 representative surface soil samples (0-15 cm) were collected from farmer's fields. The collected soil samples were shade dried, ground with a wooden hammer, passed through 2 mm sieve and 0.2 mm sieve (for organic carbon) finally stored in a labelled air tight new poly bag for laboratory analysis. Available nitrogen content in the soils was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956). The available phosphorus in the soil samples was extracted with 0.5 M $NaHCO_3$ (Olsen's reagent) of pH 8.5 and the phosphorus in the extract was estimated calorimetrically by ascorbic acid method using spectrophotometer at 660 nm (Watanabe and Olsen, 1965). The available phosphorus was expressed as P_2O_5 kg ha^{-1} by multiplying the phosphorus (P) with 2.29. Available potassium in the soil samples was extracted with neutral normal ammonium acetate (Jackson, 1973) and determined by using flame photometer (Systronics flame photometer 128) and expressed the results in kg ha^{-1}, available sulphur was determined by turbidity method (Hesse, 1971). The turbidity is measured using spectrophotometer at 420 nm wavelength and expressed the results in mg kg^{-1}. Available calcium and magnesium was extracted with neutral normal ammonium acetate and determined by titrating with 0.01 N EDTA as per procedure out lined by Jackson (1973) and was expressed in cmol (p$^+$) kg^{-1}. Available zinc, copper, manganese and iron in the soils were determined in DTPA extract, using atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Primary nutrients

Data regarding available N, P_2O_5, K_2O status of soils under different cropping systems are given in Table 1 and depicted in Figure1. Results revealed that the available nitrogen, phosphorus and potassium of soils under major cropping systems varied from 105 to 315, 12.96 to 85.37 and 117 to 469 kg ha^{-1}, respectively. Significantly the highest available nitrogen (265 kg ha^{-1}), available phosphorus (72.02 kg ha^{-1}) and available potassium (387 kg ha^{-1}) was observed under groundnut-red gram cropping system, paddy-paddy cropping system and perennial fodder system. The lowest available nitrogen (158 kg ha^{-1}) and potassium (237 kg ha^{-1}) was observed under fallow-paddy cropping system, while the lowest available phosphorus was observed under groundnut-groundnut cropping system (19.29 kg ha^{-1}).

The highest available nitrogen was recorded in groundnut-red gram cropping system. Legume is a natural mini-nitrogen manufacturing factory in the field, they have the ability to fix the atmospheric nitrogen and the farmers by growing these crops can play a vital role in increasing indigenous N production (Ghosh *et al*., 2017; Patrick *et al*., 2013; Kumar *et al*., 2020). The low available N was observed in fallow-paddy cropping system due to poor organic carbon content which was evident from high degree of correlation between available N and soil organic carbon (Pradeep *et al*., 2006).

The available phosphorus was high under paddy-paddy cropping system due to more use of DAP by farmers in the study area. Lowest was observed in groundnut-groundnut cropping system. Legumes utilize more phosphorus there by depleting the phosphorus content in soils. Significantly the highest potassium was recorded in perennial fodder system due to high application of potassium fertilizers to paddy crop in the study area. Variation in available potassium in the soils of various cropping systems as noticed by several researchers (Pulakeshi *et al*., 2012 and Dhamak *et al*., 2014). Similar results were obtained by Srivastava *et al*. (2015), who inferred that lowest potassium availability under field crop based systems compared to fodder systems may be caused by potassium depletion as a result of vegetation removal or leaching loss.

Secondary nutrients

Data regarding secondary nutrients status of soils under different cropping systems are shown in Table 2 and depicted in Figure 2. The available sulphur in soils under major cropping systems ranged from 2.98 to 18.53 mg kg^{-1}. Significantly the highest available sulphur was found in groundnut-groundnut cropping system (13.17 mg kg^{-1}), the lowest was recorded in fallow-paddy cropping system (5.33 mg kg^{-1}). The high content of available S in groundnut-red gram can be attributed to the application of gypsum to the groundnut. These soils varying levels of sulphur could be explained by changes in organic carbon and the ongoing removal of sulphur by crops without replacement by sulphur fertilisers (Manasa *et al*., 2020). The results are similar to the findings of Padhan *et al*. (2016), who inferred that sulphur availability is a function of soil organic matter (SOM) content and pH, and is highly influenced by the land use patterns. If the current rate of organic matter depletion and man-made perturbation continues, widespread S deficiency might occur in the near future, since SOM is a major source of S. Sulphur availability found more in soils with higher soil organic carbon due to more addition of roots and plant biomass as compared to the fallow land (Balapande *et al*., 2020).

The available calcium and magnesium in soils under major cropping systems ranged from 1.03 to 9.73 and 1.16 to 5.85 cmol (p^+) kg^{-1} respectively. Significantly the highest available calcium (5.97 cmol (p^+) kg^{-1}) and magnesium (3.04 cmol (p^+) kg^{-1}) was recorded in perennial fodder system, whereas, the lowest was observed in groundnut-groundnut cropping system for both calcium (2.84 cmol (p^+) kg^{-1}) and available magnesium (1.79 cmol (p^+) kg^{-1}).

The highest available calcium was observed in soils of perennial fodder system, as fodder crops requires less calcium for growth and as such have accumulated for utilization by successive groundnut crop and lowest exchangeable calcium was recorded in groundnut-groundnut cropping system which might be due to high depletion of calcium from soils of groundnut crop for pod formation. The soils of perennial fodder systems had the highest levels of available magnesium, which may have been caused by the application of nitrogen and phosphorus fertilisers, which may have a synergistic effect between phosphorus and magnesium. Conversely, groundnut-groundnut cropping systems had the lowest levels of available magnesium, which may have been caused by the common practise of applying gypsum to the groundnut crop at a rate of 500 kg ha^{-1}, which may have a detrimental effect (Charankumar and Munaswamy, 2022). Kumar and Babalad (2017) opined that, improvement in number of pods, growth and development of groundnut depends on increased availability of nutrients.

Micronutrients

Data regarding DTPA extractable micronutrients are shown in Table 3 and depicted in Figure 3. DTPA extractable zinc, copper, iron and manganese of soils under major cropping systems ranged from 0.03 to 1.54, 0.04 to 4.38, 0.57 to 15.27 and 1.68 to17.93 mg kg^{-1}, respectively. Significantly the highest DTPA extractable zinc (0.81 mg kg^{-1}), copper (1.71 mg kg^{-1}), iron (7.64 mg kg^{-1}) and manganese system (12.19 mg kg^{-1}) of soils was found in perennial fodder system, whereas, the lowest DTPA extractable zinc (0.31 mg kg^{-1}), copper (0.38 mg kg^{-1}), iron (2.51 mg kg^{-1}) and manganese system (5.47 mg kg^{-1}) was reported in fallow-paddy cropping system. The highest DTPA extractable micronutrients were found in perennial fodder system compared to crop fields.

High availability of zinc and copper might be due to the presence of relatively more organic materials will increase its availability by providing soluble complexing agents (Zhang *et al*., 2011). The accumulation of organic carbon in the surface soils alter the solubility and availability of iron through a chelation effect, thus preventing iron from oxidation and precipitation, increasing iron availability (Prasad and Sakal, 1991). These results were further supported by Sarkar *et al*. (2000) and Sarkar *et al*. (2001), who reported that positive relation of available iron with organic carbon. Higher biological activity and the chelation of organic molecules, which are generated during the decomposition of organic matter left behind after crop harvest, are the causes of the increased Mn availability.

Table 1. Primary nutrients status of soils under major cropping systems of Chittoor district

S.No.	Cropping system	N (kg ha^{-1})		P_2O_5 (kg ha^{-1})		K_2O (kg ha^{-1})	
		Range	Mean	Range	Mean	Range	Mean
1	Groundnut-Groundnut cropping system	154-274	233	13.27-24.52	19.29	205-354	277
2	Groundnut-Red gram cropping system	164-315	265	25.29-72.45	53.05	298-453	369
3	Paddy-Groundnut cropping system	158-296	242	22.43-74.39	48.69	159-452	347
4	Fallow-Paddy cropping system	105-216	158	16.37-43.61	28.65	154-296	237
5	Paddy-Paddy cropping system	148-262	223	42.58-85.37	72.02	202-415	327
6	Sugarcane-Sugarcane cropping system	148-294	229	12.96-42.48	29.96	117-397	267
7	Perennial fodder system	154-296	258	42.68-82.35	64.85	321-469	387
8	Tomato mono cropping system	128-254	208	20.45-49.43	38.20	225-395	311
9	Mango orchard	168-274	235	25.48-47.32	40.42	174-396	285

Table 2. Secondary nutrient status of soils under major cropping systems of Chittoor district

S.No.	Cropping system	S (kg ha^{-1})		Ca (cmol p(+) kg^{-1})		Mg (cmol p(+) kg^{-1})	
		Range	Mean	Range	Mean	Range	Mean
1	Groundnut-Groundnut cropping system	8.34-18.53	13.17	1.59-5.12	2.84	1.16-3.51	1.79
2	Groundnut-Red gram cropping system	8.36-15.37	12.93	1.79-9.73	5.68	1.27-4.32	2.30
3	Paddy-Groundnut cropping system	5.62-14.25	10.17	1.03-8.85	4.63	1.34-4.17	2.53
4	Fallow-Paddy cropping system	2.98-7.94	5.33	1.38-4.63	3.51	1.25-3.92	2.25
5	Paddy-Paddy cropping system	4.05-8.43	6.18	1.54-7.65	4.22	1.24-4.27	2.47
6	Sugarcane-Sugarcane cropping system	5.87-13.75	8.65	1.27-8.43	4.82	1.23-4.75	2.82
7	Perennial fodder system	4.25-10.58	6.51	2.54-9.24	5.97	1.27-5.85	3.04
8	Tomato mono cropping system	5.32-10.36	7.58	2.15-6.31	3.97	1.36-4.26	2.33
9	Mango orchard	3.57-12.98	6.96	1.32-9.59	5.24	1.24-4.26	2.48

Table 3. DTPA extractable micro nutrients of soils under major cropping systems of Chittoor district

S.No.	Cropping system	Zn (mg kg^{-1})		Cu (mg kg^{-1})		Fe (mg kg^{-1})		Mn (mg kg^{-1})	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	Groundnut-Groundnut cropping system	0.12-1.32	0.53	0.09-2.39	0.49	0.57-7.32	4.17	1.68-9.45	6.26
2	Groundnut-Red gram cropping system	0.29-1.54	0.73	0.08-2.91	1.48	2.98-8.05	4.92	3.57-17.93	11.52
3	Paddy-Groundnut cropping system	0.08-1.35	0.67	0.09-3.25	0.84	2.48-10.76	6.81	6.38-14.85	10.76
4	Fallow-Paddy cropping system	0.03-0.56	0.31	0.05-1.79	0.38	0.86-4.53	2.51	2.84-9.53	5.47
5	Paddy-Paddy cropping system	0.19-1.25	0.44	0.04-1.36	0.56	1.06-7.43	3.92	4.65-13.21	8.63
6	Sugarcane-Sugarcane cropping system	0.29-1.26	0.57	0.07-2.51	0.96	0.95-7.14	4.25	5.43-14.46	9.86
7	Perennial fodder system	0.26-1.37	0.81	0.17-4.38	1.71	1.32-15.27	7.64	5.43-17.56	12.19
8	Tomato mono cropping system	0.19-0.96	0.49	0.15-0.83	0.44	1.27-8.58	4.04	2.75-12.43	7.65
9	Mango orchard	0.32-1.25	0.61	0.05-3.87	0.71	1.25-7.83	4.52	5.21-13.43	9.52

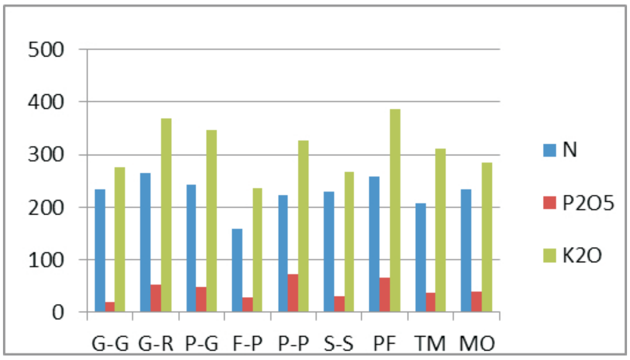

Fig 1. Primary nutrients status of soils in major cropping systems of Chittoor district

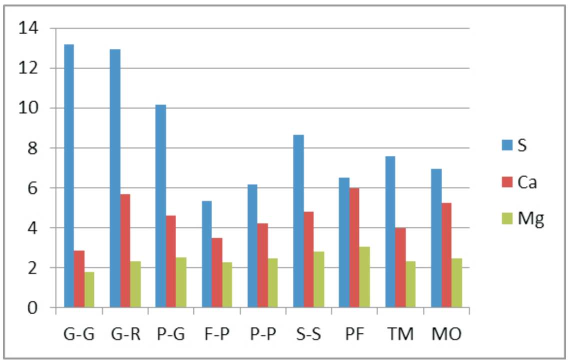

Fig 2. Secondary nutrients status of soils in major cropping systems of Chittoor district

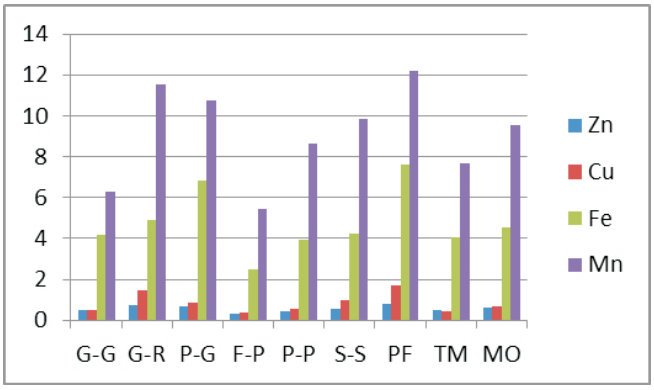

Fig 3. Micro nutrients status of soils in major cropping systems of Chittoor district

Nearly all soils had low levels of available nitrogen, phosphorus and potassium status of the soils under study area was found to be fatty. Available calcium and magnesium was sufficient, whereas, available sulphur and DTPA extractable micronutrients *viz.,* Fe, Mn, Zn and Cu were deficient to sufficient in soils under different cropping systems. Based on the nutrient status assessed by soil testing, fertilizer recommendations must be made to assist maintain soil health, which in turn enhances nutrient availability to crops for improved growth and yield enhancement over time. Without soil testing, under or over application of chemical fertilisers causes agricultural soils to degrade over time, resulting in a severe drop in production of crops.

REFERENCES

Annonymous, 2017.ONU- Organizac aodas Nac oes Unidas.New York:2017. https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html.

Balpande, S.S., R.M. Ghodpage, A.R. Mhashe, W.P. Badole, and S.L. Deotale, 2020. Soil quality of various cropping systems in Rahatmicro watershed of Vidarbha. J. Soils and Crops, **30**(1):185-90.

Chalwade, P.B., V.K. Kulkarni and S.D. Ghuge, 2006. Physico-chemical and macronutrient status of soils. J. Soils and Crops. **16**(1):127-130.

Charankumar, G.R. and V.Munaswamy, 2022. Forms of Potassium and their Distribution under Prominent Cropping Systems of Chittoor District of Andhra Pradesh, India. Indian J. Ecol. **49**(1): 109-113.

Dhamak, A.L., N.A. Meshram, and S.L. Waikar, 2014. Identification of major soil nutritional constraints in Vertisol, Inceptisol and Entisol from Ambajogai tahsil of Beed district. J. Res. Agric. Anim. Sci. **2**(10): 35-39.

Ghosh, P.K., K.K. Hazra, M.S. Venkatesh, C.P. Nath, J. Singh, N. Nadarajan, 2017. Increasing soil organic carbon through crop diversification in cereal-cereal rotations of Indo-Gangetic plain. Proc. Natl. Acad. Sci. India B- Biol. Sci. **89**(1): 429-440.

Hesse, P.R. 1971. A Text Book of Soil Chemical Analysis. John Murray Publishers, London pp. 101.

Jackson, M.L. 1973. Soil chemical analysis. Oxford IBH Publishing House, Bombay. pp.38.

Kumar, B.T.N. and H.B. Babalad, 2017. Conservation agriculture to sustain the productivity and soil health in cotton and groundnut intercropping system. J. Soils and Crops. **27**(1): 24-33.

Kumar, U., V.N. Mishra, N. Kumar, L.K. Srivastava and R.K. Bajpai, 2020. Soil physical and chemical quality under long-term rice-based cropping system in hot humid eastern plateau of India. Commun. Soil Sci. Plant Anal. **10**(01): 2748-2761.

Lindsay, W.L. and W.A. Norvell, 1978. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Sci. Soc. Am. J. **42**: 421-428.

Manasa, V., N.S. Hebsur, P.L. Patil, M. Hebbara, B.N. Kumar and R.Gobinath, 2020. Fertility status of groundnut growing calcareous Vertisols of Dharwad district, Karnataka. Int. Res. J. Pure Appl. Chem. **21**(14): 7-19.

Padhan, D., A.K. Pradhan, M. Chakraborty and A. Sen, 2016. Assessment of the effects of land use pattern on distribution of sulphur fractions in soil. J. Appl. Nat. Sci. **8**(3): 1685-1691.

Patrick, M., J.S. Tenywa, P. Fbanyat, M. M. Tenywa, D.N. Mubiru and T. A. Basamba, 2013. Soil organic carbon thresholds and N management in tropical agroecosystems: concepts and prospects. J.Sustain.Dev. **6**(12): 31-43.

Pradeep, R., G.S Dasog, and V.P. Kuligod, 2006. Nutrient status of some groundnut growing soils of upper Krishna command area, Karnataka. Karnataka J. Agric. Sci. **19** (1): 131-133.

Prasad, P.N.S., C.T. Subbarayappa, V. Ramamurthy and A. Sathish, 2020. Quantifying and mapping of major, secondary and micronutrient status of tomato growing soils in Kolar District, Karnataka using GIS and GPS approach. Int. J. Plant Soil Sci. **14**(1): 14-27.

Prasad, S.N. and R. Sakal, 1991. Availability of iron in calcareous soils in relation to soil properties. J. Indian Soc. Soil Sci. **39**: 658-661.

Pulakeshi, H.B.P., P.L. Patil, G.S. Dasog, B.M. Radder, B.I. Bidari, and C.P. Mansur, 2012. Mapping of nutrients status by geographic information system (GIS) in Mantagani village under northern transition zone of Karnataka. Karnataka J. Agric. Sci. **25**(3):332-335.

Sarkar, D., Abhijit Haldar, Alok Majumdar and M. Velayutham, 2000. Distribution of micronutrient cations in some Inceptisols and Entisols of Madhubani district, Bihar. J. Indian Soc. Soil Sci. **48**: 202-205.

Sarkar, D., S.K. Gangopadhyay, and M. Velayutham, 2001. Soil toposequence relationship and classification in lower outlier of Chotanagpur plateau. Agropedology. **11**: 29-36.

Srivastava, P., D.K. Pal, K.M. Aruche, S.P. Wani, and K.L. Sahrawat, 2015. Soils of the Indo-Gangetic Plains: a pedogenic response to landscape stability, climatic variability and anthropogenic activity during the Holocene. Earth-Sci. Rev. **140**: 54-71.

Subbiah, B.V. and C.L. Asija, 1956. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. **25**: 259-260.

Watanabe, F.S. and S.R. Olsen, 1965. Test for ascorbic acid method for determining phosphorus in water and sodium bicarbonate extracts of soil. Soil Sci. Soc. Am. J. **29**: 677-678.

Zhang, F., Z. Cui, M. Fan, W. Zhang, X. Chen, and R. Jiang, 2011. Integrated soil–crop system management: reducing environmental risk while increasing crop productivity and improving nutrient use efficiency in China. J. Environ. Qual. **40**(4): 1051-1057.

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