Enhancing Fodder Oat (*Avena sativa*) Production in Problem Soils Using Phosphate Solubilizing Fungi Isolated from Acid and Salt Affected Soils of India

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Enhancing fodder Oat (*Avena sativa*) production in problem soils using phosphate solubilizing fungi isolated from acid and salt affected soils of India

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Introduction

Tropical and subtropical soils are predominantly acidic, and often extremely phosphorus-deficient with high phosphorus sorption (fixation) capacities. Phosphorus (P) is one of the major essential macronutrients for plants, present at levels of 400–1200 mg/kg of soil. One of the drawbacks of fertilization is that only a fraction of the P added is eventually assimilated by plants, due to high reactivity of soluble phosphate with other elements the rest becomes unavailable to plants by forming complexes with either, Al, Fe, Ca or Mn depending on soil type (Rodríguez and Fraga, 1999). Even though some soils may have high levels of total P, they can still be P-deficient due to low levels of soluble phosphate available to plants. Available P concentrations for maximum pasture production are estimated to be between 20 and 50 µg/g. Because of the spiraling cost of phosphatic fertilizers coupled with low recovery (10- 30%) of phosphorous applied in the field, the developing tropical countries are attempting to utilize their indigenous reactive ground phosphate rock as a cheap alternative (Sabannavar and Lakshman, 2009). Many soil bacteria, Pseudomonas, Bacillus, Burkholderia, Arthrobacter, Alcaligenes, Serratia, Enterobacter, Acinetobacter and Flavobacterium and fungi especially Aspergillus, Penicillium, Trichoderma have the ability to solubilize elemental phosphate (Pi) and make it available to plants. They are used as biofertilizers for supplying the P requirement of the plants. However, scanty information is available on the occurrence of PSMicroorganisms (PSMs) in acid and salt affected soils. The present investigation was aimed to isolate PSMs from acid and salt affected soils that could survive and solubilize insoluble phosphate efficiently in the presence of higher salt concentration and acidic medium so as to obtain efficient isolates for application as a potential biofertilizer in acid and saline or problematic soils.

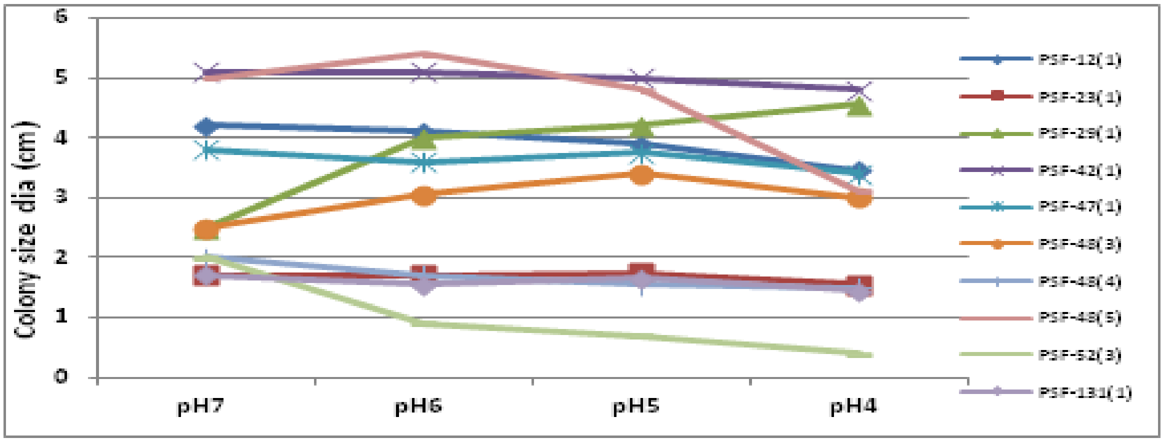
Materials and Methods

About 90 PSF isolates have been isolated using Pikovskaya's medium (Pikovskaya, 1948) from acidic, saline and sodic soil samples collected from Himachal Pradesh, Haryana, Kerala and Karnataka states of India. They were screened for phosphate solubilisation in broth medium containing tricalcium phosphate and Udaipur rock phosphate (URP) as P source in separate experiments. 25 efficient PSF isolates were selected and screened for salt and acid tolerance in broth as well as solid medium. About 10 isolates have been selected based on acid and salt tolerance. An experiment was conducted *in vitro* in the net house condition at IGFRI, Jhansi, to evaluate the performance of phosphate solubilizing fungi isolates during *Rabi* season using normal soil (pH 6.9, EC 0.2), acid soil (pH 5.5, EC 0.18) and saline-alkali soil (pH 8.8, EC 4.9) in enhancing biomass of fodder oats variety JHO 822. The treatments included control, 100% recommended dose of fertilizers (RDF) @ 80:40:40 NPK for single cut and 10 different phosphate solubilizing fungal isolates viz., PSF-12(1), PSF-23(1), PSF-29(1), PSF-42(1), PSF-47(1), PSF-48(3), PSF-48(4), PSF-48(5), PSF-52(3), PSF-131(1) were applied as seed treatment with 100% of recommended P as Udaipur rock phosphate and 100% RDF (N & K) and the design of the experiment was completely randomized block design with three replications during *Rabi* 2014-15. The parameters like dry fodder weight, number of seeds produced and seed weight data were recorded after harvest and analysis of variance (ANOVA) was run using online statistical portal WASP (Web Agri Stat Package) of ICAR Research Complex for Goa.

Results and Discussion

In screening of the PSF isolates for acid and salt tolerance, it was found that all the PSF isolates could tolerate up to pH 4.0, though there is a reduction in the growth with increase in acidity. However PSF 29(1) can grow well at pH4.0 with maximum growth 4.55cm (Fig.1). PSF 131(1), PSF 23(1) and PSF 48(4) are more tolerant to increasing acidity. Whereas PSF 52(3) was found to be more sensitive to acidity. Similarly, all the PSF could able to grow up to 4% NaCl concentration (Fig.2). The maximum growth of all PSF was recorded at 2% salt stress except PSF 29(1) which recorded at 4% salt stress. Except PSF 52(3), PSF 23(1) and PSF 48(4) all other PSF isolates could tolerate up to 10% salt concentration. These results are comparable with the results of Srinivasan *et al*., 2012.

Fig. 1: Analysis of PSF isolates growth by colony size (diameter in cm) for acid tolerance



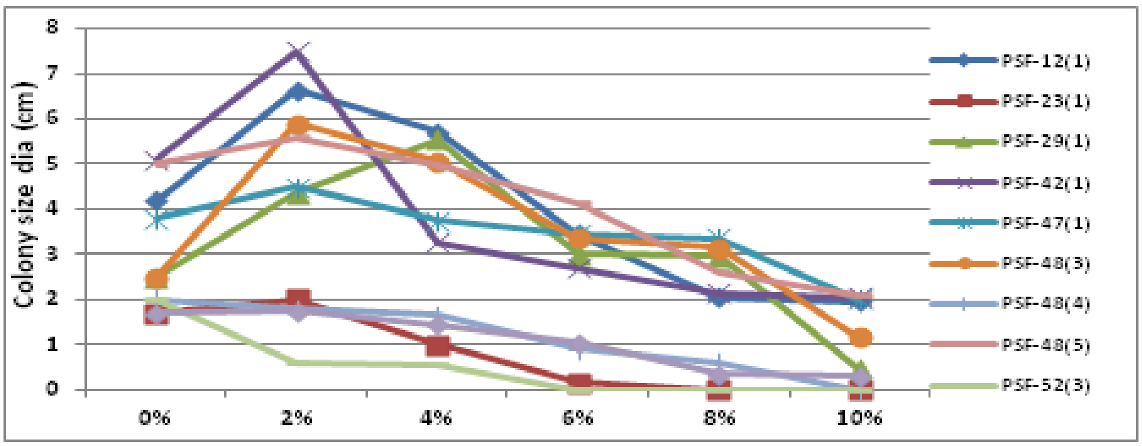


Fig. 2: Analysis of PSF isolates growth by colony size (diameter in cm) at for salt tolerance

These selected PSF isolates were used as biofertilizers to test their influence on production of oats under three different soil types. Maximum number of seeds per plant and seed weight per pot were recorded in 100% RDF NPK treatment in normal (53.7 and 26.3) and saline-alkali (51.7 and 19.7) soil (Table. 1). However three PSF in normal [PSF 23(1), PSF-47(1) and PSF-48(3)] and three in saline-alkali soil [PSF-48(4), PSF-52(3) and PSF-131(1)] produced number of seeds at par with RDF. In case of seed weight PSF-12(1), PSF-23(1) and PSF-47(1) in normal soil and PSF-29(1), PSF-48(4) and PSF-48(5) were on par with RDF. All these treatments were significantly superior to control. Whereas, in acid soil PSF 47(1) and PSF 48(4) recorded significantly highest seed count (41.4 and 41.2) which was at par with RDF (35). The seed weight in acid soil was non significant.

Table 1: Oat production in problem soils using phosphate solubilizing fungi

Treatments	Seed count (No./plant)			Seed weight (g/pot)			Dry fodder weight (g/pot)		
	Normal soil	Acid soil	Saline-alkali soil	Normal soil	Acid soil	Saline-alkali soil	Normal soil	Acid soil	Saline-alkali soil
Control	26.2d	30.5cd	25.3c	14.2f	15.0	12.0c	12.2d	15.0bc	8.5c
RDF (NPK)	53.7a	35.0abcd	51.7a	26.3a	20.8	19.7a	21.0a	13.5bc	15.7a
PSF-12(1)	43.2bc	30.6cd	33.2bc	21.9ab	15.1	13.2bc	15.7bcd	14.1bc	13.2ab
PSF-23(1)	47.9ab	38.3ab	35.4bc	21.5abc	19.9	12.0c	15.6bcd	14.4bc	14.1ab
PSF-29(1)	37.9c	38.9ab	36.3bc	14.4ef	19.5	16.9ab	14.3cd	18.6ab	12.4abc
PSF-42(1)	41.7bc	30.7d	36.2bc	15.7	17.3	14.1bc	19.3ab	16.0bc	15.3a
PSF-47(1)	47.5abc	41.4a	36.5bc	20.8abcd	17.2	14.6bc	18.2abc	17.8abc	10.7bc
PSF-48(3)	46.1abc	37.3abc	38.7b	20.1	15.8	13.5bc	16.0bcd	18.3abc	10.2bc
PSF-48(4)	38.9bc	41.2a	42.3ab	16.6	17.1	16.2ab	15.6bcd	22.4a	14.2ab
PSF-48(5)	39.5bc	33.8bcd	36.8bc	15.0	18.5	16.9ab	19.5ab	17.6abc	15.1a

PSF-52(3)	42.3bc	39.5ab	41.3ab	15.4	16.0	13.7bc	15.7bcd	13.3c	16.6a
PSF-131(1)	38.6bc	40.4ab	45.3ab	18.9	17.6	15.2bc	15.4bcd	14.3bc	16.5a
CD (0.05)	9.7	7.3	12.6	5.8	NS	3.8	4.7	5.1	4.4

Non significant ($p<0.05$) difference among means with the same alphabet in the columns

Highest dry fodder weight was recorded at RDF treatment in case of normal soil (21g) followed by PSF-48(5), PSF-42(1) and PSF-47(1) which were statistically at par with RDF (Table. 1). In saline-alkali soil, the maximum dry fodder weight (16.6g) was produced by PSF-52(3) followed by PSF-131(1), RDF, PSF-42(1) and PSF-48(5) which were significantly superior over all other treatments. Whereas in acid soil, PSF-48(4) recorded the highest dry matter (22.4g) production, followed by PSF-29(1), PSF-48(3), PSF-47(1) and PSF-48(5) which were at par among themselves and with PSF-48(4). These results are comparable with the results of Henri et al., 2014.

Conclusion

It is found that all isolates used were not performing similarly in different soils. However, this study suggests that PSF can be used with rock phosphate in place of P fertilizers to enhance dry matter and seed production in oats. This could save the cost of P fertilizer application involved in oat production and it is environmentally safer. PSF isolates with rock phosphate viz., 47(1) and 48(5) in normal soil, 48(4) in acid soil, 52(3), 131(1), 48(5) and 29(1) in saline-alkali soil performed at par with RDF, they could be used as suitable candidates for developing potential biofertilizers for enhancing production of oat in normal as well as problem soils.

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