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Effect of biofertilizers, graded levels of chemical fertilizers and FYM on soil properties and yield of *Gobhi sarson* (*Brassica napus* L.)

Rekha Ratanoo, SS Walia, KS Saini and GS Dheri

Abstract
In the present study, different levels of inorganic fertilizers, FYM and biofertilizers were used as different treatments to evaluate the performance of *gobhi sarson* and soil properties. Application of 50% RDF + FYM @ 10 t/ha resulted into significantly higher seed, stover and biological yield over other inorganic fertilizers at different doses. 50% RDF + FYM @ 10 t ha^{-1}also caused significantly higher organic carbon content in soil than all other treatments. Maximum reduction to soil pH was found in 50% RDF + FYM @ 10 t ha^{-1}. Available N, P, K and S in soil were also significantly higher in 50% RDF + FYM @ 10 t/ha than all other treatments. Microbial count and enzymatic activity were most favorably affected by 50% RDF + FYM @ 10 t ha^{-1}. Maximum positive effect on yield and soil properties among different biofertilizer treatments was shown by consortium treatment followed by Azotobacter + PSB, Azotobacter, PSB and no biofertilizer application. Thus application of consortium and integration of FYM affected the *gobhi sarson* yields most favourably which can be attributed to their significant effect of soil chemical properties.

Keywords: biofertilizers, chemical fertilizers, FYM, *gobhi sarson*, soil chemical and biological properties

Introduction
India is a premier rapeseed-mustard economy of the world with 2nd and 3rd rank in area and production, respectively. In India, it is second most important crop (contributing 23.1% in acreage and 24.5% in production) among major oilseeds next only to soybean. Rapeseed-mustard being rich in oil content (37-49%) is the largest contributor of edible oil production. Therefore, increase in its productivity level may be one of the useful future strategies in reducing dependence on edible oil import. Productivity of rapeseed-mustard in India, however, is very low as compared to world average.
Inadequate nutrient availability becomes a major hindrance to realize the full potential of the crop because despite being a highly nutrient exhaustive crop, rapeseed-mustard crop is mostly grown by small and marginal farmers who have unfortunately poor access to most inputs and the area where it is grown also come under marginal and poor fertility soils. Therefore, for significant achievement in production and productivity of rapeseed and mustard crops, increase in nutrient use efficiency through integrated nutrient management has been greatly emphasized (Shekhawat *et al* 2012; Kumar 2012) [20, 10]. Biofertilizers are the potential source of the supply of nutrients at low cost and may prove as an important component of Integrated Nutrient Management (INM) system in oilseed crops.
Biofertilizers are an eco-friendly approach to improve soil fertility and crop productivity in agriculture. They substitute the chemical fertilizers demand to a certain extent for meeting the total nutrient requirement of the crops. Application of biofertilizers resulted in increased nutrient availability by bio-fixation (in case of N) or solubilizing the unavailable form into available form (in case of P), higher uptake of mineral and water, better vegetative growth, root development and nitrogen fixation. In oilseeds, particularly rapeseed and mustard being a non-legume crop there has been a limited investigation in integrated nutrient management methods involving biofertilizers. Biofertilizers which are able to enhance crop growth and development and higher biomass accumulation instead of accumulation of cellulose, starch and other secondary metabolites will be useful for crops like rapeseed-mustard. Therefore, present study was aimed at evaluating the effect of different doses of chemical fertilizers, their combination with FYM and different biofertilizers on performance of *gobhi sarson* and soil chemical and biological properties.

Materials and Methods

Field experiments were conducted in 2016-17 and 2017-18 at University Seed Farm, Nabha, Patiala of Punjab Agricultural University. Nabha is located in North-Western Indo-Gangetic plains. Latitude and longitude coordinates of Nabha are 30.37 ^{0}N and 76.14 ^{0}E, respectively. This region is characterized by sub-tropical and semi-arid climate**.** The mean maximum and minimum temperature show considerable fluctuation during summer and winter. Maximum air temperature above 38 °C is common during summer and touches 45 ^{0}C during May-June. Average annual rainfall ranges between 500-750 mm and greater portion (about 75%) of which is received during south-west monsoon season from July to September while in winter a few showers of cyclonic rains are received.

The soil was loam in texture, medium in organic carbon, low in available nitrogen and high in available phosphorus and potassium (Table 3). The pH of the soil was 8.10 and 0.240 dS m^{-1}, respectively (table 2).

Experimental design and cultural practices

The influence of different biofertilizers under graded levels of fertilizers on productivity of *gobhi sarson* and soil properties was studied in a field experiment which was designed according to split plot design having 0%, 50%, 75%, 100% RDF and 50% RDF + FYM @ 10 t/ha) as main plot treatments and no biofertilizer, Azotobacter, PSB, Azotobacter + PSB and consortium as sub-plot treatments. The variety used in *gobhi sarson* cultivation was 'GSC7'.

Seed treatment

200 g of each biofertilizer (carrier based formulation containing 2×10^8 cfu/g) Azotobacter, PSB and consortium was mixed with 40 ml of sterile water. each solution was mixed with 1.5 kg seeds of *gobhi sarson*. For dual inoculation of Azotobacter and PSB 125.g of each biofertilizer was mixed together in 40 ml of sterile water and this solution was mixed with 1.5 kg seeds of *gobhi sarson*.

Fertilizer application

Recommended dose of nitrogen (N) and phosphorous (P_2O_5) for *gobhi sarson* is 100 kg ha^{-1}, 30 kg ha^{-1}. Half of the Nitrogen and entire dose of phosphorous was applied before sowing and rest of the half of the nitrogen was applied at first irrigation in *gobhi sarson*. FYM was applied 15 days before sowing in pre marked plots. Nitrogen and Phosphorous were applied in the form of urea, single super phosphate.

Yield

Crop was harvested manually. Seeds were separated from total produce of each plot were separated manually. Seed and Stover yields were calculated and expressed as kg ha^{-1}.

Soil chemical analysis

The soil samples were taken from 0-15 cm soil, composited, air dried under shade, ground and stored for further analysis. Soil pH and EC were determined by using methods given by Jackson (1967) [9]. Soil organic carbon content was determined by rapid titration method of Walkley and Black (1934) [36]. Soil available nitrogen, phosphorous, potassium and sulphur were determined by using Alkaline Potassium Permanganate method (Subbiah and Asija 1956) [26], 0.5 N Sodium Bicarbonate method (Olsen *et al* 1954) [14], Ammonium acetate extraction method (Jackson 1967) [35] and turbidimetric method (Chesnin and Yien 1950) [5], respectively.

Soil microbial analysis

Soil samples were collected from experimental plots at harvest and stored at temperature below 4^{0}C after packing in polythene bags. The technique used for enumeration of microbes was serial dilution spread plate technique. For enumeration of bacteria, actinomycetes fungi, PSB, Azotobacter and PGPR Nutrient Agar medium, Jenson's medium, Glucose Yeast Extract medium, NDRIB medium, Kenknight's medium and King's B medium, respectively were used after autoclaving at 121 ^{0}C and 15 psi for 20 minutes. Among different enzymatic activities, alkaline phosphatase, dehydrogenase and urease were analysed by using the method of Tabatabai and Bremmer (1969), Tabatabai (1994) and Douglas and Bremmer (1970) [28, 27, 6], respectively.

Statistical analysis

The data were analyzed using standard statistical procedures. To find out the significant difference among different treatment mean LSD or CD (Least Significant Difference or Critical Difference) method was used.

Results and Discussion

Seed yield

The treatment with 50% RDF + FYM @ 10 t ha^{-1} recorded highest seed yield which was significantly superior than all treatments i.e. control, 50% RDF, 75% RDF whereas 100% RDF was statistically at par (Table 1). 50% RDF + FYM produced 2.6%, 8.9%, 22.6% and 79.1% higher yield as compared to 100% RDF, 75% RDF, 50% RDF and control, respectively. Successive increase in dose of inorganic fertilizers also resulted into significant increase in seed yield. Seed yield increased with combining the FYM with inorganic fertilizers (at 50% RDF) by 3.6%. (Sahoo *et al* 2018) [19]. Similar findings were also reported by Singh *et al* (2017) [24]. Across the years, the increase in seed yield with application of 50% RDF, 75% RDF, 100% RDF and 50% RDF + FYM @ 10 t ha^{-1} over the control was 46.1, 64.5, 74.5 and 79.1%, respectively.

Application of biofertilizers also affected the seed yield significantly at both the locations and both the years. Maximum yield was obtained with application of consortium which was significantly higher than all other biofertilizer treatments except *Azotobacter* + PSB treatment. Application of *Azotobacter* resulted into significantly higher seed yield as compared to control i.e. no biofertiliser application although this treatment resulted into higher but statistically at par yield with application of PSB alone. Combined application of *Azotobacter* + PSB produced higher seed yield than control, *Azotobacter* alone and PSB alone, however, the yield was statistically at par with *Azotobacter* alone and consortium. The increase in mean yield was 3.0%, 1.7%, 5.2% and 6.7% in treatments having application of *Azotobacter*, PSB, *Azotobacter* + PSB and consortium, respectively over the control (no biofertilizer) treatment. Positive effect of *Azotobacter* and PSB on seed yield of mustard was also reported by Beenish *et al* (2018) [3].

Stover yield

Application of inorganic fertilizers and FYM resulted into significantly higher yield as compared to control, irrespective of their doses (Table 1). The treatment with 50% RDF + FYM

@ 10 t ha^{-1} was statistically at par with 100% RDF and significantly superior than all other treatments i.e. control, 50% RDF and 75% RDF. Similar findings on stover yield were reported by Sahoo *et al* (2018) [19], Singh *et al* (2017) [24] and Mandal and Sinha (2004) [12]. Increasing the dose of chemical fertilizers alos had significant effect on yield. Singh *et al* (2017) [24] reported significant increase in seed and stover yield at 100% RDF and 75% RDF as compared to control.

Application of biofertilizers also affected the stover yield significantly during both the years. No biofertilizer application was significantly lower in stover yield than different biofertilizer applications. As compared to control, *Azotobacter*, PSB, *Azotobacter* + PSB and consortium recorded 4.5, 4.2, 6.6 and 8.2%, respectively, higher stover yield across the years. Maximum yield was obtained with application of consortium which was significantly higher than all other biofertilizer treatments except *Azotobacter* + PSB treatment. Application of *Azotobacter* resulted into significantly higher stover yield as compared to control i.e. no biofertiliser application although this treatment resulted into higher but statistically at par yield with application of PSB alone. Combined application of *Azotobacter* + PSB produced higher stover yield than control, *Azotobacter* alone and PSB alone, however, the yield was statistically at par with *Azotobacter* alone and consortium. Effect of different inoculation treatments i.e. *Azotobacter*, PSB etc. has also been studied by Beenish *et al* 2018 [3] and Saini *et al* (2017).

Biological yield

Biological yield increased significantly at each successive increase in the dose of inorganic fertilizer (Table 1). This may be ascribed to supply of adequate nutrients for plant vigour and growth by higher doses of chemical fertilizers and FYM application which promotes rapid vegetative growth and branching thereby increasing the sink size in terms of flowering, fruiting and seed setting. Besides, this increased sink size was able to tap more photosynthates towards itself which ultimately resulted into higher economic as well as biological yield. (Singh and Pal 2011) [23]. Application of 50% RDF + FYM @ 10 t ha^{-1} produced maximum yield which was significantly more than control, 50% RDF and 75% RDF and statistically at par with 100% RDF.

Application of biofertilizers also affected the seed yield significantly at both the locations and both the years. Maximum yield was obtained with application of consortium which was significantly higher than all other biofertilizer treatments except *Azotobacter* + PSB treatment. Application of *Azotobacter* resulted into significantly higher seed yield as compared to control i.e. no biofertiliser application although this treatment resulted into higher but statistically at par yield with application of PSB alone. Combined application of *Azotobacter* and PSB produced higher yield than control, *Azotobacter* alone and PSB alone. The increase in mean yield was 4.3, 3.8, 7.5 and 9.1% in treatments having application of *Azotobacter*, PSB, *Azotobacter* + PSB and consortium, respectively over the control (no biofertilizer) treatment. Enhancement of growth by plant growth promoting rhizobacteria is through multiple mechanisms such as N_2-fixation, P-solubilization, ACC deaminase and antifungal activities, IAA and siderophore biosynthesis etc. (Dutta *et al* 2017) [7].

Table 1: Effect of biofertilizers under graded levels of fertilizers on yield (kg ha^{-1}) of *gobhi sarson*

Treatments	Seed yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Biological yield (kg ha^{-1})	
	2016	2017	2016	2017	2016	2017
Chemical Fertilizers						
Control (0% RDF)	1322	1392	4619	4872	5942	6264
50% RDF	1944	2020	5747	5993	7693	8013
75% RDF	2198	2266	6613	6857	8814	9123
100% RDF	2321	2415	7414	7758	9736	10173
50% RDF + FYM	2397	2464	7615	7807	10014	10271
SEm±	36	37	238	249	216	244
CD (p=0.05)	121	122	777	813	703	794
Biofertilizers						
Control (No biofertilizers)	1963	2052	6108	6364	8042	8416
Azotobacter	2034	2101	6406	6632	8440	8733
PSB	2001	2084	6354	6637	8355	8721
Azotobacter + PSB	2081	2141	6510	6787	8606	8928
Consortium	2104	2179	6631	6868	8757	9046
SEm±	16	14	54	85	52	83
CD (p=0.05)	46	40	154	242	149	236

Soil chemical properties

Organic carbon

Perusal of data on organic carbon in table showed that organic carbon content increased in all the treatments as compared to its initial status in the soil during both the years (table 2). Increase in fertilizer doses resulted into increase in organic carbon content. Fertilizer application promotes the crop growth including root proliferation and this root biomass is added as organic matter to the soil. The difference was non-significant with each successive dose, however, organic carbon content increased significantly at increasing the dose from 0% to 75%, 100% RDF and 50 to 100% RDF. Similar findings on increase in organic carbon content with fertilizer dose increase was also reported by Saha *et al* (2010) and Singh *et al* (2015) [18, 21], Application of 50% RDF + FYM @ 10 t ha^{-1} resulted into significant increase in organic carbon content as compared to all other fertilizer doses. Moreover, combined application of organic and inorganic nutrient sources is a great input to root biomass in the form of better crop productivity (Gunjal and Chitodkar 2017) [8].

Organic carbon content in biofertilizer treatments was significantly higher as compared to control. Combined application of *Azotobacter*, PSB and PGPR through consortium resulted into highest and significant increase in organic carbon content as compared to control and single inoculation with either *Azotobacter* or PSB. Similar results were also found by Ramalakshmi *et al* (2008) [15], Solanki *et al* (2015) [25] and Banerjee *et al* (2011) [2]. Bioinoculants proliferate in the soil and produce different plant growth promoting substances which promote the rhizodeposition of photosynthetic carbon in the form of root exudates and they also increase overall crop growth including root biomass as well which ultimately turns into organic matter in the soil.

Soil pH

Soil pH in all the treatments decreased after harvest of the crop from its initial status (Table 2). Increase in fertilizer doses increased the soil pH. Combined application of 50% RDF + FYM @ 10 t ha^{-1} recorded maximum reduction in soil pH. The decrease in soil pH with addition of FYM is due to organic acids in the organic manures (Reddy *et al* 2006). Mulyani *et al* (2017) [17, 13] also reported that soil pH increased with each successive dose of chemical fertilizers irrespective of the biofertilizers applied in combination after harvest of the sugarcane. Biofertilizers also lowered the soil pH as compared to non-inoculation treatments and maximum reduction was seen in consortium application. Similar findings i.e. maximum reduction in soil pH witn combined application of biofertilizers were also reported by Ramalakshmi *et al* (2008) [15].

Table 2: Effect of biofertilizers under graded levels of fertilizers on soil chemical properties at harvest of *gobhi sarson*

Treatments	Soil pH		Soil EC (dS m^{-1})		Organic carbon (%)	
	2016	2017	2016	2017	2016	2017
Chemical Fertilizers						
Control (0% RDF)	7.98	7.96	0.197	0.190	0.53	0.55
50% RDF	8.01	7.99	0.211	0.205	0.56	0.57
75% RDF	8.02	8.00	0.224	0.220	0.57	0.58
100% RDF	8.05	8.04	0.230	0.225	0.59	0.59
50% RDF + FYM	7.80	7.71	0.218	0.210	0.63	0.64
SEm±	0.01	0.01	0.004	0.004	0.01	0.01
CD (p=0.05)	0.03	0.04	0.015	0.014	0.03	0.04
Biofertilizers						
Control (No biofertilizers)	8.03	8.01	0.212	0.205	0.55	0.56
Azotobacter	8.00	7.97	0.214	0.207	0.56	0.57
PSB	7.96	7.92	0.217	0.211	0.58	0.59
Azotobacter + PSB	7.94	7.91	0.218	0.212	0.59	0.6
Consortium	7.93	7.90	0.219	0.214	0.60	0.61
SEm±	0.01	0.01	0.003	0.003	0.01	0.00
CD (p=0.05)	0.03	0.03	0.009	0.007	0.02	0.01
Initial value	8.10		0.240		0.53	

Electrical conductivity

Electrical conductivity in all the treatments decreased after harvest of crop (Table 2). Maximum electrical conductivity was observed in the treatment receiving 100% RDF which was significantly higher than control, 50% RDF and 50% RDF + FYM @ 10 t ha^{-1} treatments. This treatment was followed by 75% RDF, 50% RDF with FYM, 50% RDF and control. Application of 50% RDF + FYM @ 10 t ha^{-1} increased the electrical conductivity as compared to 50% RDF alone. Addition of different biofertilizers had non-significant effect on electrical conductivity, however, biofertilisation increased electrical conductivity as compared to no biofertilization with consortium having increased it to the maximum. Electrical conductivity is direct parameter for concentration of soluble salts in the medium. Addition of chemical fertilizers directly adds to the concentration of soluble salts in the soil whereas addition of FYM and biofertilizers increase the organic acids in the soil which react with the sparingly soluble salts already present converting them to soluble salts. Similar findings on effect of integrated nutrient supply on electrical conductivity were reported by Singh *et al* (2016) [22] and Banerjee *et al* (2011) [2].

Nutrient availability

Available N, P, K and S were affected significantly by different doses of inorganic, organic and biofertilizers in general during both the years (Table 3). In unfertilized treatments i.e. control nutrient availability reduced. Different doses of chemical fertilizers increased nutrient availability significantly as compared to control. However, in general, successive increase in doses of chemical fertilizers did not improve the nutrient status significantly. Further increase i.e. 50 to 100% recommended dose of chemical fertilizers generally increased the nutrient availability significantly. Application of 50% RDF + FYM @ 10 t ha^{-1} increased the amount of available nutrients significantly as compared to all other main plot treatments. These results are corroborated with Chand *et al* (2006) [4]. Addition of FYM resulting into post-harvest availability of nutrients can be attributed to enhanced release of nutrients from soil native pool as well as via means of favouring the growth of beneficial microorganisms. Organic acids and chelation effects by organic manure also convert the insoluble form of P to soluble forms. (Rao 2003) [16].

Among different sub-plot treatments i.e. biofertilizers, N, P, K and S availability increased significantly with combined application of biofertilizers i.e. consortium and *Azotobacter* + PSB as compared to single inoculation and non-inoculation. Among single inoculation treatments *Azotobacter* and PSB had more pronounced effect on N and P availability, respectively as compared to other nutrients, however, availability of all the nutrients was affected positively with application of biofertilizers either single inoculation or co-inoculation.

Table 3: Effect of biofertilizers under graded levels of fertilizers on soil available nutrients at harvest of *gobhi sarson*

Treatments	Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})		Available S (kg ha^{-1})	
	2016	2017	2016	2017	2016	2017	2016	2017
Chemical Fertilizers								
Control (0% RDF)	233	236	35.2	36.1	430	431	15.4	16.0
50% RDF	248	249	37.5	38.5	434	433	15.9	16.5
75% RDF	252	254	38.2	39.1	435	434	16.6	16.9
100% RDF	256	257	39.8	40.4	436	434	16.9	17.4
50% RDF + FYM	268	272	42.2	44.0	438	441	17.8	18.5
SEm±	3	4	0.7	1.1		2	0.3	0.3
CD (p=0.05)	11	13	2.2	3.3	NS	6	0.8	1.0
Biofertilizers								
Control (No biofertilizers)	248	251	37.4	38.4	433	433	15.7	16.1
Azotobacter	252	254	37.6	38.7	434	434	16.1	16.4
PSB	250	253	38.6	39.8	434	434	16.4	17.0
Azotobacter + PSB	252	255	39.4	40.1	435	436	16.9	17.6
Consortium	256	256	39.8	41.1	436	436	17.5	18.1
SEm±	1	1	0.3	0.3			0.2	0.2
CD (p=0.05)	4	3	0.9	1.0	NS	NS	0.5	0.7
Initial value	251		36.3		433		16.1	

Soil biological properties

Microbial population

The microbial population (bacteria, *Azotobacter*, PSB, PGPR Actinomycetes and Fungi) was significantly highest in 50% RDF + FYM @ 10 t ha^{-1} (Table 4 and Table 5). Increasing the dose of chemical fertilizers from 0 to 100% RDF resulted into increased population of bacteria, PSB and PGPR whereas fungi, Actinomycetes, *Azotobacter* showed the inverse trend in these treatments. Scarce nutrient availability and lower N application favour the Actinomycets and *Azotobacter* population, respectively (MacKenziem and Quideau 2010) [11]. Proper plant growth due to higher application of chemical fertilizers results into flourished population of bacteria. Among different biofertilizers treatments lowest bacterial, *Azotobacter*, PSB, PGPR anf fungal population was found in uninoculated treatment. Bacteria, *Azotobacter*, PSB, PGPR were significantly higher in consortium treatment than all other treatments followed by *Azotobacter* + PSB. Actinomycetes and fungal population showed the trend inverse to all other microbes. The results were corroborated with Ramalakshmi *et al* (2008) [15].

Table 4: Effect of biofertilizers with graded levels of fertilizers on microbial population (Bacteria, Actinomycetes and Fungi) of *gobhi sarson*

Treatments	Bacteria (× 10^7 cfu g^{-1} soil)		Actinomycetes (× 10^4 cfu g^{-1} soil)		Fungi (× 10^3 cfu g^{-1} soil)	
	2016	2017	2016	2017	2016	2017
Chemical Fertilizers						
Control (0% RDF)	78.4	85.2	24.0	24.8	9.1	9.5
50% RDF	85.0	94.5	18.3	19.9	11.0	11.8
75% RDF	94.8	101.6	15.1	16.2	10.7	12.1
100% RDF	98.4	103.4	13.4	14.7	10.2	12.1
50% RDF + FYM @ 10 t ha^{-1}	122.2	129.3	21.9	23.6	11.5	12.7
SEm±	1.3	2.1	1.0	1.2	0.2	0.1
CD (p=0.05)	4.2	6.8	3.0	4.1	0.8	0.4
Biofertilizers						
Control (No biofertilizers)	76.2	83.8	21.0	22.3	10.3	11.3
Azotobacter	91.0	98.4	19.0	20.2	10.8	11.8
PSB	88.0	92.8	19.9	20.7	11.2	12.0
Azotobacter + PSB	103.4	110.0	17.9	19.4	10.3	11.6
Consortium	120.2	129.0	14.9	16.7	9.9	11.5
SEm±	1.2	2.2	0.3	0.4	0.2	0.1
CD (p=0.05)	3.4	6.3	1.0	1.2	0.5	0.3
Initial value	60		19		8.8	

Table 5: Effect of biofertilizers with graded levels of fertilizers on microbial population (*Azotobacter*, PSB and PGPR) of *gobhi sarson* at Nabha

Treatments	*Azotobacter* (× 10^5 cfu g^{-1} soil)		PSB (× 10^5 cfu g^{-1} soil)		PGPR (× 10^5 cfu g^{-1} soil)	
	2016	2017	2016	2017	2016	2017
Chemical Fertilizers						
Control (0% RDF)	19.9	22.2	11.7	12.7	74.8	80.4
50% RDF	25.2	26.2	14.3	16.0	81.4	88.4
75% RDF	28.0	28.0	16.1	18.6	91.2	97.8
100% RDF	25.4	26.1	17.6	19.0	94.0	100.8
50% RDF + FYM @ 10 t ha^{-1}	38.2	42.6	22.3	23.1	117.8	125.6
SEm±	1.1	1.1	0.6	1.2	1.9	2.3
CD (p=0.05)	3.6	3.8	2.1	3.9	6.2	7.6
Biofertilizers						

Control (No biofertilizers)	18.3	20.7	13.3	15.0	72.8	80.4
Azotobacter	26.4	28.4	14.6	16.3	87.2	94.2
PSB	20.6	21.6	16.7	18.2	83.6	89.2
Azotobacter + PSB	33.3	24.4	18.1	19.5	99.0	105.4
Consortium	38.2	40.0	19.2	20.5	116.6	123.8
SEm±	1.0	0.5	0.5	0.8	1.5	2.0
CD (p=0.05)	2.8	1.3	1.6	2.2	4.2	5.8
Initial value	13.3		8.6		44	

Enzymatic activity

Alkaline phosphatase, dehydrogenase and urease activity increased significantly with increasing the dose of chemical fertilizers with minimum level in unfertilized treatment (Table 6). Maximum enzymatic activity was found in treatment having 50% RDF + FYM @ 10 t ha-1. Among different biofertilizers treatments maximum activity of enzymes was found in consortium treatment followed by co-inoculation with *Azotobacter* + PSB. Activity of these enzymes may be attributed to higher bacterial and PSB population in co-inoculation treatments as compared to single inoculation treatments. Improvement in soil enzymatic activity by biofertilizer application has also been shown by Aseri *et al* (2008) [1].

Table 6: Effect of biofertilizers with graded levels of fertilizers on enzymatic activity in soil at harvest of *gobhi sarson* at Nabha

Treatments	Alkaline phosphatase (µg PNP formed g^{-1} soil h^{-1})		Dehydrogenase (µg TPF formed g^{-1} soil h^{-1})		Urease (µg urea hydrolysed g^{-1} soil h^{-1})	
	2016	2017	2016	2017	2016	2017
Chemical Fertilizers						
Control (0% RDF)	2.33	2.36	7.64	8.69	414	429
50% RDF	2.51	2.69	9.05	10.43	429	441
75% RDF	2.63	2.86	9.87	11.56	435	448
100% RDF	2.78	3.02	10.88	12.12	442	454
50% RDF + FYM @ 10 t ha^{-1}	3.85	4.30	12.51	14.05	451	467
SEm±	0.08	0.07	0.44	0.56	2	2
CD (p=0.05)	0.25	0.24	1.42	1.82	7	7
Biofertilizers						
Control (No biofertilizers)	2.52	2.82	8.31	9.47	418	432
Azotobacter	2.57	2.87	9.22	10.58	435	450
PSB	2.77	3.03	8.74	10.12	428	441
Azotobacter + PSB	3.04	3.18	11.33	12.79	444	456
Consortium	3.20	3.31	12.34	13.90	448	460
SEm±	0.04	0.04	0.27	0.20	2	1
CD (p=0.05)	0.103	0.125	0.77	0.57	6	4

Conclusion

Integration of FYM with 50% RDF was significantly superior treatment over different doses of chemical fertilizers without FYM in terms of yield, nutrient availability and biological properties. Seed treatment with consortium gave significantly higher yield as compared to other biofertilizers treatments. Therefore, it can be concluded the integrated use of FYM and consortium at reduced dose of chemical fertilizers can prove as a best nutrient management practice for *gobhi sarson*.

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