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Evaluation of soil fertility status for available sulphur in various location of Myorpur block, district Sonbhadra, Uttar Pradesh, India

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ABSTRACT

Available sulphur status in soils of Myorpur block, district Shonbhadra, Utter Pradesh, India was studied to evaluate soil fertility. For this purpose, thirty soil samples (0-15 cm depth) were randomly collected from 30 different GPS locations. All the collected soil samples were analyzed for pH, Electrical Conductivity, Organic Carbon, available sulphur as per standard procedures. The available S content in soils of shonbhadra district varied from 11.60-33.30 kgha^{-1} with a mean value 21.39 kgha^{-1}. Results reveal that the 90 percent of the soil samples were found under low category (< 22.4 kgha^{-1}) as per nutrients index value. Nutrient Index Value (NIV) of Shonbhadra district was below 1.67 due to acidic soil reaction and low content of organic matter in soil and also due to continuous removal of sulphur by the crops for intense cultivation without using sulphur fertilization. For this reason, enrichment and or modification of soil acidity and organic matter content at desired level, as well as frequent application of sulphur fertilizer during crop growing seasons is essential for reducing or changing sulphur deficiency or status for agricultural crops. Soils would highly need sulphur management through addition of inorganic sulphur, organic manures or sulphonated compost and biocomposts or gypsum, sulphur - solubilizing microbes.

Key Words: *Available Sulphur, Nutrient Index Value, nutrient management and soil analysis*

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I. Introduction

Cropping systems, application of manures and fertilizers and other activities during cultivation are responsible for changes in soil fertility. Soil analysis and consequently fertilizer recommendation (Sultana et al. 2015) is very significant for any cropping system and farm sustainability and this practice

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should be communicated adequately with the farmers and community. It is expected ideally that every farm would be sampled and evaluated for soil analysis and evaluated against soil properties such as soil aggregate stability (Siddique et al. 2017). Any application of chemical fertilizers in cropping system should be justified based on the requirement of crops (plant nutrients requirements) and soils (for example pH, OM status, N mineralization, total N and cation exchange capacity of soils) (Siddique, 2015; Ahmed et al. 2014) Recent agricultural practices with high yielding varieties obviously increase yields and profitability but these practices are responsible for land degradation, soil acidity, water pollution, safe water scarcity, pesticide residual in farm produce, atmospheric and water pollution (Khan et al. 2017; Hossain 2015; Siddique et al. 2014; Kamaruzzaman et al. 2014; Halim et al. 2014; Sultana et al. 2014; Nduwumuremyi, 2013). To avoid these land and physical resource degradation it is essential to evaluate soils characteristics at preferred scales and dimensions such as soil fertility mapping, textural fractions characterization and management zones identification for land areas to support farm management decisions (Siddique 2015; Siddique et al. 2014a). For increasing soil fertility, plant nutrients efficiency and plant nutrients uptake by microorganisms such as arbuscular mycorrhizal fungi (AMF) soil degradation should be avoided at any cost for arable lands (Sultana et al. 2017; Sultana and Siddique, 2015). In addition, the actors involve is production system is also require to be identified for sustainable productivity (Siddique et al. 2015a). Agricultural soils of India do not possess adequate soil fertility because soil nutrients are being depleted regularly for the intensive agricultural practices over the many years. Therefore, soil fertility status need to be estimated and determined frequently as there is prolonged extraction of plant nutrients (macro and micronutrients) by the crops extensively grown in each crop-growing season.

For the management of soil fertility, level of fertility of arable lands is imperative and level of fertility based on soil analysis can facility soil management at farm level. However, status of fertility is usually determined by the presence and or absence of plant nutrients, i.e., macro and micronutrients that are necessary for plants. Only adequate and or balanced nutrients availability in soils can ensure higher level of farm profitability and crop yield returns; and helps. Goovaerts (1998) stated that ''soil test-based fertility management is an effective tool for increasing productivity of agricultural soils that have high degree of spatial variability resulting from the combined effects of physical, chemical or biological processes". Nevertheless, the wider adoption of fertilizer recommendation by soil test based approach is constraints in many ways at farmer level in the developing countries (Sultana et al. 2015). For developing countries like India and Bangladesh, these constraints include the persistence of stallholder management systems, absence of skilled human resource, extension activities, lack of infrastructural facilities such as soil analysis laboratories in district and sub-district level to facilitate extensive soil testing (Sultana et al. 2015; Sen et al. 2008). There is no doubt that soil test based fertilizer recommendation is essential in farming systems of Asia and beyond to uphold productivity and maintain farm soil fertility. In some developing countries, there are soil fertility maps, which are meant for highlighting/interpreting the nutrient status(s) as well as plant nutrient(s) requirement assumption decisions. Based on soil fertility status of arable lands, these maps prevails also adverse land conditions, which require attention of planners for improvement. However, soil test values are used to determine soil nutrients status critical levels such as low, medium and high level of nutrient (Welch et al. 1987). The recent technologies like Global Positioning System (GPS) thus have much to offer for preparing soil fertility maps.

In consideration to Indian agriculture, after nitrogen, phosphorus and zinc, sulphur is considered the fourth most important plant nutrient. This nutrient element is known for protein synthesis, synthesis of plant oils, vitamin and flavored compounds. The building blocks of protein, amino acids such as Methionine (21% S), Cysteine (26% S) and Cysteine (27% S), are the three main constituents of Sulphur. Plant sulphur in 90% of cases present as these amino acids. In addition, the formation of chlorophyll, glucosides and glucosinolates (mustard oils), activation of enzymes and sulphydryl (SH-) linkages that are the source of pungency in onion, oils, etc., sulphur play a significant role. Tondon (1995) mentioned that in India sulphur deficiency found in about 40% of arable land areas. Until these days, sulphur deficiency is becoming evident and widespread; and several agricultural and farm management practices are responsible for this status of sulphur in India. For example, higher level of intensive cropping patterns/practices in irrigated areas and there in such systems developed a wide gap between addition and removal of sulphur from soils. On the other hand, some crops such as pulses and oilseeds, which require more sulphur in per unit of crop area and or produced and the acreage under these crops have been increased greatly. Nevertheless, these pulse and oilseed growing areas are not usually as fertilized as other crops of the area such as irrigated cereals. Moreover, the fertilizer use pattern that is underway lacks sulphur fertilizers in most of the cases. While the role and importance of sulphur fertilizer is gaining interest in India because it contribute in crop production, which is not only for the pulses, oilseeds, legumes and forages but also for many other cereals that are producing in the country (Singh et al. 2000). To be more precise, only adequate sulphur in arable lands can ensure the full potential of crops in terms of yield, grain quality or associated protein content; and also facilitate the efficient use of applied nitrogen in arable lands (Sahota, 2006). In the arable lands of India, use of nitrogenous fertilizer is somewhat higher in many areas; this continuous use of nitrogen fertilizer without supplemental sulphur on low sulphur soils responsible for yield quality such as can reduce flour quality of wheat(Ruiter and Martin, 2001; Flaete et al., 2005). More specifically, sulphur does not affect only nitrogen utilisation and grain quality of crops, but it also play significant role in the formation of protein and the baking quality of winter wheat (Ryant and Hřivna, 2004). Therefore, this study was undertaken to evaluate soil fertility with special prevalence to soil sulphur in Myorpur block, District Sonbhadra, Uttar Pradesh, India.

II. Materials and Methods

Experimental site characteristics: The largest district of Uttar Pradesh is Sonbhadra. It has geographical land area 6788 square kilometer. Sonbhadra average height from sea level is 285 feet. This district average rainfall 1036.6, temperatures in summer 10-45^{0}C and temperature in winter 8-25 ^{0}C. Renukut is located at 24°12' of Northern latitude and 83°02' Eastern latitude. It has an average elevation of 283 meters (931 feet). Summers peak in May and June. Renukut has the largest integrated Aluminum plant in Asia. Monsoon generally sets in the First week of June and last up to last week of September. 90-95 percent rainfall is received during June to September. The temperature begins to rise from the first week February and reaches it maximum by the middle of May or end of June. The location maps of the study area were shown in Figure 01.

Soil sampling and processing: Surface soil samples (0-15cm) of arable lands from the thirty different locations were collected using probe anger following grid-based method. The sampling points in each village of study area were selected on the basis of flat terrain agricultural land and far from major roads of the area. The locations from where soil samples were collected, recorded by a global positioning system (GPS). The sampling sites fall within 10 km circle of the Aluminium plant. The collected soil samples were air - dried at room temperature, ground, sieved using a 2 mm mesh sieve and then bagged using polyethylene bag in readiness for laboratory soil analysis.

Laboratory analysis: pH and electrical conductivity (EC) was measured following the methods described by Piper (1967) and Jackson (1973) respectively. Organic matter (OM) and Organic carbon was determined by following the method, chromic acid rapid titration, described by Walkley and Black (1934). Organic carbon content was estimated by using the following formulae:

Organic carbon (%) = (X-Y) X0.003/100/2
Where, X = Blank reading and Y = Titrated value

Available sulphur in studied soil was determined by the $CaCl_2.H_2O$ (0.15% Solution) by turbid metric method described by Williams and Steinbergs (1969).

III. Results and Discussion

Descriptions of results obtained after soil analysis (pH, EC, OM and available sulphur) are presented in Table 02. While limits for the soil test values used for rating the studied soil analysis results are shown in Table 1. However, soil pH is an important chemical parameter as it helps in ensuring availability of plant essential nutrients (Deshmukh, 2012). The pH of soil was varied from 5.2 to 8.5 with a mean value of 6.67 (Table 02). This indicates moderately acidic soil reaction (pH). The pH of soil samples was found to be 22 % of sample showed moderately acidic, 20 % samples were slightly acidic, 50% samples were very acidic, while 7% samples were nearly neutral and only 2% samples were slightly alkaline in nature.

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The soils are acidic might be as a result of the leaching of basic cation or due to incessant uptake by crops grown on the field (Brady and Weil, 2002).

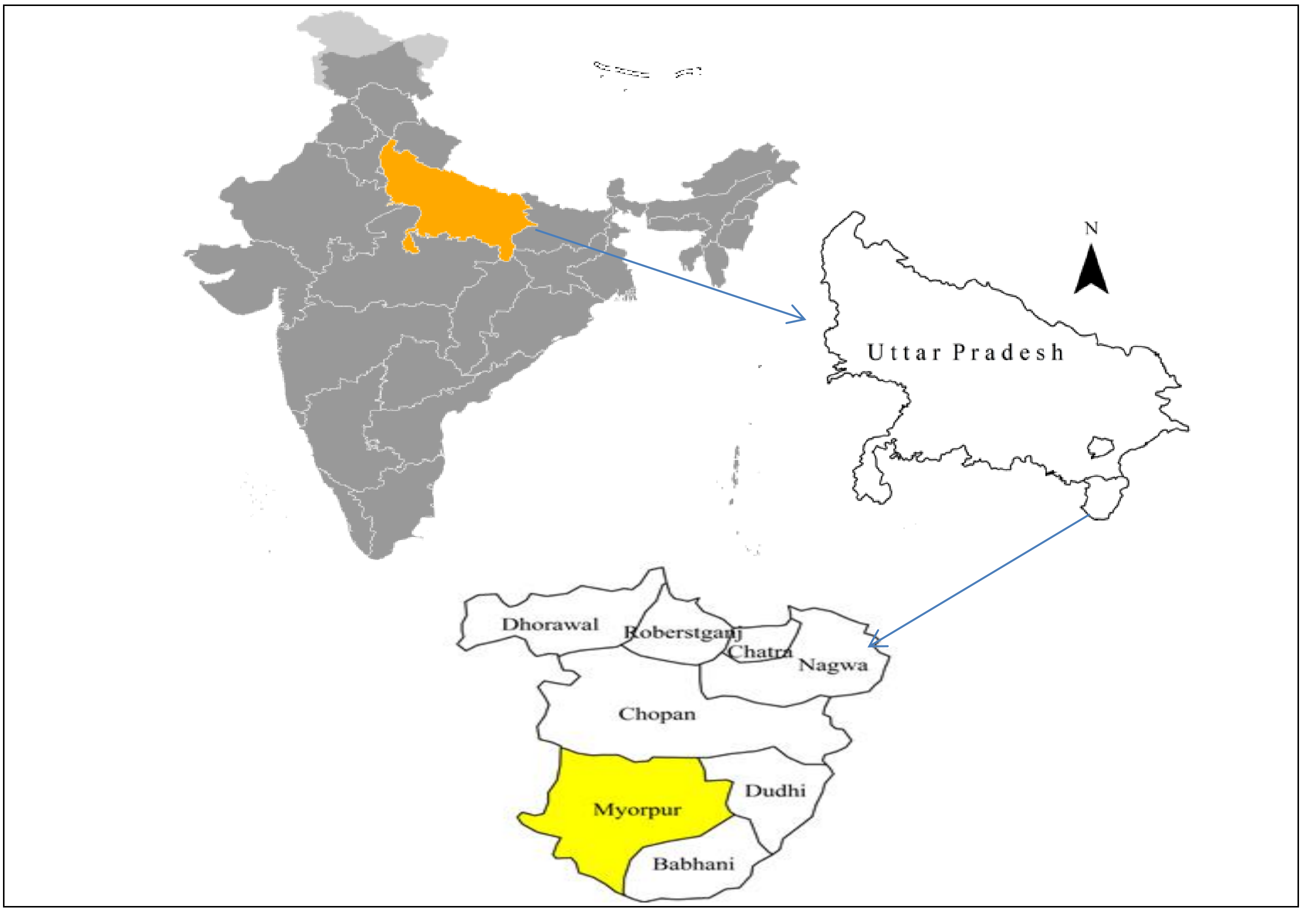

Figure 01. Experimental site Myorpur, Uttar Pradesh, India.

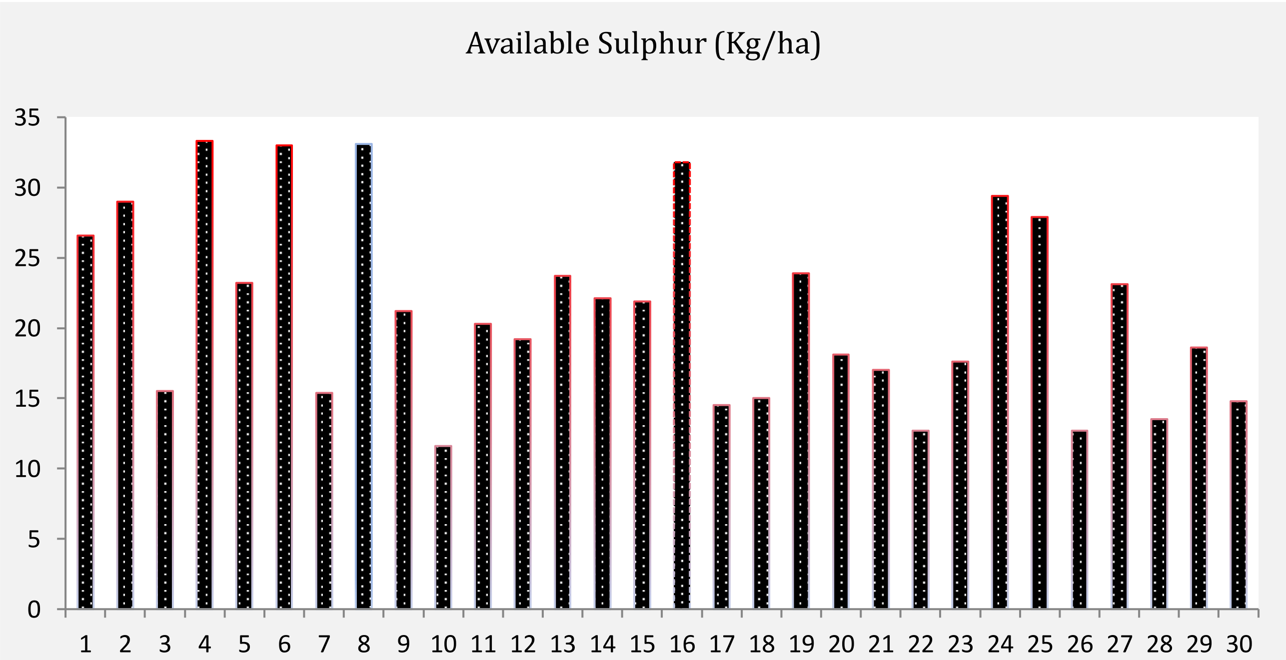

Figure 02. Available sulphur content in different samples.

Table 01. Limits for the soil test values used for rating the studied soil analysis results.

<table>
<tr><td colspan="8">Classification for pH values</td></tr>
<tr><td>Strongly acid</td><td>Moderately</td><td colspan="2">Slightly acid</td><td colspan="2">Neutral</td><td colspan="2">Slightly alkaline</td></tr>
<tr><td>5.5</td><td>5.5-6.5</td><td colspan="2">6.5-7.5</td><td colspan="2">7.5-8.5</td><td colspan="2">>8.5</td></tr>
<tr><td colspan="8">Classification for Total Soluble Salt Content (EC as dS m^{-1})</td></tr>
<tr><td><0.1</td><td colspan="2">0.1-0.2</td><td colspan="2">0.2-0.3</td><td colspan="3">>0.3</td></tr>
<tr><td>Parameters</td><td colspan="2">Very Low</td><td colspan="2">Low</td><td colspan="2">Medium</td><td>High</td></tr>
<tr><td>Organic carbon (%)</td><td colspan="2">0.25</td><td colspan="2">0.25-0.50</td><td colspan="2">0.50-0.75</td><td>>0.75</td></tr>
<tr><td colspan="3" rowspan="2">Available S kg ha^{-1}</td><td colspan="2">Deficient</td><td colspan="2">Sufficient</td><td>High level</td></tr>
<tr><td colspan="2"><22.4</td><td colspan="2">22.4-35</td><td>>35</td></tr>
<tr><td rowspan="2">Available S mg kg^{-1}</td><td colspan="2">Very Low</td><td>Low</td><td>Medium</td><td colspan="2">High</td><td>Very High</td></tr>
<tr><td colspan="2"><4</td><td>4-10</td><td>10-20</td><td colspan="2">20-50</td><td>>50</td></tr>
</table>

Table 02. Composition of Soils of Myorpur, Sonbhadra district, India

Locations	Sampling location GPS reading	pH	EC (d Sm^{-1})	Organic Matter (g kg^{-1})	Available S (kg ha^{-1})	Sulphur rating
Patritola	N24^0 07.156 ' E 83^0 0.941'	7.1	1.190	1.40	26.6	Medium
Myorpur	N24^0 07.729 ' E 83^0 0 .031'	7.2	0.752	2.40	29.0	Medium
Rajpahari	N24^0 09.271 ' E 8303.520'	6.9	0.328	1.80	15.5	Low
Labhari	N24^0 12.491' E 8356.966'	7.4	0.452	3.96	33.3	Medium
Balliary	N24^0 07.080' E 83^0 04.241'	5.9	0.521	2.06	23.2	Medium
Balliary	N24^0 07.404' E 83^{0}03625'	7.1	0.325	1.94	33.0	Medium
Patritola	N24^0 07.094 ' E 83^{0}02.799'	5.4	0.840	2.52	15.4	Low
Balliary	N24^0 07.524' E 83^{0}03.423'	5.7	0.230	1.51	33.1	Medium
Myorpur	N24^0 06.923' E 83^{0}09.555'	6.4	0.880	1.70	21.2	Low
Patritola	N24^0 07.118 ' E 83^{0}02.741'	5.9	0.156	3.0	11.6	Low
Navatola	N24^0 06.690 ' E 83^{0}04.839'	7.3	0.370	2.41	20.3	Low
Navatola	N24^0 06.934 ' E 83^{0}04.996'	5.2	0.440	5.90	19.2	Low
Navatola	N24^0 06.729' E 83^{0}04.857'	7.0	0.136	2.13	23.7	Medium
Balliary	N24^0 07.265 ' E 83^{0}03.849'	8.5	0.284	2.08	22.1	Low
Rajpahari	N24^0 08.523' E 83^{0}04.437'	5.2	0.140	2.28	21.9	Low
Kharpatthar	N24^0 14.247' E 83^0 04.249'	7.2	0.786	2.28	31.8	Medium
Makara	N24^{0}12.787 ' E 83^{0}57.719'	8.3	1.430	5.86	14.5	Low
Sidhwa	N24^0 12.796 ' E 83^{0}45.292'	6.5	0.156	4.03	15.0	Low

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Sidhwa	N24^0 12.803' E 83^{0}56.390'	5.7	0.147	3.17	23.9	Medium
Bairpan	N24^0 12.817 ' E 83^{0}53.586'	7.0	0.760	3.48	18.1	Low
Hathwnia	N24^0 16.056 ' E 83^{0}05.785'	6.3	0.220	2.55	17.0	Low
Hathwnia	N24^0 06.679 ' E 83^{0}05 849'	7.1	0.744	2.26	12.7	Low
Shaudhi	N24^0 16.257' E 83^{0}05.932'	6.1	0.282	6.06	17.6	Low
Shaudhi	N24^0 16.049 ' E 83^{0}05.795'	6.8	0.523	3.06	29.4	Medium
Dhaulinala	N24^0 14.498' E 83^{0}04.486'	6.4	0.402	3.86	27.9	Medium
Dhaulinala	N24^0 18.909' E 83^{0}06.813'	6.3	0.361	4.93	12.7	Low
Dhaulinala	N24^0 13.418 ' E 83^{0}04.347'	6.1	0.245	3.89	23.1	Medium
Dhaulinala	N24^0 13.022 ' E 83^{0}04.588'	7.4	0.390	4.44	13.5	Low
Hathnia	N24^0 15.086 ' E 83^{0}04.849'	6.9	0.354	3.97	18.6	Low
Hathnia	N24^0 19.196 ' E 83^{0}09.101'	7.3	0.435	3.30	14.8	Low
Range		*5.2-8.5*	*0.125-1.19*	*1.40-5.9*	*11.60-33.30*	
Mean		*6.67*	*8.19*	*3.0*	*21.39*	
S.D. ±		*0.84*	*41.9*	*2.80*	*21.32*	
C.V.		*12.73*	*19.41*	*63.98*	*6.7*	

Organic carbon

The organic matter content varied from 1.40 to 5.90 g/kg with a mean of 3.0 g/kg. The lower contents of organic carbon might be resulted because of high temperature, which induced rapid rate of organic matter oxidation and decomposition. While the declining trend towards to accumulation of crop residues every year is also a reason for decline in organic matter.

Available sulphur

The available sulphur varied from 11.60 to 33.30 kgha^{-1} with a mean value of 21.39 kgha^{-1}. Out of 30 soil samples of the district, 18 soil samples were found under low and rest 12 soil samples were found under medium categories for available sulphur. Available sulphur was low in status (Figure 02 and Table 02). The high acidity and low content of organic matter in the soil as well as continuous removal of sulphur by the crops due to intense cultivation without adding sulphur element might be the cause of low amounts of sulphur. Soils of study area would highly need sulphur management.

Nutrients index (NI) for sulphur

The NI of sulphur level into low, medium and high was calculated following Muhr et al. (1965) by using the following formulae:

$$\text{Nutrient index (N. I.)} = (NL\times1+NM\times2+NH\times3)/NT$$

Where, NL = number of samples falling in low, NM = number of samples falling in medium and NH = number of samples falling in high. NT is total number of samples analyzed for a given area. During the percentage assessment, a NI less than 1.67 denotes low category and that falling between 1.67 and 2.33 represents the medium fertility class. Value of 2.33 and above (maxi 3.00) signifies a high fertility class in respect of the particular nutrient (Ghosh and Hasan, 1976).The rating of soil test value for the three levels was done following Ramamooarhy and Bajaj (1969). NI value of Myorpur, district Shonbhadra were found below 1.67 indicating low sulphur fertility status of soils.

IV. Conclusion

Lack of knowledge and importance about sulphur among farmers, exhaustive and high yielding cultivars of crops and avoiding usage of farmyard manures seems to have terminated to a wide occurrence of sulphur deficiency. It is obvious that the soil available sulphur varied with variation in soil properties of different locations of Myorpur block. It was observed that the soils of Shonbhadra district have low status of available sulphur indicating the need to supply sulphur fertilizer to meet sulphur requirement of crops. Soils would highly need sulphur management through addition of inorganic S, organic manures or sulphonated compost and biocomposts or gypsum, sulphur - solubilizing microbes.

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