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Impact of pond deposit soils for improving Vigour index and AMF status of Soybean in renovated land

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ABSTRACT

Glycine max (L.) Merr soybean is one of the important pulse and oilseed crops of India. It grows well during the *kharif* or monsoon season (July-October) in the dry land areas of peninsular India. Pond deposit soil had a rich source of humus, minerals and micronutrients. When it comes in contact with agricultural field then productivity would be increased. This study attributed consecutive two generation data from renovated agricultural land. In M_1 generation, when pond deposit soil amended with newly renovated land decreased the all studied factors than crop land soil+ pond deposit soil, while in M_2 generation it was significantly increased. In M_2 generation significant growth rate was observed in case of nodules, leaves, pods; shoot length, fresh and dry wt of shoot, leaf area and productivity. Length of shoot (87cm) & root (28cm) was increased in M2 generation as compared to cropland + pond deposit soil. In M_2 generation total leaf area are extensively increased due to prosperity of organic matter. Therefore, productivity of soybean was increased. Percent root Arbuscular mycorrhizal fungi (AMF) colonization and spore density was showed potential in both soils in both generations. AMF association was found but suppressed in M_2 generation in some extent. In both soils & generations, *Acaulospora, Gigaspora, Glomus, Entrophospora, Sclerocystis* and *Scutellospora* was found frequently but *Acaulospora, Sclerocystis* and *Glomus* genera was found dominant. Vesicular, arbuscular and hyphal root colonization was found in both soils of soybean fields.

Key words: *Glycine max*, Generations, renovated land, pond deposit soils, productivity, AMF association.

INTRODUCTION

Soybean is one of the important pulse and oilseed crops of India. It grows well during the *kharif* or monsoon, season (July-October) in the dry land areas of peninsular India. The region is rocky and dry with low and uncertain rainfall. The fertility index with respect to Nitrogen

and Potash varies in all the districts of Marathwada. Major crops in this region are Sorghum, Cotton, Pigeonpea, Sunflower, Groundnut, Beans and Sugarcane. Region also contributes to fruit crops like Banana, Orange, Grape, Mango, Papaya, Guava, Ber, Lime and vegetable crops like Tomato, Brinjal, Chilli, Cucurbits, Cauliflower, Cabbage, Onion, Garlic, Leafy Vegetables like Spinach, Fenugreek etc. Agriculture is a major source of income for about 70 % population of rural part. It is a species of legume native to East Asia, widely grown for its edible bean which has numerous uses. Fat free (defatted) soybean meal is a significant and cheap source of protein for animal feeds and many prepackaged meals; soy vegetable oil is another product of processing the soybean crop. Arbuscular mycorrhizae (AM) are symbiotic associations, formed between plants and soil fungi that play an essential role in plant growth, plant protection, and soil quality. The effectiveness of a mycorrhiza in improving plant growth appears to be governed by the interplay between edaphic factors, the host plant, edaphic factors, and the fungal isolate **(**Bethlenfalvay *et al*.,1985). Government of Maharashtra noticed farmers living on bank of ponds and river to lift the slit soil deposited in pond and river for their agricultural purpose. Soil is a natural resource with crucial ecological, economic and social function. Soil is the essential component of the terrestrial environment and forms the interface between geosphere, atmosphere, hydrosphere and biosphere **(**Doran and Parkin, 1994) Soil provides the medium for the production of plant biomass for use as food, feed and fiber. The capacity of soil to supply sufficient quantities and proportions of essential chemical elements (nutrients) and water required for optimal growth of specified plants as governed by the soil's chemical, physical and biological attributes. Soil is the foundation of an agricultural field and mediates processes essential to the functioning of the system, including: biogeochemical cycling of elements such as carbon and other mineral nutrients; provision of habitat for soil organisms; movement, storage, and decontamination of water; and promotion of plant growth (Brady and Weil, 2002). Soil organic Matter (SOM) encompasses living microorganisms as well as plant and animal tissues in various stages of decomposition (Craswell and Lefroy, 2001).

MATERIALS AND METHODS

Study Site Description

The study was carried out two generation on soybean **(***Glycine max)* crop plant during *Kharif* or monsoon, season (July-October-2013 & 2014) from agricultural land of Naldurg (17.82^0N 76.30^0 E) Osmanabad districts of Marathwada region of Maharashtra. Naldurg is located at an altitude of 566 m and receives an average annual rainfall of 760 mm.

Physico-chemical parameters

Available Nitrogen was assessed by alkaline permanganate method by using Kjeldhal tube (Subbiah and Asija, 1956). Available Phosphorus in soil was determined by Olsens method by using spectrophotometer (Olsen *et al*, 1954) and Bray & Kurtz (1945). Water soluble and exchangeable Potassium was calculated by Ammonium acetate method of Hanway and Heidel (1952) using Flame photometer. Analysis of Ferrous, Copper and Zinc were done by acid digestion of soil (Jackson, 1967).

Biomass Production

Three plants were harvested 8 weeks after planting for soybean. At harvest, the soils from the roots were washed off carefully and the nodule number was counted visually. Fresh weight of root and shoot samples were recorded. Shoots (including fruit & flowers) and roots were separated and oven dried at 60°C for 48 h for the determination of dry mass after recording their lengths **(**Muthukumar and Udaiyan, 2000). Leaf area was measured at harvest by disc method by Vivekanandan *et al*.(1972).

Soil and Root Sampling

Soil samples and roots were collected from the rhizospheric region of soybean plant from pond (PS) soil amended with renovated land (LS) soil. The samples consisting of feeder roots + soil were collected with the help of a soil auger (0-25cm) so as to represent the complex root zone. Root systems of common plant species were excavated taking care to ensure that fine root predominates in the sample and to exclude entangled roots of other species. Sufficient samples were taken to determine, if there is any variation in the constituency and degree of mycorrhizal colonization roots between or within the

sampling sites. Roots were gently washed and immediately fixed in Formalin Acetic Acid Alcohol (FAA) in the field (Kormanik *et al*.,1980). Rhizospheric soil was collected in polythene bags and after drying stored at 4^0C.

Mycorrhizal study

Numerous techniques were available to recover AMF spores from soil. The most basis of this is wet sieving and decanting, which remove the clay, sand and organic matter fractions while retaining spores and other similar sized soil particles on sieves of various with stainless steel mesh (35, 63, 125,150 212 and 355µm). For the isolation, 100g of soil was weighed and is added to1000 ml of water taken in a conical flask. Then the flask was shaken well in a vortex mixture and allowed to sediment for few seconds and was immediately transferred to a series of sieves. The jar was washed twice with water and added in to sieves series. This sieving was collected in respected jars by washing with water. Then transferred the sieving on to a gridded petriplate and observed it under the binocular microscope 400X (Lawrence & Mayo LM-52-3521). The number of spores were counted and expressed as number of spores/100g of soil sample. These isolated spores were picked up using micropipette and were mounted in Poly Vinyl Lacto Glycerol (PVLG) to make permanent slides.

Root Colonization and Spore Density

Collected fresh roots were washed in tap water and cut into 1 cm pieces in length and cleared with 10% KOH and acidified in 5NHCL and stained with Trypan Blue (Phillips and Hayman, 1970). Root colonization percentage was measured according to the by following formula (Giovannetti and Mosse,1980) Hundred grams of rhizosphere soil from each sample was analyzed for spore isolation by wet sieving and decanting method (Gerdemann and Nicolson,1963). Identification of AM fungal species was done by using the manual (Schenck and Perez, 1990).

Statistical Analyses

The arcsine transformed values is used for biomass production meaning that if the difference between three values are different or above, then that difference is significant (McDonald, 2008).

RESULTS AND DISCUSSION

The study was carried out in two generation (Year 2013 &2014) on soybean *(Glycine max)* crop plant during *Kharif* or monsoon season and data represented following.

I. Physico-chemical parameters

Plant health is linked with soil health. Proper management of the soil by conserving and enhancing the soil biota improve crop yields and quality. During investigation, soil studied from two different sites i.e blackish & blackish red & it was found alkaline in nature with pH 7.21 & 7.80. EC responsible for movement of cataions and anions from soil to root was sufficient and ranging from 0.28 to 0.10 dS/m. Nitrogen, Phosphorus & potassium which is important factor for AMF development was deficient in renovated field. Zinc, Ferrous & copper was least increased in renovated field soil (Table 1).

Table 1. Physico-chemical Parameters of soil.

Sr. No	Parameters of soil	Naldurg sites	Renovated field
1	Soil type	Blackish	Blackish red
2	pH	7.31	7.80
3	EC (dS/m)	0.28	0.10
4	Nirogen (kg/ha)	205.84	232.06
5	Phosphrous (kg/ha)	51.32	15.20
6	Potassium (kg/ha)	616	470.86
7	Zinc (ppm)	1.78	1.110
8	Ferrous (ppm)	0.98	1.011
9	Copper (ppm)	0.84	0.98

Table 2. Biomass production of *Glycine max* renovated and crop land field in two generation.

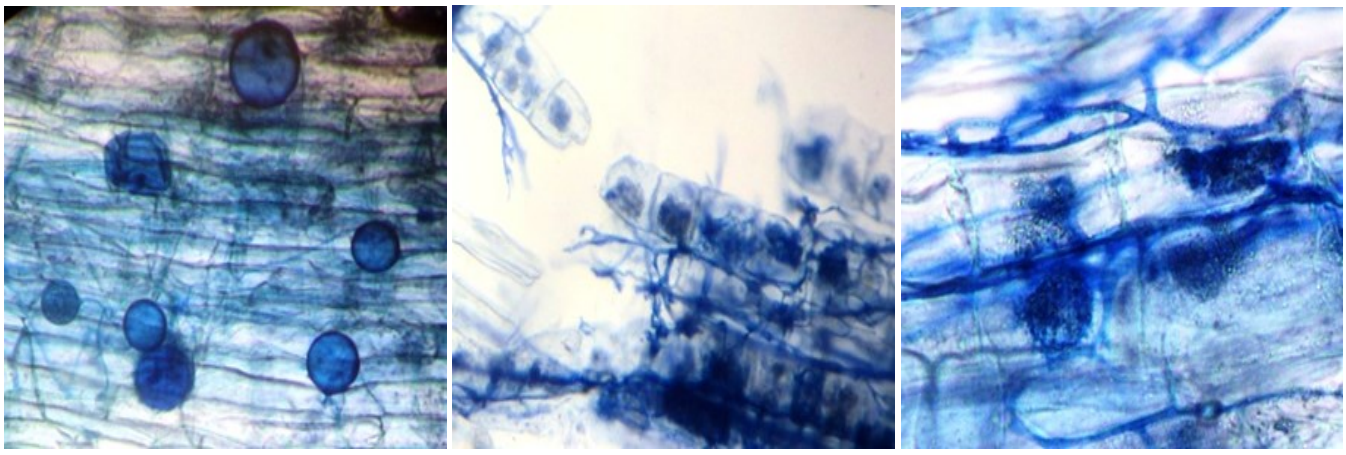
Sr. No.	Parameters	M_1 Generation (2013)		M_2 Generation (2014)	
		R L + PS	CS + PS	R L + PS	CS + PS
1	No of nodules	09 (12.33)	42 (47.51)	67 (70.12)	72 (75.11)
2	No of leaves	10.33 (12.33)	12.66 (14.23)	71 (76.33)	107 (114.54)
3	No of auxiliary branch	07.66 (8.11)	08 (10)	42 (47.11)	71 (76.33)
4	No of pods	61.66 (67.33)	154 (177.22)	103 (110.11)	240 (253.63)
5	Length of Shoot (cm)	52.83 (60.76)	63 (65.11)	87 (93.11)	65 (72.23)
6	Length of Root (cm)	26.66(28.54)	19.26 (23.34)	28 (32.22)	22 (27.27)
7	Fresh Wt of Shoot (g)	29.43 (32,22)	32.62 (34.11)	62.71 (71.11)	120.76 (134.34)
8	Fresh Wt of Root(g)	3.30 (7.11)	3.77 (4.23)	10.69 912.11)	19.38 (26.11)
9	Dry Wt of Shoot (g)	8.69 (10.11)	9.98 (12.33)	38.85 (43.11)	70.39 (74.22)
10	Dry Wt of Root (g)	1.51 (3.51)	1.61 (3.87)	4.07 (7.22)	9.02 (11.11)
11	Area of Total Leaves(cm^2)	2128.49	2449.03	3445.93	4867.16
12	Yield (Quintal/ha)	10 (14)	19 (24)	15 (18)	22 (27)

Legands :Values in parentheses are arcsine transformed values, RL=Renovated Land, PS=Pond Sedimentary Soil, CS= Cropland soil

Table 3. Myorrhizal association of *Glycine max* renovated and crop land field in two generations

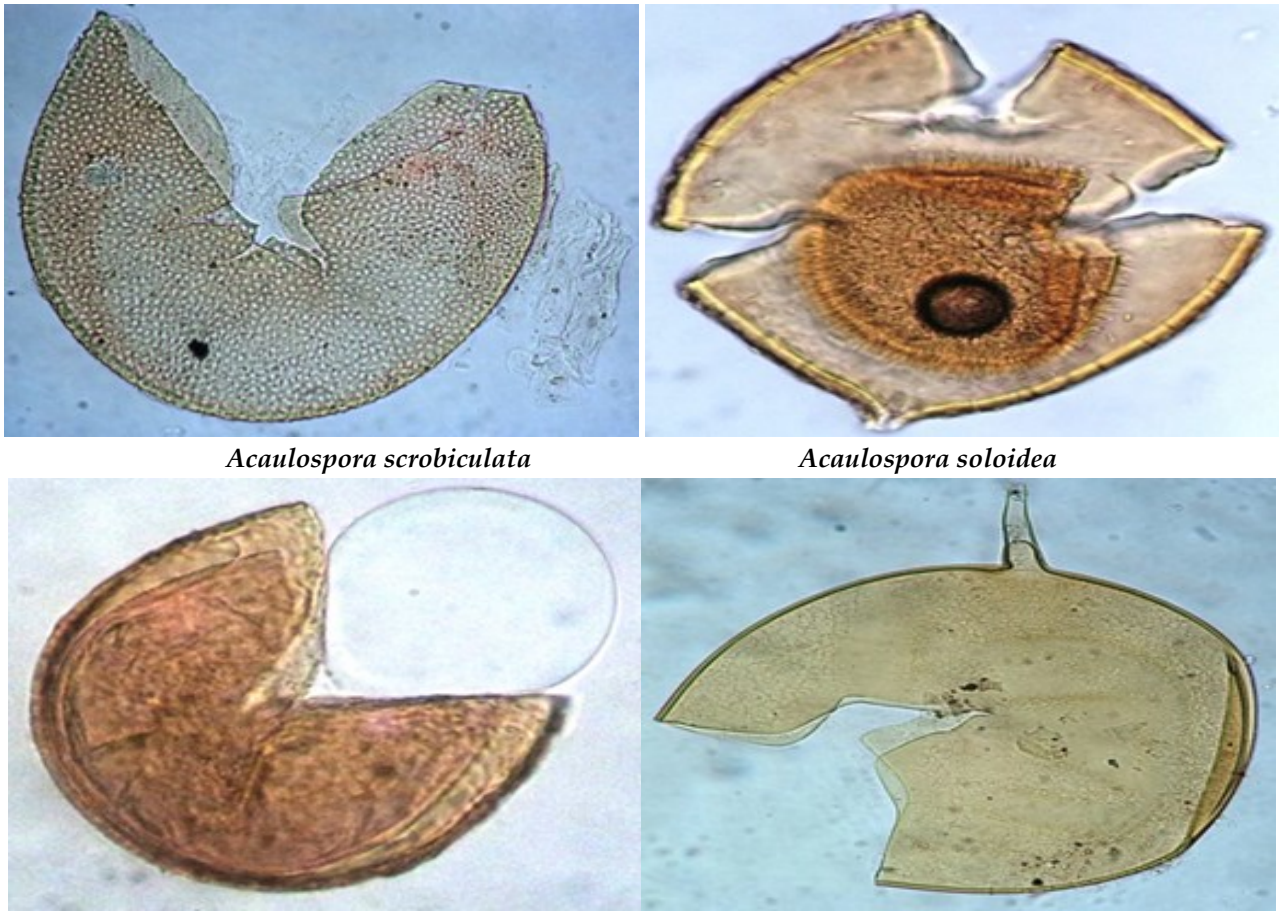
Sr. No.	Parameters	M_1 Generation (2013)		M_2 Generation (2014)	
		R L + PS	CS + PS	R L + PS	CS + PS
1	AMF Root colonization (%)	82.5 ± 2.11	80 ± 0.2525	58.21±10.1	63.75 ±3.0
2	AMF spore Density (per 100g)	730 ± 0.33	735 ±1.1	215 ±21.11	239 ±23.13
3	Type of colonization	Vesicles, Arbuscules & Hyphal	Vesicles, Arbuscules & Hyphal	Vesicles, Arbuscules & Hyphal	Vesicles, Arbuscules & Hyphal
4	Types of spores	*Acaulospora scrobiculata, Acaulospora soloidea, Acaulospora undulata and Glomus mosseae*			

Legands: RL=Renovated Land, PS=Pond Sedimentary Soil, CS= Cropland soil



Vesicles **Arbuscles** **Hyphal**

Fig.1. Types of AMF root colonization (400X magnification).



Acaulospora scrobiculata *Acaulospora soloidea*

Acaulospora morrowiae *Glomus mosseae*

Fig.2. Isolated and identified Arbuscular mycorrhizal fungal spores (400X magnification).

II. Biomass Productivity

This study accredited promising two generation consecutive data from newly renovated agricultural land. In M_1 generation, when pond sedimentary soil (PS) amended with newly renovated land decreased the all studied parameters than cropland soil + Pond soil (CS+PS), while in M_2 generation it was significantly increased. In M_2 generation significant growth rate was observed i.e. no of nodules, leaves, pods, shoot length, fresh wt & dry wt of shoot, leaf area and productivity. Length of shoot (87cm) & root (28cm) was increased in M_2 generation as compared to cropland + pond soil (CS+PS). Consecutively root systems are increased in both generations. In M_2 generation total leaf area are considerably increased due to richness of organic matter progressively. Number of pods (103 & 240) are considerably increased therefore productivity was increased in M_2 generation in both soils (Table 2).

III. Mycorrhizal Status

AMF colonization and spore density were found promising in both soils in both generations. AMF association was found but suppressed in M2 generation. Percent root mycorrhizal colonization (82.5 & 80%) was found in both soils but in M2 generation it was reduced (58.21 & 63.75%). Mycorrhizal spore density was also decreased in M2 generation. In tested soil more vesicles (V) and Paris type arbuscles (A) was developed Vesicular, arbuscular and hyphal mycorrhizal colonization was present in both soils and generations. Arbuscular type of colonization was dominant in treated soybean roots in both generations (Table 3; fig. 1 &2). *Acaulospora, Gigaspora, Glomus, Entrophospora* and *Scutellospora* were found frequently but *Acaulospora* and *Glomus* genera were found dominant i.e. *Acaulospora scrobiculata, Acaulospora soloidea, Acaulospora undulata and Glomus mosseae.*

Results observed during investigation was supported by Vyas and Vyas (2012) where spore density of AMF had a strong positive correlation with soil pH and organic carbon content and a negative correlation with Olsen's P content of the soil. Sreevani and Reddy (2004) studied relation between soil characters and occurrence of AMF where greater number of AM fungal propagules were found in neutral to slightly alkaline (pH 7 to 8) soil whereas alkaline soils (pH higher than 8.0) have not favored mycorrhizal fungi. Nutritionally deficient soils (zinc, copper, nitrogen, phosphorus and potassium) had greater number of AM fungal propagules whereas high levels of these nutrients inhibited the population of AM fungi.

The study was in accordance with earlier workers, Doran and Zeiss (2000) defined soil health as: "the continued capacity of soil to function as a vital living system, by recognizing that it contains the biological elements that are the key to ecosystem function within land use boundaries". The results showed that the VAM fungi helped to stabilize wind-borne soil that settled under dense canopies, enhanced the establishment of colonizer plants in bare soils of disturbed areas and influenced plant associations through differences in the mycotrophic status of the associates **(**Carrillo-Garcia *et al*., 1999). Large populations of *Glomus aggregatum* were associated with dense weed populations in a com-soybean sequence **(**Johnson *et al*.,1991). HarnerNora *et al*. (2011) studied abundance of AMF propagules (colonized roots, spores, and hyphae) within sediments of Tagliamento River in northeastern Italy; Root inoculums in fresh deposits were absent however; some viable spores and hyphae were available. Positive effects of AMF on host-plant growth and development were already observed in low soil fertility conditions and also in drought environments **(**Sylvia and Williams, 1991: Picone.2003 ;). Reclamation of River deposit soil when amended with renovated land decreased biomass productivity in soybean crop plant than crop land soil but cropland soil showed significant growth rate whereas infection of AMF root colonization & spore density found in both the soils (Bhale and Bansode,2013). Pond soil when amended with renovated land soil decreased biomass productivity than crop land soil in soybean crop plant but Cropland soil showed significant growth rate whereas infection of AMF root colonization & spore density found in both the soils (Bansode and Bhale,2014).

CONCLUSION

The results concluded that when sedimentary soil was amended in agricultural land, it was enhanced the growth parameter of Soybean and AMF infection. Sedimentary soil had rich source of humus, minerals and micronutrients and when contact with agricultural field then biomass would be increased even in M_2 generation.

Conflicts of interest: The authors stated that no conflicts of interest.

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