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Bonge CO
M.Sc. Agri, Ph.D Agri in Department of soil science and Agricultural, Chemistry, Vasantrao Naik Marathwada Krishi, Vidhyapeeth, Parbhani, Maharashtra, India

Patil VD
Director of Education of Nanasaheb Kadam college of Agriculture, Gandheli, Aurangabad. Maharashtra, India

Kausadikar HK
Director of Education and Research, MCAER, Pune, Maharashtra, India

Correspondence
Bonge CO
M.Sc. Agri, Ph.D Agri in Department of soil science and Agricultural, Chemistry, Vasantrao Naik Marathwada Krishi, Vidhyapeeth, Parbhani, Maharashtra, India

Studies on effect of consortia of beneficial organisms on chemical properties of spinach in pot culture experiment

Bonge CO, Patil VD and Kausadikar HK

Abstract
The research entitled with "studies on effect of consortia of beneficial organisms on chemical properties of Spinach in pot culture experiment" was conducted during the year 2017-2018 in two phases. In first phase the consortia was prepared from different nine beneficial bacteria and applied to the spinach. In second phase, pot culture experiment was carried out with six set of treatments replicated trice to study the effect of consortia on beneficial organisms on chemical properties (pH, electrical conductivity and calcium carbonate) of spinach. The results revealed that improved chemical properties and plant growth. Amongst the six treatments RDF+ consortia (T_5) showed significantly higher results followed by only consortia (T_3) compared with other treatments and absolute control. Amongst RDF +consortia treatment was slightly acidic to neutral in pH, highest content of organic carbon and lowest in lime.

Keywords: Consortia, acidic, pH, electrical conductivity, organic carbon and calcium carbonate

Introduction
The consortia refer to a two or more microbial groups living symbiotically (Hideto Takami, 2019) [3]. The concept of consortium was first introduced by Johnnes Reinke 1872. The rhizosphere inhabits lots of soil microorganisms, such as bacteria and fungi, which compete for water, nutrients and space and sometimes improve their competitiveness by developing an intimate association with plant. The metabolites act as chemical signals for bacteria to move to the root surface, also represent the main nutrient sources available to support growth and persistence in the rhizosphere. Some of the microbes that inhabit this area are bacteria that are able to colonize very efficiently the roots or the rhizosphere soil of crop plants. These bacteria are referred to as plant growth promoting rhizobacteria (PGPR). The most common objective of developing microbial consortium is to capitalise on both the capabilities of individual microbes and their interactions to create useful systems in tune with enhanced productivity and, soil health improvements through efficient metabolic functionality (Brenner *et al.,* 2008).

Materials and Methods
The research entitled "Studies on Effect of consortia of beneficial organisms on chemical properties of Spinach in pot culture experiment" was conducted during the year 2017-18 in two phase's research project was planned and implemented research work. In the first phase, consortia of nine beneficial bacteria were prepared i.e., *Azotobactor, Azospirillum, Bacillus megaterium (PSB), Baccilus subtilis, Pseudomonas fluroscens, Pseudomonas striata, Rhodococcus ruber, Bacillus licheniformis and Penibacillus thylacticus.* While in second phase these consortia was applied on spinach according to treatments. This bacterial consortium was tested by conducting the pot culture experiment on spinach over a growth stages from first cutting to third cutting. Treatment details T1 (Absolute control), T2 (only RDF), T3 (Only conrtia), T4 (Biofertilizers (*PSB+ Azotobactor*), T5 (RDF + consortia) and T6 (RDF+ *PSB +Azotobactor*).

Results and Discussion
Effect of application of consortia of beneficial organisms on chemical properties of spinach at various cuttings.

pH

Effect of application of consortia of beneficial organisms on pH showed little variation in average pH. It is observed that among the various treatments application of RDF + Consortia (7.18) showed lowest pH followed by only consortia (7.20). The highest pH was found in control i.e., 7.58. Further it is also observed that as the application of consortia treatment decreased the pH value. The similar type of effect was noticed at 2nd and 3rd cutting stages. Even though the treatment differences were non-significant, there was increased in pH with each cutting growth upto3rd cutting. Shen *et al.,* (2001) [11] reported that the acidic pH under most of the tree species was probably due to the release of acidic exudates. Pandey and Palni (2007) [6] further observed decrease in the pH of rhizosphere soil over the non rhizosphere soil samples to the extent of 0.6 to 0.9 units.

Further release of acidic exudates decreases the pH of rhizosphere soil (Shen *et al.,* 2001; Radhapriya *et al.,* 2013; Mukhopadhyay *et al.,* 2013) [11, 10, 5]. Dinesh *et al.,* (2010) [2] showed variation in rhizosphere pH due to different tree species, while Shilpkar *et al.,* (2010) [12] showed seasonal variation in pH of some rhizosphere soil the same results was given.

Electrical Conductivity

The data depicted in Table 1, revealed that the electrical conductivity was found to be low in applied consortia as compared with absolute control at all stages of cutting. Significantly lowest EC was recorded in RDF + Consortia which was 0.22, 0.21 and 0.25 at 1st, 2nd and 3rd cutting respectively. While absolute control showed highest in EC value of 0.27, 0.29 and0.29dSm^{-1} at 1st, 2nd and 3rd cutting respectively.

The results presented above indicated that the application of consortia tended to decrease the pH and Electrical conductivity irrespective of the growth stage at various cuttings, these might be because of the high concentration of organic matter and decomposed material, further the high bacterial population of consortia might have influenced the pH and EC, and these by lower pH and EC. Similar type of observations were also recorded by Patil *et al*. (2013) [8].

Table 1: Effect of application of consortia on pH and EC (dSm^{-1}) in soil of spinach at various cuttings.

Treatments	Treatment details	pH				EC (dSm^{-1})			
		Istcut	IIndcut	IIIrdcut	Mean	Istcut	IIndCut	IIIrdcut	Mean
T_1	Absolute control	7.58	7.58	7.59	7.58	0.27	0.29	0.29	0.28
T_2	Only RDF	7.25	7.25	7.22	7.24	0.24	0.26	0.23	0.24
T_3	Only consortia	7.21	7.21	7.20	7.20	0.25	0.24	0.23	0.24
T_4	Biofertilizers (*PSB*+ *Azotobactor*)	7.27	7.27	7.25	7.26	0.26	0.26	0.26	0.26
T_5	RDF + Consortia	7.19	7.19	7.18	7.18	0.22	0.21	0.25	0.22
T_6	RDF+ *PSB* +*Azotobactor*	7.23	7.21	7.21	7.21	0.25	0.24	0.25	0.24
	S.Em±	0.002	0.002	0.002	0.002	0.01	0.01	0.01	0.01
	C.D. @ 1%	NS	NS	0.009	NS	NS	NS	NS	NS
	Mean	7.28	7.28	7.27	7.27	0.24	0.25	0.25	0.25

Table 2: Effect of application of consortia on Organic carbon (g kg^{-1}) and Calcium Carbonate (g kg^{-1}) in soil of spinach at various cuttings.

Treatments	Treatment details	Organic carbon (g kg^{-1})				$CaCO_3$ (g kg^{-1})			
		Ist cut	IInd cut	IIIrd cut	Mean	Ist cut	IInd cut	IIIrd cut	Mean
T_1	Absolute control	7.46	5.12	4.02	5.53	53.46	53.76	53.79	53.67
T_2	Only RDF	17.84	20.96	18.86	19.22	47.57	47.67	47.87	47.70
T_3	Only consortia	25.77	26.65	25.94	26.12	41.43	41.36	41.91	41.56
T_4	Biofertilizers (*PSB*+ *Azotobactor*)	15.53	19.36	16.78	17.22	47.45	47.33	46.14	46.97
T_5	RDF + Consortia	28.46	30.71	26.58	28.58	39.77	39.63	39.31	39.57
T_6	RDF+ *PSB* +*Azotobactor*	21.25	25.50	21.21	22.65	44.86	44.72	44.52	44.7
	S.Em±	0.02	0.02	0.02	0.08	0.06	0.07	0.08	0.07
	C.D. @ 1%	0.09	0.09	0.09	0.38	0.29	0.35	0.35	0.33
	Mean	19.39	21.38	18.11	19.62	44.94	43.11	41.29	43.11

Organic carbon and calcium carbonate

The organic carbon content showed very high degree of variation among treatments. The O.C. content of RDF+ consortia (T_5) is very higher than absolute control. Among all treatments RDF+ Consortia (T_5) had higher Organic carbon content 28.46, 30.71 and 26.58 kg^{-1} at 1st, 2nd and 3rd cutting respectively followed by only consortia (T_3). Absolute control showed very minimum content of organic carbon.

The results are showed that the O.C. content in T5 treatment was higher than other treatment it might be due to in addition, the rate of decomposition of organic matter was low underneath the tree because of low temperature that varies between 22 ^{0}C to 27 ^{0}C. Many research papers (Lynch and Whips, 1991; Priha *et al*., 1999; Bielinska, 2008) [1] indicated that rhizosphere zone soils contain higher concentration of soluble carbon than non rhizosphere zone soils.

The effect of application of consortia of beneficial organisms on $CaCO_3$ showed higher in absolute control and treatment RDF + consortia showed minimum content of calcium carbonate as compared with other treatments, it ranged between 44.94, 43.11 and 41.29 at 1st, 2nd and 3rd cutting respective. Where

$CaCO_3$ showed higher in case of absolute control (T_1) treatment. In RDF+ Consortia (T_5) showed minimum content of calcium carbonate as compare to all other treatments. The results interpreted in respect of organic carbon and calcium carbonate revealed that there was overall improvement in these properties due to application of consortia, thus the organic carbon content and reduction in calcareousness of soil are the positive effects towards making a soil healthy.

The calcium carbonate content tended to decrease with application of organic matter (Patil 2013) [8] rather application of organic matter is the only way to mitigate the detrimental

effect of high calcium carbonate on plant growth. pH enhanced decomposition of materials in the soil. This has been revealed in other findings who found that the pH can affect the soil environment through influence on sorption potential, cation availability and microbial degradation rates. Similar consistent patterns have been identified in other studies who found that the enhanced soil acidity may act directly on the functioning of the microbial community which increases the carbon input through biomass production during the crops growth. The increase in the total organic carbon can enhance fertility, productivity and sustainability of agro-ecologies because it acts as a basis for the global carbon cycle. (Wekha *et al.,* 2016) [13]

The lower content of free calcium carbonate in sacred tree rhizosphere was probably due to high organic carbon, acidic secretions and higher concentration of CO2 which in turn solublize the insoluble calcium carbonate in to soluble calcium bicarbonate. The similar effect of high organic matter content on calcium carbonate was also recorded by Patil, 1997, 2013 [7-8].

Conclusions

pH showed slightly acidic to neutral in pH, highest content of Organic carbon and lowest level of lime due to the application of consortia of beneficial organisms on spinach pot culture experiment.

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