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Effect of silicon solubilizing bacteria on availability of nutrients with different sources of organic residues under *Pongamia pinnata* (Karanj)

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Abstract
The present study was undertaken to investigation "Effect of silicon solubilizing bacteria with organic N inputs on fertility status of soil and growth of *Pongamia pinnata*" (Karanj) was carried out during 2017 – 2018. There were nine treatments comprising of SSB and organic residues. The treatments were replicated for four times.It was observed that, the application of 5 ml SSB along with 200 g N from V C tree^{-1} increased availability of N, P and K. Organic carbon content of soil was also improved due to application of 5 ml SSB along with 200 g N from V C tree^{-1}. Thus, 5 ml SSB along with 200 g N from V C tree^{-1} improved the soil health by improving the soil chemical properties of soil.

Keywords: Silicon solubilizing bacteria, organic residue, availability of nutrients

Introduction
Karanj (*Pongamia pinnata*) is the fastest growing leguminous tree with the potential for high oil seed production which belongs to family Fabaceae. It's native habitat is in tropical and temperate Asia. The plant is most likely originated in India and where it is one of the most popular oil seed plant. Karanj is also known as Beech, Pongam, Honge, Kanj. 'Pongamia' name is derived from Tamil name of plant viz, 'pongam' or 'pungam'. In latin "pinnata' means 'feathered' and 'glabra' means without hair. It is a nitrogen fixing tree that produces seeds containing 25-30 per cent oil. It is often planted as an ornamental and shade tree.

The silicon in silicate minerals is surrounded by four oxygen atoms in tetrahedral fashion. The primary and secondary silicate minerals in rocks are mineralized through microbial metabolism and chemical reaction, where the silica is converted and made available to plant. Bacterial metabolic activity in relation to micronutrient fixation in plants is the predominant role in this PGPR organism like iron bacteria, sulphur bacteria, silicon solubilizing bacteria. Bacteria when applied to root, cause alternation in the rhizosphere, where its population persist and has continuously increases in the ecosystem. Silicon solubilizing bacteria can play efficient role by solubilizing insoluble forms of silicates hence, increasing soil fertility and enhancing plant defence mechanism. Efficient silicate solubilizing bacteria can help release other essential nutrients in soil. Hence, the present study was planned to find out the effect of silicon solubilizing bacteria on availability of nutrients under the different sources of silica.

Material and Methods
The present investigation entitled "Effect of silicon solubilizing bacteria on availability of nutrients with different sources of organic residues under *Pongamia pinnata*." was carried out during 2017-18 at Agroforestry Research Farm, College of Agriculture, Nagpur. The layout of experiment at field was laid out in randomized block design with nine different treatments which were replicated thrice. Different organic residues viz., FYM, VC, bamboo litter, teak litter, CDS and compost were selected as silicon sources. The treatments were T_1- absolute control, T_2- 5 ml lit^{-1} tree^{-1} SSB, T_3- 5 ml SSB + 200 g N tree^{-1}, T_4- 5 ml SSB + 200 g N from FYM tree^{-1}, T_5- 5 ml SSB + 200 g N from VC tree^{-1}, T_6- 5 ml SSB + 200 g N from bamboo litter tree^{-1}, T_7- 5 ml SSB + 200 g N from teak litter tree^{-1}, T_8- 5 ml SSB + 200 g N from CDS litter tree^{-1} and T_9- 5 ml SSB + 200 g N from compost tree^{-1}.

The samples organic sources of were then analyzed for nutrient content. As per treatments the organic residues were applied in the soil. From the N content of organic residue the quantity required for 200 g N was calculated. 5 ml SSB was mixed in about one litre water and was then mixed in the organic residue. This mixture was then incorporated in the soil and was mixed well with the help of spade. Irrigation was given as and when required.

Results and Discussion

The experiment was initiated in May 2018. The initial composite soil sample was collected from the experimental plot and analysed soil properties. The data revealed that the pH of experimental soil was neutral and EC of the soil was found moderately low. The values of available nitrogen, phosphorus and potassium content in initial soil sample were also recorded. It was found that, available N and P of initial soil was 190.89 kg ha^{-1} and 12.35 kg ha^{-1} which were found in low level while K of initial soil was 325.19 kg ha^{-1}. The available sulphur and silicon content in initial soil sample observed to 15.25 mg kg^{-1} and 175.68 mg kg^{-1}.

Nutrient content of different organic sources

In the present investigation FYM, VC and CDS were procured from AHDS Department whereas compost, bamboo litter and teak leaf litter were taken from Agroforestry Research Farm, Nagpur. Silicon Solubilising Bacteria (SSB) used in this study is a product of VSI, Manjari, Pune and it was collected from there. The samples of organic sources were then analyzed for nutrient content. It was found that, the highest organic carbon was present in teak leaf litter followed by bamboo litter, whereas highest level of N was observed in VC, the highest C: N ratio was observed in FYM and the lowest one was observed in VC. Anonymus (2011) [1] concluded that, understanding C:N ratios of crop residues and other material applied to the soil is important to manage soil cover and crop nutrient recycling, providing quality habitat for soil micro-organisms should be the goal in improving soil. Sharma *et al*., (2009) [8] reported that the highest available NPK content was observed in case of treatments receiving Vermicompost at 10 t ha^{-1} to and FYM at 25 t ha^{-1}.

Table 1: Nutrient content of different organic sources

Residues	OC %	N%	C:N	P%	K %
Vermicompost	20.05	1.85	10.84	1.91	2.00
Compost	20.89	1.20	17.40	1.00	1.97
Cow dung slurry	47.68	0.50	25.00	0.40	0.50
Farm Yard Manure	20.10	0.50	40.20	0.20	0.50
Bamboo litter	35.50	0.89	36.60	0.072	0.40
Teak litter	35.81	1.00	35.81	0.30	0.40

Effect of silicon solubilizing bacteria and organic N inputs on soil physico- chemical properties and availability of nutrients

Organic residues have a significant effect on soil properties such as improving soil aggregation and increasing soil water holding capacity and also increasing the exchange and buffering capacity of soils. Along with these residues it has also been suggested that the organosalicic compounds play a specific role in organic matter formation.

pH and EC (dSm^{-1})

Soil pH is an important intrinsic property of soil which usually does not change easily. However, long term use of organic materials/inputs has been associated with the decrease in soil pH. Result revealed that soil pH and EC was non significantly influenced by the incorporation of various organic nutrient sources.

Table 2: Effect of silicon solubilizing bacteria and organic N inputs on chemical properties of soil (2017-18).

	Treatment	pH	EC (dS m^{-1})	O.C (g kg-1)
T_1	Absolute control	7.17	0.12	4.87
T_2	5 ml $lit^{-1}tree^{-1}$ SSB	7.15	0.12	5.18
T_3	5ml SSB +200 g N $tree^{-1}$	7.16	0.13	5.34
T_4	5mlSSB +200 g N from FYM $tree^{-1}$	7.12	0.12	6.42
T_5	5mlSSB+ 200g N from VC $tree^{-1}$	7.09	0.12	6.65
T_6	5ml SSB +200 g N from Bamboo litter $tree^{-1}$	7.13	0.12	6.39
T_7	5ml SSB + 200 g N from Teak litter $tree^{-1}$	7.10	0.12	5.73
T_8	5ml SSB + 200 g N from Cow dung slurry $tree^{-1}$	7.09	0.12	5.97
T_9	5ml SSB + 200 g N from Compost $tree^{-1}$	7.07	0.12	6.24
S. E. ±		0.009	0.001	0.03
C. D. @5 %		-	-	0.07
Initial		7.12	0.12	4.91

After application of treatment the highest soil pH value was(7.17) in treatment T_1- absolute control while, the highest EC of soil was (0.125 dSm^{-1}) was observed in treatment T_7 5 ml SSB along with 200 g N from teak leaf litter. The lowest values of pH and EC were observed in treatment T_1 absolute control. Mponya *et al*., (2014) [6] reported that, the application of vermicopmost @ 15 t ha^{-1} recorded soil pH 7.6 than the control value of pH8.4. Srikant *et al*., (2000) [10] also reported that, the application of various organic sources FYM, Compost recorded the soil pH between 6.66 to 7.04.

Organic carbon (g kg^{-1})

The result obtained of soil organic carbon as influenced by various treatments is presented in table 2. Different treatment combinations significantly improved the OC content of soil. The value of soil OC ranged from 4.87 to 6.65 g kg^{-1} after application of different organic residue along with SSB to *Pongamia pinnata*. It was found that, there was increase in OC content of soil in different treatments except control where there was depletion in OC. Regarding different treatments, it was observed that, treatment T_5 receiving 5 ml SSB along with 200 g N through VC $tree^{-1}$recorded highest OC content i.e (6.65 g kg^{-1}); while, the lowest (4.87 g kg^{-1}) was recorded under treatment T_1 which was absolute control. Treatment T_5 recorded 26.17 per cent increment over initial value and 26.76 per cent over control. Treatment T_5 receiving 5ml SSB along with 200g N through VC $tree^{-1}$ was found significantly superior over other all treatments for OC content. In all the order of OC content in different treatments combinations was observed as $T_5>T_4>T_6>T_9>T_8>T_7>T_3>T>T_1$.

Though organic carbon content in VC was lower as compared CDS and bamboo and teak litter; but after treatment application OC content found more in VC applied plot. The VC which is product of non thermophilic biodegradation of joint action of earthworms and hormones might have resulted in increased OC content of soil (Erashin *et al*., 2009) [3]. Ilkar *et al*., 2016 [4] also observed increased OC content of soil by application of VC against FYM. Srikant *et al*., (2000) [10] reported that, incorporation of various compost resulted in increase in organic carbon over control.

Available nitrogen

Nitrogen is the pre-requisite and most important nutrient for growth of *Pongamia pinnata*. It is needed in adequate amounts especially at initial growth stage.

The results revealed that, available nitrogen ranged from 191.25 kg ha^{-1}to 299.54 kg ha^{-1} during course of study. Significantly highest soil available nitrogen was299.54 kg ha^{-1} observed in treatment T_5 receiving 5ml SSB along with 200 g N from VC tree^{-1}, followed by treatment T_9 277.22 kg ha^{-1} with application of 5 ml SSB along with 200g N from composttree^{-1}. While, treatment T_7 ranked third by recording 259.68 kg ha^{-1} available nitrogen which was at par with treatment T_6 and T_4. The lowest available nitrogen 191.25 kg ha^{-1} was recorded without addition of any inputs in T_1 i.e. absolute control. Treatment T_5 recorded 36.27 per cent and 36.15 per cent increment in available nitrogen over initial and control values respectively.

The organic matter applied to the soil not only increases OC content of soil but also enriches soil with N, P, K, etc. (Zakir *et al*., 2012) [12]. Among various sources used in study VC was the most concentrated source of nitrogen along with P and K. This might be the reason behind highest availability of nitrogen in treatment T_5. Shwetha and Narayana (2014) [9] conducted an experiment on paddy where they found that increased availability of nitrogen with application of VC compare to FYM and inorganic fertilizers.

Table 3: Effect of silicon solubilizing bacteria and organic N inputs on availability of nutrients (kgha^{-1}) in soil

Treatment		N	P	K
T_1	Absolute control	191.25	12.37	327.10
T_2	5 ml lit^{-1} tree^{-1} SSB	205.29	13.07	329.67
T_3	5 ml SSB +200 g N tree^{-1}	229.84	13.67	341.83
T_4	5 ml SSB +200 g N from FYM tree^{-1}	254.41	14.13	350.83
T_5	5 ml SSB+ 200g N from VC tree^{-1}	299.54	15.64	356.77
T_6	5 ml SSB +200 g N from Bamboo litter tree^{-1}	259.67	14.88	345.63
T_7	5 ml SSB + 200 g N from Teak litter tree^{-1}	259.68	17.15	348.03
T_8	5 ml SSB + 200 g N from Cow dung slurry tree^{-1}	238.63	15.29	341.43
T_9	5 ml SSB + 200 g N from Compost tree^{-1}	277.22	15.35	346.10
S.E. ±		1.79	0.10	0.28
C.D.@ 5%		5.26	0.29	0.83
Initial		190.89	12.35	325.19

Chitra and Sharavanan (2014) [5], reported that, phosphate solubilizing bacteria (PSB) plays an important role in soil by solubilizing phosphorus and making it available to plants. PSB are potential solubilizers of bound phosphates in soil and vary in their ability to solubilize di and tricalcium phosphate and organic carbon. Further it was correlated with soil nutrients like total nitrogen, organic carbon, available phosphorous contents.

Available phosphorus

There was positive impact of SSB and organic residues on availability of phosphorus in soil. The significantly highest soil available phosphorus (17.15 kg ha^{-1}) was observed in treatment T_7 with application of 5 ml SSB and 200g N from teak litter tree^{-1} and the second next highest treatment T_5 recorded 15.64 kg ha^{-1} available phosphorus which received 5 ml SSB and 200 g N from VC tree^{-1}. Treatment T_7 was found significantly superior over other treatments. It recorded 27.98 per cent and 27.87 per cent more available phosphorous than found in initial soil and control plot. The basic mechanisms considered for phosphate solubilization are mediated by production of organic acids (gluconic acid etc) assimilation of ammonium ion or phytase activity. The compost used in the study was made up from forest leaf litter. Though it contains lesser phosphorous than VC its decomposition might have resulted in liberation of different organic acids and thus helped to solubilized more phosphorous from soil. Takeda *et al*., 2009 observed enhanced soil phosphatase activity was enhance in compost applied plots which resulted in higher available phosphorous in compost treated plots. They also observed increased fungal population in compost treated plots which might have resulted in solubilization of phosphorous from organic as well as inorganic sources. Sarkar *et al*., (2010) [7] who reported highest available phosphorous in the soil with Teak leaf litter.

Available potassium

The availability of potassium among all the treatments ranged from 327.10 kg ha^{-1} to 356.77 kg ha^{-1}. The observations recorded on soil K content revealed that, during the year of study various treatments of SSB along with different organic residues had significantly influenced the availability of potassium in soil. The significantly superior available potassium (356.77 kg ha^{-1}) was recorded in treatment T_5 which received 5 ml SSB + 200 g N from VC from tree^{-1} as soil application. While, the lowest available potassium was recorded in treatment T_1 without any external inputs (327.10 kg ha^{-1}). Treatment T_4 with application of 5ml SSB + 200 g N from FYM tree^{-1} (350.83 kg ha^{-1}) stand second while treatment T_7 with application of 5 ml SSB and 200 g N from teak leaf litter ranked third by recording 348.03 kg ha^{-1} available potassium treatments T5 which was significantly superior over other treatments recorded 8.85 per cent available potassium than initial values and 8.31 per cent increased availability of potassium over control.

Bahadur *et al*., (2014) [2] reported that, the organic and inorganic acids convert insoluble K (mica, muscovite, biotite feldspar) to the solubleform of K (soil solution form) with the net result increasing the availability of nutrients to plant. Production of inorganic acids also helps the solubilization, these acids convert insoluble K (mica, muscovite, biotite and feldspar) to soluble form of K (soil solution form) with the net result increasing the availability of the nutrients in to the soil for plants. The increasing available K in soil due to addition of organic sources may be described to the reduction of K fixation and release of K due to interaction of organic material with clays besides the direct K addition in the soil. Subehia and Sepehya (2012) [11].

Conclusion

From the present finding, it was found that, the application SSB along with different organic inputs influence soil chemical and biological properties and growth parameters of *Pongamia pinnata* (Karanj). It can be concluded that, the application of 5ml SSB along with 200gm N from Vermicompost tree^{-1} improving the soil health by improving the soil physico-chemical properties and plant growth parameters.

In general it can be observed that, the combined use of organic matter like compost, VC with silicon solubilizing bacteria and inorganic fertilizer was helpful for improving soil nutrient status and maintained the fertility of soil which is of utmost significance for sustained productivity. The availability of nitrogen, phosphorous and potassium, sulphur, silicon increased significantly with the organic matter application over initial status.

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