International Journal of Agricultural Sciences
Volume 17 | Issue 2 | June, 2021 | 156-161

DOI:10.15740/HAS/IJAS/17.2/156-161
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ISSN : 0973-130X

RESEARCH PAPER

Effect of silicon solubilizing bacteria with organic N inputs on fertility status of soil and *Pongamia pinnata* (Karanj)

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Abstract : The present investigation entitled "Effect of silicon solubilizing bacteria with organic N inputs on fertility status of soil and growth of *Pongamia pinnata*." was carried out during 2017-18 and the details of materials used and methods adopted during the period of investigation. was conducted at Agroforestry Research farm, College of Agriculture Nagpur. The representative soil samples from the zone of maximum feeder root concentration at a depth of 0 – 20 cm and at a distance of 110 to 125 cm from the trunk were collected by using soil auger during May 2017 and final soil samples were collected treatment wise.the application of 5ml SSB along with 200g N from Vermicompost tree^{-1} improving the soil health by improving the soil physico-chemical properties and plant growth parameters.It is concluded that, the application of 5 ml SSB along with 200 g N from VC tree^{-1} have positive effect on availability of all nutrient as well as biological properties and microbial population of soil. For the better growth of *Pongamia pinnata* application of SSB along with organic residues in general and specifically VC was beneficial than using SSB alone.

Key Words : Silica, Solublizing, Alkaline, Phosphorus, Micronutrients, Extrctable

View Point Article : Tembhurkar, R.A., Dahule, D.D. and Pathare, I.S. (2021). Effect of silicon solubilizing bacteria with organic N inputs on fertility status of soil and *Pongamia pinnata* (Karanj). *Internat. J. agric. Sci.*, **17** (2) : 156-161, **DOI:10.15740/HAS/IJAS/17.2/156-161.**

Article History : Received : 21.02.2021; **Accepted :** 13.03.2021

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.The area (ha) under Karanj in India is 36000 and in Maharashtra 220. Karanj (*Pongamia pinnata)* is a drought tolerant, semi-deciduous, medium size tree with short bole and spreading crown. It is widely grown from tropical dry to subtropical dry forest zones. It is a good shade bearer, suitable for planting in pastures, for afforestation in watershed areas and drier part of the country. 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. It is native to India and receiving a widespread attention at present as a TBOS. It is a

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medium sized tree that generally attains a height of about 8.0 m and a trunk diameter of more than 50 cm. The alternate compound pinnate leaves consists of 5 or 7 leaflets which are arranged in 2 or 3 pairs, and a single terminal leaflet. Pods are elliptical, 3-6 cm long and 2-3 cm wide, thick walled, and usually contain a single seed. Seeds are long, flat, oblong and light brown in colour. (Daniel, 1997).

MATERIAL AND METHODS

The present investigation entitled "Effect of silicon solubilizing bacteria with organic N inputs on fertility status of soil and growth of *Pongamia pinnata*." was carried out during 2017-18 and the details of materials used and methods adopted during the period of investigation was conducted at Agroforestry Research farm, College of Agriculture Nagpur. The layout of experiment at field was done by using Randomized Block Design. The representative soil samples from the zone of maximum feeder root concentration at a depth of 0 – 20 cm and at a distance of 110 to 125 cm from the trunk were collected by using soil auger during May 2017 and final soil samples were collected treatment wise. The soil samples were air dried in shade and ground using wooden mortar and pestle with a care that concretions in the samples were not crushed and then passed through 2 mm sieve. The processed samples were well mixed and stored in clean cloth bags with proper labels for subsequent analysis. about 1-1.5 kg representative soil samples from the zone of maximum feeder root concentration at 0 to 20 cm depth were collected in cloth bag for laboratory characterization. The bulk soil samples were allowed to air dry in shade and then weighed soil aggregates were passed through 2 mm and 0.5 mm sieve. Soil material passing through the sieve was placed in labelled polythene bags and again weighed. A small portion of 0.2 mm sample was ground to pass sieve for organic carbon determination.

Estimation of various parameters:

Soil pH: It was determined in 1:2.5 soils water suspension with the help of Glass Electrode using pH meter (Jackson, 1973). electrical conductivity (EC) of the soil was determined in 1:2.5 soil water supernant using ELICO Conductivity Bridge (Jackson, 1973).

Organic carbon (g kg^{-1}): It was determined by oxidizing soil organic matter by chromic acid using heat of dilution sulphuric acid by Wet Oxidation method. (Walkley and Black, 1934).available nitrogen, (kg ha^{-1}) available nitrogen was estimated using Alkalinepotassium permanganate method (Subbiah and Asija, 1956).

Available phosphorus, (kg ha^{-1}) : It was determined by using Olsen's method (Jackson, 1973). available potassium, (kg ha^{-1}) available potassium in soil was extracted by Neutral Normal Ammonium Acetate solution and potassium was determined using flame photometer (Jackson, 1973).

Available Sulphur : It was determined by turbidimetric method given by Chesnin and Yien (1951). Available Silicon: The available potassium was estimated by extracting the soil with ammonium acetate extract and the available Si was estimated by using spectrophotometer as per Fox (1969).

Determination of Zn, Fe, Cu and Mn (mg kg^{-1}): It was determined by DTPA extract using atomic absorption spectrophotometer method given by Lindsay and Norvell (1978).

Biological properties SMBC, mg/kg : Chloroform fumigation (Jenkinson and Powlson, 1976) was followed for determination of soil microbial biomass carbon. In this method fumigation of soil samples was accomplished by placing the beakers of soil in large vacuum desiccator that is lined with moist paper. A beaker containing $CHCl_3$ is placed in desiccator. The desiccator was then evacuated until $CHCl_3$ boils vigorously, and then place the desiccator in dark at 25°C for 18-24 hours. After this period, the beaker of $CHCl_3$ and moist paper are removed from dissector and all residual $CHCl_3$ vapor was removed from soil samples by repeated evacuation. The same procedure but without $CHCl_3$ was be applied for unfumigated soil. After this each sample was placed in 1000 ml conical flask containing test tubes with 1N NaOH in it and is sealed properly with paraffin wax. The samples were then incubated for 10 days in humid conditions and the CO_2 evolved from both fumigated and unfumigated samples is then determined by back titrating in 1N Hcl. Total microbial biomass carbon = F / K

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Chemical properties of soil:

Soil pH :

Soil pH and EC values ranged from 7.7 to 7.17 and

0.117 to 125 dSm^{-1}, respectively during investigation. 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 was observed in treatment T_1 absolute control.

Organic carbon:

The result obtained of soil organic carbon as influenced by various treatments is presented in Table 5 and depicted in Fig 1. 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*. After application of different organic sources 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.

Available nitrogen (kg ha^{-1}):

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 was 299.54 kg ha^{-1} observed in treatment T_5 receiving 5 ml SSB along with 200 g N from VC $tree^{-1}$. Fallowed by treatment T_9 277.22 kg ha^{-1} with application of 5 ml SSB along with 200g N from compost $tree^{-1}$. 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

Available phosphorous (kg ha^{-1}):

There was positive impact of SSB and organic residues on availability of phosphorus in soil. The

Table 1 : Effect of silicon solubilizing bacteria and organic N inputs on content of Si (mg kg^{-1}) in plant

	Treatments	Si (mg kg^{-1})
T_1	Absolute control	46.33
T_2	5 ml lit^{-1} $tree^{-1}$ SSB	47.52
T_3	5 ml SSB +200 g N $tree^{-1}$	56.18
T_4	5 ml SSB +200 g N from FYM $tree^{-1}$	51.35
T_5	5 ml SSB+ 200g N from VC $tree^{-1}$	66.35
T_6	5 ml SSB +200 g N from Bamboo litter $tree^{-1}$	62.22
T_7	5 ml SSB + 200 g N from Teak litter $tree^{-1}$	68.67
T_8	5 ml SSB + 200 g N from Cow dung slurry $tree^{-1}$	61.65
T_9	5 ml SSB + 200 g N from Compost $tree^{-1}$	68.03
S.E.±		0.17
C.D. (P=0.05)		0.50

Table 2 : Effect of silicon solubilizing bacteria and organic N inputs on leaf macronutrient content (%)

	Treatments	N (%)	P (%)	K (%)	S (%)
T_1	Absolute control	0.91	0.11	0.38	0.13
T_2	5 ml lit^{-1} $tree^{-1}$ SSB	1.15	0.13	0.40	0.13
T_3	5 ml SSB +200 g N $tree^{-1}$	1.41	0.12	0.42	0.13
T_4	5 ml SSB +200 g N from FYM $tree^{-1}$	1.63	0.14	0.45	0.13
T_5	5 ml SSB+ 200g N from VC $tree^{-1}$	1.78	0.15	0.49	0.15
T_6	5 ml SSB +200 g N from Bamboo litter $tree^{-1}$	1.40	0.14	0.42	0.14
T_7	5 ml SSB + 200 g N from Teak litter $tree^{-1}$	1.59	0.13	0.49	0.15
T_8	5 ml SSB + 200 g N from Cow dung slurry $tree^{-1}$	1.44	0.14	0.47	0.14
T_9	5 ml SSB + 200 g N from Compost $tree^{-1}$	1.41	0.14	0.50	0.14
S. E. ±		0.002	0.001	0.003	0.001
C. D. (P=0.05)		0.01	0.003	0.01	0.003

significantly highest soil available phosphorus (17.15 kg ha^{-1}) was observed in treatment T_7 with application of 5 ml SSB and 200 g 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. Treatment T_9 with application of 5 ml SSB and 200 g N from compost ranked third by recording 15.35 kg ha^{-1} available phosphorus. This treatment was found at par with treatment T_5.

Available potassium(kg ha^{-1}):

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 5 ml 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 T_5 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.

Available Sulphur of soil mg kg^{-1}:

The data of available sulphur content of soil is presented in table. The available sulphur found to be sufficient in soil and ranged from 14.83 to 22.80 mg kg^{-1} after the application of SSB, inorganic nitrogen and different organic residues. The significantly superior

Table 3: Effect of silicon solubilizing bacteria and organic N inputs on plant diameter (cm)

	Treatments	Initial	Final	% increase	Difference
T_1	Absolute control	3.63	3.88	6.43	0.25
T_2	5 ml lit^{-1} tree^{-1} SSB	3.88	4.44	12.57	0.56
T_3	5 ml SSB +200 g N tree^{-1}	4.00	4.48	10.65	0.48
T_4	5 ml SSB +200 g N from FYM tree^{-1}	3.33	5.77	42.31	2.44
T_5	5 ml SSB+ 200g N from VC tree^{-1}	4.32	5.58	22.50	1.26
T_6	5 ml SSB +200 g N from Bamboo litter tree^{-1}	3.84	4.93	22.07	1.09
T_7	5 ml SSB + 200 g N from Teak litter tree^{-1}	4.02	5.08	23.34	1.06
T_8	5 ml SSB + 200 g N from Cow dung slurry tree^{-1}	3.98	5.07	21.45	1.09
T_9	5 ml SSB + 200 g N from Compost tree^{-1}	4.22	5.51	20.81	1.29
S. E. ±		-	-	-	-
C.D. (P=0.05)		-	0.52	-	-

Table 4 : Effect of silicon solubilizing bacteria and organic N inputs on microbial population (%)

Treatments		Actinom 10^4 cfu g^{-1}	Fungi 10^5 cfu g^{-1}	Bacteria 10^6 cfu g^{-1}	SSB 10^{12} cfu g^{-1}
T_1	Absolute control	23.31	13.77	82.35	12.23
T_2	5 ml lit^{-1} tree^{-1} SSB	24.03	14.41	84.83	15.35
T_3	5 ml SSB +200 g N tree^{-1}	24.00	15.39	83.14	16.15
T_4	5 ml SSB +200 g N from FYM tree^{-1}	25.38	15.48	85.21	17.28
T_5	5 ml SSB+ 200g N from VC tree^{-1}	26.59	16.60	86.46	19.31
T_6	5 ml SSB +200 g N from Bamboo litter tree^{-1}	24.68	17.19	83.01	13.18
T_7	5 ml SSB + 200 g N from Teak litter tree^{-1}	25.25	19.87	84.16	15.54
T_8	5 ml SSB + 200 g N from Cow dung slurry tree^{-1}	26.83	17.48	85.68	16.45
T_9	5 ml SSB + 200 g N from Compost tree^{-1}	27.43	18.15	87.51	18.38
	S. E. ±	1.03	1.16	1.17	1.20
	C. D.(P=0.05)	-	3.40	-	3.53

availability of S (22.80 mg kg^{-1}) was recorded with application of 5 ml SSB +200g N from VC tree^{-1} in treatment T_5. The second highest treatment in respect of available sulphur was treatment T_4 with application of 5 ml SSB + 200 g N from FYM tree^{-1} (22.19 mg kg^{-1}) while next to FYM 200 g N along with 5 ml SSB tree^{-1} recorded 20.76 g kg^{-1} S. All the treatments recorded increased in availability of S compared to initial values and control plots results. It was observed that, treatment T_5 *i.e.* 5 ml SSB along with 200 g N from VC increased available S to the tune of 33.11 per cent over initial values and about increment of 34.95 per cent compared with control plot.

Available Silicon of soil mg kg^{-1}:

Silicon (Si) is the second most abundant element in the earth's crust, almost exclusively found in the form of silicon dioxide (SiO_2) in association with a wide array of Si-bearing minerals in crystalline, poorly crystalline, and amorphous phases (Epstein *et al.*, 1999). It is agronomically essential for sustainable for plant growth. The data of available silicon content in soil is presented in table and depicted. There was significant variation in availability of silicon due to addition of different organic sources. Silicon solubilizing bacteria and different organic N inputs have significant impact on availability of silicon in soil. The available silicon ranged between 170.47 mg kg^{-1} to 247.55 mg kg^{-1}. The higher amount of silicon was recorded in treatment T_9 which received 5 ml SSB along with 200 g N from compost tree^{-1} (247.55 mg kg^{-1}) and was found significantly superior over all other treatments. The second higher amount of available silicon was present in treatment T_6 with 5 ml SSB along with 200 g N from Bamboo litter tree^{-1} (235.16 mg kg^{-1}). In general descending order of silicon availability was $T_9 > T_6 > T_8 > T_5 > T_7 > T_4 > T_2 > T_3 > T_1$. In this sequence it was observed that treatment T_5 was at par with treatment T_8. It was also recorded that, treatment T_9 shown 31.13 per cent more availability of silicon as compared to control and 29.03 per cent increase in availability of silicon as compared with initial values.

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