International Journal of Tropical Agriculture
Volume 42, Numbers (3-4) • 2024 : pp. 241-247
ISSN: 0254-8755

Studies on Soil Nutrient Status at Different crop growth stages and yield of chia (*salvia hispanica* l.) at different sources and levels of organics

Prabhakar Goni[1], Bhairappanavar S.T.[2] and Prakash Koler[3]

[1]*M.Sc. Student of Agronomy, UAS, GKVK-Bangalore-06* [2]*Professor of Agronomy, College of Agriculture Karekere, Hassan*
[3]*Assistant Professor of Crop Physiology, College of Agriculture Karekere, Hassan*
E-mail: pkap2013uashsn@gmail.com

Abstract: Field experiments was conducted during *kharif* -2019 at College of Agriculture, Hassan, University of Agricultural Sciences, Bengaluru to study soil nutrient status at different crop growth stages and yield of Chia (*Salvia hispanica* L.) at different sources and levels of organics. At 30,60 DAT and at harvest T_9: application of pressmud @15 t/ha recorded significantly higher available nitrogen (500 kg ha^{-1}, 460 kg $ha^{-1}$and 361 kg ha^{-1}, respectively), available phosphorus (108 kg ha^{-1}, 97 kg $ha^{-1}$and 86 kg ha^{-1}, respectively) and available potash (436 kg ha^{-1}, 403 kg $ha^{-1}$and 335 kg ha^{-1}, respectively) followed by T_6: application of vermicompost @ 15 t/ha. Significantly lowest available nitrogen phosphorus and potash was recorded in T_1: application of FYM @ 5 t/ha. This soil nutrient status at different crop stages reflected in significantly higher Grain yield and Straw yield (1277 kg ha^{-1} and 3365 kg ha^{-1}, respectively) followed by T_6: application of vermicompost @ 15 t/ha (1137 kg/ha kg/ha, respectively). Significantly lower grain and straw yield $ha^{-1}$was recorded in T_1: application of FYM @ 5 t/ha (540 kg/ha and 1403 ka/ha).

Keywords: Organic sources, Available nitrogen, phosphorus and potassium

INTRODUCTION

Improving and maintaining soil quality for enhancing and sustaining agricultural production is of utmost importance for world's food and nutritional security. Natural resources viz., land and water available for agricultural production is limited in most of the regions in world. So increasing yields from current limited available land is the only solution in order to feed the increasing population. Integrated plant nutrient supply system is the only possible way, which can reduce the dependency on chemical fertilizers (CF) to attain the sustainable and profitable Improving and maintaining soil quality for enhancing and sustaining agricultural production is of utmost importance for world's food and nutritional security. Natural resources viz., land and water available for agricultural production is limited in most of the regions in world. So increasing yields from current limited available land is the only solution in order to feed the increasing population. Integrated plant nutrient supply system is the only possible way, which can reduce the dependency on chemical fertilizers (CF) to attain the sustainable and profitable. Improving and maintaining soil quality for enhancing and sustaining agricultural production is of utmost importance for world's food and nutritional security. Natural resources *viz.,* land and water available for agricultural production is limited in most of the regions in world. So increasing yields from current limited available land is the only solution in order to feed the increasing population. The increasing cost of CF day-by- day is a serious matter of concern and their frequent application is deteriorating bio-

Article History: Received: 10 October 2024; Revised: 11 Novembmer 2024; Accepted: 14 November 2024; Published: 30 December 2024

physicochemical properties of soil (Mahajan *et al*. 2008). As a result, soil fertility is being diminished gradually. This in turn is leading to reduction in crop yield per unit area. Besides fertilizers, there are several sources of plant nutrients like organic manures and biofertilizers (Sreedevi *et al*. 2013). Use of organic manures produced/prepared from various organic wastes will save our environment as a whole; simultaneously organic wastes can also be managed properly. Moreover, it will enhance soil health which is the balance between soil function for productivity, environmental quality, and plant and animal health (Doran and Zeiss 2000; Doran 2002). Application of organic manures help in mitigating multiple nutrient deficiencies at the same time provides better environment for growth and development by improving in physical, chemical and biological properties of soil (Avitoli *et al*. 2012). In this context, use of organic manures such as press mud vermicompost (VC), farmyard manure (FYM), *etc*. may supply sufficient amount of micronutrients in available form to crops and improve the quality of the agricultural produces (Maynard 1993). Farmyard manure is the most important organic source but its non-availability or high cost necessitates searching of other sources. Farm wastes are potential and cheapest sources of organic matter. Hence, the present investigation was carried out to study the effect of different organic sources on nutrient availability, uptake, yield and economics of Chia.

MATERIALS AND METHODS

A field experiment was conducted during *Kharif*-2019 to Studies on soil nutrient status at different crop growth stages and yield of Chia (*Salvia hispanica* L.) at different sources and levels of organics''. The experimental site is geographically located in the Southern Transitional Zone (Zone-7) of Karnataka and situated between 12° 13′ to 13° 33′ N latitude and 75° 33′ to 76° 38′ E longitude at an altitude of 827 m above mean sea level. The experimental site was red sandy loam with neutral in reaction (pH 7.3) and the electrical conductivity was normal (0.29 dSm^{-1} at 25 °C). The available nitrogen present in the soil was Medium (345 kg ha^{-1}) and the available phosphorus was high 45.6 kg ha^{-1} and potassium 297 kg ha^{-1}.

EXPERIMENTAL DETAILS

To study the Studies on soil nutrient status at different crop growth stages and yield of Chia (*Salvia hispanica* L.) at different sources and levels of organics. The experimental details are as follows

Details of the experiment

Crop	Chia
Variety	Local variety
Replications	Three
Treatments	Nine
Design	RCBD
Gross plot size	5.4 x 3.0 m
Net plot size	4.2 x 2.4 m
Spacing	60 cm x 30 cm
Seed rate	1.5 kg ha^{-1}
Location	College of Agriculture, Hassan.
Season	*Kharif*-2019
Date of transplanting	01^{st} August 2019
Date of harvesting	14^{th}November2019

Treatment details are given below:

T_1: FYM @ 5 t ha^{-1}

T_2: FYM @ 10 t ha^{-1}

T_3: FYM @ 15 t ha^{-1}

T_4: Vermicompost @ 5 t ha^{-1}

T_5: Vermicompost @ 10 t ha^{-1}

T_6: Vermicompost @ 15 t ha^{-1}

T_7: Pressmud @ 5 t ha^{-1}

T_8:Pressmud @ 10 t ha^{-1}

T_9:Pressmud @ 15 t ha^{-1}

RESULTS AND DISCUSSION

Effect of different sources of organic manures on soil nutrient status

Major nutrients

The data on available nitrogen (N), phosphorus (P) and potassium (K) status of soil as influenced by different organics sources and levels are given in table 1 to 3.

Available Nitrogen

At 30 DAT T_9: application of pressmud @15 t/ha recorded significantly greater available nitrogen ha^{-1}(500 kg) which was on par with T_6: application of vermicompost @ 15 t/ha (485 kg) and T_8 pressmud @ 10 t/ha (446 kg). Significantly lower available nitrogen was recorded in T_1: application of FYM @ 5 t/ha (313 kg).(Table-1)

At 60 DAT T_9: application of pressmud @15 t/ha recorded significantly greater available nitrogen ha^{-1}(460 kg) which was on par with T_6: application of vermicompost @ 15 t/ha (456 kg). Significantly lower available nitrogenha^{-1}was recorded in T_1: application of FYM @ 5 t/ha (289 kg).

At harvest T_9: application of pressmud @15 t/ha recorded significantly greater available nitrogen ha^{-1}(361 kg) followed by T_6: application of vermicompost @ 15 t/ha (314 kg). Significantly lower available nitrogen ha^{-1}was recorded in T_1: application of FYM @ 5 t/ha (246 kg).

This might also be partially expected to release of N from organic matter Duffera *et al.*, (1999) and partly due to release of native soil nitrogen. It might also due to the direct addition of N from the decomposition of organic matter leads to mineralization of organically bound nitrogen. The result are confirmative with the findings of Mohanty *et al.,* (2010), Kolahchi *et al.*, (2012).

Increased addition of FYM, Vermicompost and Pressmud increased the soil available nutrients at all different crop stages of crop growth which was expected to release of nutrients coinciding with the crop demand. At later stages mineralization of organic nutrients (FYM, Vermicompost and Pressmud) may synchronize the release of N for crop which helps the growth and development Bipin*et al.*, 2018 and Prabhavathi *et al*., 2018.

Available phosphorus

Application of different sources and levels of organics increased the soil available phosphorus (P) at 30 and 60 DAT and at harvest (Table 2).

At 30 DAT T_9: application of pressmud @15 tha^{-1} recorded significantly greater available phosphorus ha^{-1} (108 kg) which was on par with T_6: application of vermicompost @ 15 tha^{-1} (92 kg). Significantly lower available phosphorus was recorded in T_1: application of FYM @ 5 t ha^{-1}(49 kg).

At 60 DAT T_9: application of pressmud @15 t ha^{-1}recorded significantly greater available phosphorus ha^{-1} (97 kg) which was on par with T_6: application of vermicompost @ 15 t ha^{-1}(82 kg). Significantly lower available phosphorus ha^{-1} was recorded in T_1: application of FYM @ 5 t ha^{-1}(44 kg).

At harvest T_9: application of pressmud @15 t ha^{-1}recorded significantly greater available phosphorus ha^{-1} (86 kg) which was on par with T_6: application of vermicompost @ 15 t ha^{-1}(75 kg). Lower available phosphorus ha^{-1} was recorded in T_1: application of FYM @ 5 t ha^{-1}(38 kg).

The increase in available-P content of soil is mainly attributed to the increase in the (organic matter) content of soil and on its decomposition release of organic acids which facilitates P solubilization. In addition, roots release exudates which convert inorganically bound P into available form. The favorable effect of FYM, Vermicompost and Pressmud on P availability is ascribed to its effect on biotic activity and P release *via* biotic activity. Yadvinder Singh *et al.* (2008) concluded that addition of 60 kg N ha^{-1} along with pressmud cake (5 t ha^{-1}) increased available P contents in soil under rice-wheat cropping system. Md Zahangir Hossain *et al.* (2016) recorded that pressmud and molasses contain different nutrients and can be substituted for phosphatic fertilizers, in crop production, it increases soil availability of P for agricultural crops.

Similar data were recorded by Yaduvanshi and Yadav (1996), Deshmukh *et al.*(2012) resulted that addition of sludge at the rate of 10 t ha^{-1} increased the availability of N, P and K. Borkar *et al*. (1991) studied that the addition of Organic manure increased the microbial activity by reducing the phosphorus fixing in soil, thus making it greater availability to the plants.

Available potassium

Application of different sources and levels of organics increased the soil available Potassium(K) at 30 and 60 DAT and at harvest (Table 3).

At 30 DAT T_9: application of pressmud @15 t/ha recorded significantly greater available potassium per ha (436 kg) and followed by T_6: application of vermicompost @ 15 t/ha (365 kg). Significantly lower available potassium was recorded in T_1: application of FYM @ 5 t/ha (281 kg). At 60 DAT T_9: application of pressmud @15 t/ha recorded significantly greater available potassium per ha(403 kg) and followed by T_6: application of vermicompost @ 15 t/ha (331 kg). Significantly lower available potassium $ha^{-1}$was recorded in T_1: application of FYM @ 5 t/ha (234 kg).

At harvest T_9: application of pressmud @15 t/ha recorded significantly greater available potassium ha^{-1}(335 kg) followed by T_6: application of vermicompost @ 15 t/ha (289 kg). Significantly lower available potassium $ha^{-1}$was recorded in T_1: application of FYM @ 5 t/ha (179 kg).

Increase in K may be the release of K from the applied organic matter on mineralization and from K bearing minerals. Higher available potassium was recorded in pressmud treated plots as pressmud is a rich source of potassium. Increased availability of K on pressmud addition to sugarcane was recorded by Rama Lakshmi *et al.,* (2011). Singh *et al.,* (2015) recorded that organics were superior in improving available K. The experiment are understanding with the findings of Mohanty *et al.,* (2010), Kolahchi *et al.*, (2012), Bipin *et al*., 2018 and Prabhavathi *et al*., 2018.

Grain yield and Haulm yield of Chia crop

Grain yield

Grain yield of Chia differs substantially due to the effect of different organic Sources and levels are presented in table 4.

Among the different organic treatments effect. Application of T_9: pressmud @15 t/ha recorded significantly higher Grain yield ha^{-1}(1277 kg/ha) followed by T_6: application of vermicompost @ 15 t/ha (1137 kg/ha). Lower Grain yield $ha^{-1}$was recorded in T_1: application of FYM @ 5 t/ha (540 kg/ha)

Haulm yield

Among the different organics treatment effect. Application of T_9: pressmud @15 t/ha recorded significantly higher haulm yield ha^{-1}(3365 kg/ha)which was on par with T_6: application of vermicompost @ 15 t/ha (3188 kg/ha and3188 kg/ha, respectively). Significantly lower haulm yield per ha was recorded in T_1: application of FYM @ 5 t/ha (1403 ka/ha).

Harvest index

Harvest index did vary substantially due to the application of Organic sources. Significantly highest harvest index was observed in T_3which was of 0.29 and it is on par with T_4(0.29), T_7 (0.29), T_2 (0.28), T_1 (0.28), T_8 (0.28), T_5(0.28) and T_9(0.27). Treatment T_6 recorded significantly lowest harvest index of 0.26.

Effect of different source of organic addition on grain yield (kg/ha), haulm yield (kg/ha) and harvest index of Chia

The addition of press mud @ 15 t ha^{-1} recorded greater grain yield (1277kg ha^{-1}), which was followed by with vermicompost @ 15 t ha^{-1} (1137 kg ha^{-1}) it's mainly due to addition of pressmud and vermicompost has substantially impact on grain yield (Nehra and Hooda, 2002; Naik and Rao, 2004), who recorded increased plant height in lentil crop due to pressmud addition.

Press mud and vermicompost improved the yield attributing parameters then it increased grain yield and a haulm yield (Shankaraiah and Kalyanamurthy 2005; Rakesh *et al.,* 2015) this might also be due to movement of nutrient supply by more organics, which improves or alters a soil physical, biological and chemical properties by supplying essential food to microbes by Surekha (2007), it also higher availability of soil enzymes, important for the metamorphosis of unavailable form of nutrients to available form (Singh *et al.*, 2006). Similar trend was also showed by Pandey and Tripathi (1993), Salik and Shah (1999).

The suitability of vermicompost and press mud application to soil for boosting plant growth and biological activity is a function of physical and a chemical property which depends on soil organic matter, porosity, water holding capacity and moisture content. Compost addition caused a significant increase of moisture content due to more porosity of the soil (Bazzoffi *et al.,* 1998, Surekha (2007) and Koushalya (2018).

Table 1: Effect of different sources and levels of organics on available Nitrogen status of soil at different crop growth stages

Available N status in soil (kg/ha)			
Treatments	*30DAT*	*60 DAT*	*At harvest*
T_1=FYM @ 5 t ha^{-1}	313	289	246
T_2= FYM @ 10 t ha^{-1}	337	315	258
T_3= FYM @ 15 t ha^{-1}	370	348	279
T_4= Vermicompost @ 5 t ha^{-1}	358	335	266
T_5= Vermicompost @ 10 t ha^{-1}	412	383	296
T_6= Vermicompost @ 15 t ha^{-1}	485	456	314
T_7= Pressmud @ 5 t ha^{-1}	373	356	281
T_8= Pressmud @ 10 t ha^{-1}	446	401	308
T_9= Pressmud @ 15 t ha^{-1}	500	460	361
F - test	*	*	*
SE.m±	**25.08**	**16.66**	**15.58**
CD @ 5 %	**75.19**	**49.95**	46.71

Table 2: Effect of different sources and levels of organics on available Phosphorus status of soil at different crop growth stages

Available P status in soil (kg/ha)			
Treatments	*30DAT*	*60 DAT*	*At harvest*
T_1=FYM @ 5 t ha^{-1}	49	44	38
T_2= FYM @ 10 t ha^{-1}	53	47	40
T_3= FYM @ 15 t ha^{-1}	68	59	57
T_4= Vermicompost @ 5 t ha^{-1}	60	51	46
T_5= Vermicompost @ 10 t ha^{-1}	77	65	61
T_6= Vermicompost @ 15 t ha^{-1}	92	82	75
T_7= Pressmud @ 5 t ha^{-1}	62	56	50
T_8= Pressmud @ 10 t ha^{-1}	83	73	67
T_9= Pressmud @ 15 t ha^{-1}	108	97	86
F - test	*	*	*
SE.m±	**5.29**	**3.49**	**4.52**
CD @ 5 %	**15.85**	**10.46**	13.54

Table 3: Effect of different sources and levels of organics on available Potassium status of soil at different crop growth stages

Available K status in soil (kg/ha)			
Treatments	*30 DAT*	*60 DAT*	*At harvest*
T_1=FYM @ 5 t ha^{-1}	281	234	179
T_2= FYM @ 10 t ha^{-1}	285	260	215
T_3= FYM @ 15 t ha^{-1}	344	320	256
T_4= Vermicompost @ 5 t ha^{-1}	292	286	226
T_5= Vermicompost @ 10 t ha^{-1}	340	318	276
T_6= Vermicompost @ 15 t ha^{-1}	365	331	289
T_7= Pressmud @ 5 t ha^{-1}	319	281	249
T_8= Pressmud @ 10 t ha^{-1}	369	341	283
T_9= Pressmud @ 15 t ha^{-1}	436	403	335
F - test	*	*	*
SE.m±	**14.03**	**10.93**	**12.88**
CD @ 5 %	**42.05**	32.76	38.60

Table 4: Grain yield kg/ha, Haulm yield kg/ha and Harvest index of Chia as influenced by different organic sources and levels

Treatments	*Grain yield kg ha^{-1}*	*Haulm yield kg ha^{-1}*	*Harvest index*
T_1=FYM @ 5 t ha^{-1}	540	1403	0.28
T_2= FYM @ 10 t ha^{-1}	703	1825	0.28
T_3= FYM @ 15 t ha^{-1}	911	2211	0.29
T_4= Vermicompost @ 5 t ha^{-1}	774	1911	0.29
T_5= Vermicompost @ 10 t ha^{-1}	933	2403	0.28
T_6= Vermicompost @ 15 t ha^{-1}	1137	3188	0.26
T_7= Pressmud @ 5 t ha^{-1}	851	2100	0.29
T_8= Pressmud @ 10 t ha^{-1}	955	2422	0.28
T_9= Pressmud @ 15 t ha^{-1}	1277	3365	0.27
F - test	*	*	*
SE.m±	**41.19**	**133.10**	**0.01**
CD @ 5 %	**123.50**	**399.04**	0.02

REFERENCES

AVITOLI, K., SINGH, A.K., KANAUJIA, S.P. AND SINGH, V.B., 2012, Quality production of *kharif* onion (*Allium cepa* L.) in response to fertilizers inoculated organic manures. *Indian Journal of Agricultural Sciences* **82**, 236-240.

BAZZOFFI, P., PELLEGRINI, S., ROCCHINI, A, MORANDI, M. AND GRASSELLI, O., 1998, The effects of urban refuse compost and different tractors tyres on soil physical properties, soil erosion and maize yield. *Soil Till. Res*., **48**: 275-286.

BIPIN BIHARI, RAGINI KUMARI AND SHWETA SHAMBHAVI.2018, Release Pattern of Inorganic N, Phosphorus and Potassium as Influenced by Farmyard Manure and Pressmud Compost under Laboratory Incubation Study. *Int.J.Curr.Microbiol. App.Sci.* 7(09): 2476-2483.

BORKAR, D. K., DESHMUKH, E. S. AND BHOYAR, V. S., 1991, Manurial values of FYM and compost as influenced by raw materials used, methods and period of decomposition. *J. Soils Crops,***1**: 117-119.

DESHMUKH, J. P., POTKILE, S. N., SHINGRUP, P. V. AND PATIL, S. P., 2012, Effect of organic nutrient management on soybean-wheat crop sequence under irrigated condition. *3rd Inter.Agron. Congress*, **2***:* 549-550.

DORAN, J.W. ,2002, Soil health and global sustainability: translating science into practice. *Agriculture, Ecosystems and Environment* **88**, 119-127.

DORAN, J.W. AND ZEISS, M.R. ,2000, Soil health and sustainability: managing the biotic component of soil quality. *Applied Soil Ecology* **15**, 3-11.

DUFFERA, M., ROBARGE, W. P. AND MIKKELSEN, R. L. (1999). Estimating the availability of nutrients from processed swine lagoon solids through incubation studies. *Bioresource technology*. 70(3): 261-268.

KAMBLE, B.M. , KATHMALE D.K. AND RATHOD S.D. ,2018, Soil Nutrient Status, Uptake, Yield and Economics of Groundnut- Wheat Cropping Sequence as Influenced by Organic Sources and Fertilizers. *Journal of the Indian Society of Soil Science.* 1(**66**) 66-75 (2018)

KOLAHCHI, Z., AND JALALI, M. (2012). Kinetics of nutrient release from different organic residues using a laboratory system, *Archives of Agronomy and Soil Science.* 58 (9):1013–1031.

KOUSHALYA, T. N., 2018, *Impact of Treated Sugar Mill Effluent and Soil Amendments on the Productivity of Finger Millet (Eleusine Coracana* L. *Gaertn.).* Diss. University of Agricultural Sciences, GKVK, Bengaluru, 2018.

MAHAJAN, A., BHAGAT, R.M. AND GUPTA, R.D., 2008, Integrated nutrient management in sustainable rice- wheat cropping system for food security in India. *SAARC Journal of Agriculture* **6**, 29-32.

MOHANTY, M., PROBERT, M. E., REDDY, K.S., DALAL, R.C., RAO, A.S. AND MENZIES, N.W., (2010) Modelling N mineralization from green manure and farmyard manure from a laboratory incubation study 19th World Congress of Soil Science, Soil Solutions for a Changing World 24, 1-6 August 2010, Brisbane, Australia.

MOHANTY, M., PROBERT, M. E., REDDY, K.S., DALAL, R.C., RAO, A.S. AND MENZIES, N.W., (2010) Modelling N mineralization from green manure and farmyard manure from a laboratory incubation study 19th World Congress of Soil Science, Soil Solutions for a Changing World 24, 1-6 August 2010, Brisbane, Australia.

PANDEY, N. AND TRIPATHI, R. S., 1993, Effect of agronomic management practices for maximizing rice (*Oryza sativa*) production under vertisols. *Indian J. Agron.*, **38** (3): 470-471.

PRABHAVATHI, N. *Effect of Sugar Industry Solid Wastes on Soil Properties, Growth and Yield of Finger Millet (Eleusine Coracana L.)*. Diss. UNIVERSITY OF AGRICULTURAL SCIENCES GKVK, BENGALURU, 2018.

PRABHAVATHI, N. *Effect of Sugar Industry Solid Wastes on Soil Properties, Growth and Yield of Finger Millet (Eleusine Coracana L.)*. Diss. UNIVERSITY OF AGRICULTURAL SCIENCES GKVK, BENGALURU, 2018.

RAKESH CHOUDHARY, YADAV, L. R. AND PARIHAR, S., 2015, Effect of vermicompost and fertility levels on growth and yield of pearl millet *(Pennisetum glaucum* L.). *Annals Arid Zone,* **54** (*1&2*): 59-61.

SALIK RAM AND SHAH, 1999, Economics of conjunctive use of organics and chemical fertilizer in rice crop grown under shallow lowland situation. *Oryza,* **36** (3): 286-286.

SHANKARAIAH, C. AND KALYANAMURTHY, K. N., 2005, Effect of enriched press mud cake on growth, yield and quality of sugarcane. *Sugar Technol*., **7** (2&3): 1-4.

SINGH, N. J., ATHOKPAM, H. S., DEVI, K. N., CHONGTHAM, N., SINGH, N. B., SHARMA, P. T. AND DAYANANDA, S., 2015, Effect of farm yard manure and press mud on fertility status of alkaline soil under maize-wheat cropping sequence. *African J. Agric. Res*.,**10**(24): 2421-2431.

SINGH, Y., SINGH, C. S., SINGH, T. K. AND SINGH, J. P., 2006, Effect of fertilizer on productivity nutrient uptake and economics of rice (*Oryza sativa*). *Indian J. Agron.*, **51** (4): 297-300.

SREEDEVI SHANKAR, K., SUMATHI, S., SHANKAR, M., USHA RANI,K. AND REDDY, N.N. ,2013, Effect of organic farming on nutritional profile, quality characteristics and toxic parameters of *amaranthus*. *Indian Journal of Horticulture* **70**, 378-382.

YADUVANSHI, N. P. S. AND YADAV, D. V., 1996, Residual effect of pressmud cake with nitrogen on cane yield, juice quality and soil nitrogen in sugarcane ratoon. *J.Indian Soc. Soil Sci.*,**44**(1): 158-160.