Effect of Biofertilizers at Different Fertility Levels on Nutrient Content and Uptake by*Gobhi Sarson* (*Brassica napus* L.) under Himalayan Region

Abstract

The field experiment was conducted during *Rabi* 2023 at CSKHPKV Shivalik Agricultural Research and Extension Centre (SAREC), Kangra, Himachal Pradesh to assess the effect of biofertilizers at varying fertility levels on soil properties and nutrient uptake by *gobhi sarson*. Theexperimentwas conducted in split plot design having main plot treatments, comprised three fertility levels (control, 75% recommended dose of fertilizer (RDF) and 100% RDF) and six treatments of liquid biofertilizers viz. *Azotobacter*, phosphate solubilizing microorganism (PSMO), potassium mobilizing biofertilizer (KMB), zinc solubilizing biofertilizer (ZSB), NPK consortia + ZSB and control (no biofertilizer) as sub-plots, replicated thrice. Results showed that application of 100% RDF recorded higher N, P, K and Zn content (3.90, 0.58, 0.65% and 34.31ppm and 0.81, 0.19, 1.35% and 29.36ppm in seed and straw, respectively) and thereby enhanced their uptake (73.1, 10.9, 12.2 kgha^{-1} and 64.3 ppm in seed and 66.4, 16.3, 110.1 kgha^{-1} and 240 ppm in straw, respectively). Among biofertilizers, seed inoculation with *Azotobacter* recorded higher nutrient content and uptake of NPK and Zn by seed and straw; the increase was being (45.29, 45.45, 57.97, 46.80 and 31.34, 37.96, 32.22, 34.66%, respectively) over control (no inoculation). Hence, *Azotobacter* and PSMO was found to be most efficient biofertilizers.

Key words: *Azotobacter, biofertilizer, gobhi sarson, nutrient content and uptake*

INTRODUCTION

India ranks as the third largest producer of oilseeds globally. Among various oilseed crops, rapeseed-mustard occupies significant position in terms of both total cultivated area and production in India. Rapeseed (*Brassica* spp.) classified within the family *Brassicaceae*, serves as one of the major oilseed crop as well as leading source of edible oil and occupies a remarkable place being next to soybean in area and groundnut in terms ofyield. The oil content of rapeseed ranges from 36-42 %.During 2020-21 area, production and productivity of rapeseed-mustard in the world was 34.89 million hectares, 69.23 million tones and 1980 kg ha^{-1} while in India it was 6.69 million hectares, 10.11 million tonnes and 1511 kg ha^{-1}, respectively. Globally, India account for 19.8 % and 9.8% of the total acreage and production. In Himachal Pradesh, rapeseed-mustard had acreage of 8.6 thousand hectares with 4.9 thousand tonnes production (Anonymous 2019) and 650 kg ha^{-1} of productivity (Anonymous 2021). Nevertheless, as compared to other nations, the productivity levels of mustard-rapeseed in India remain considerably low.

The productivity of rapeseed-mustard crops is often significantly constrained by nutrient deficiencies. These crops have a high nutrient demand, but they are largely grown by small and marginal farmers who typically have limited access to necessary inputs and cultivate them on soils with poor fertility. Consequently, despite their high nutrient requirements, rapeseed-mustard crops often fail to achieve their full growth potential. Enhancing nutrient use efficiency through integrated nutrient management has therefore gained considerable attention.

Biofertilizers, which provide nutrients at a low cost, could play a key role in Integrated Nutrient Management (INM) strategies for oilseed crops (Shekhawat *et al.* 2012; Shahu *et al.* 2024).

Biofertilizers consist of living microbial inoculants of bacteria, fungi and algae, either alone or in combination. They enhance plant growth and development by converting unavailable forms of nutrients into available forms. Biofertilizers contribute nitrogen through biological nitrogen fixation (BNF), solubilize fixed macro-micronutrients, mobilize essential elements and synthesize plant growth-promoting hormones. They also offer protection against soil-borne diseases. Eco-friendly, non-toxic and cost-effective nature of biofertilizers serve as valuable supplements to chemical fertilizers and are increasingly adopted in agricultural systems. Due to the high costs and negative impacts of chemical fertilizers on plant health, soil fertility and human well-being, relying solely on chemical fertilizers is not a sustainable option. The use of biofertilizers in combination with chemical fertilizers reduces dependency on the chemical fertilizers while offering an eco-friendly and cost-effective approach (Choudhary *et al*. 2024). This practice enhances long-term soil fertility and contributes to achieving sustainability in agricultural production (Kumawat 2017;Seenivasagan*et al.* 2021; Manhas *et al.* 2021; Salaria *et al.* 2024; Sharma *et al.* 2024b). Therefore, the present study was aimed at evaluating the effect of biofertilizers at varying fertility levels on nutrient uptake by *gobhi sarson* and its effect on soil bio-chemical properties.

Materials and Methods

Experimental site

A field experiment was conducted during *Rabi* 2022-23 at the experimental farm of CSK HPKV, Shivalik Agricultural Research and Extension Centre (SAREC), Kangra (H.P.), India. Geographically, the experimental farm is situated at 32° 09′ N latitude, 76° 22′ E longitude and 700 meter above the mean sea level. The soil of field experimentation was clay loam in texture having pH 5.61. The soil sample was taken prior to experiment was low in available nitrogen (275.7 kg ha^{-1}), medium in available phosphorus (18.3 kg ha^{-1}) and available potassium (227.4 kg ha^{-1}).

Treatment details

The experiment was laid out in split plot design allocating fertility levels in main plots *viz.*, control (no fertilizer), 75% RDF (recommended dose of fertilizers) and 100% RDF and six treatments of liquid biofertilizers *viz.*, *Azotobacter*, phosphate solubilizing microorganism (PSMO), potassium mobilizing biofertilizer (KMB), zinc solubilizing biofertilizers (ZSB), NPK consortia + ZSB and control (no biofertilizer) in sub plots, replicated thrice. Seed inoculation with liquid biofertilizers was done by soaking the seeds for 30 minutes in liquid biofertilizers and then dried in shade for half an hour before sowing in field plots of an area of 11.76 m^2 of each. The nitrogen was supplied by IFFCO (12:32:16) and urea whereas the source of potash was the muriate of potash (MOP). As per main plot treatments, full dose of phosphorus and potassium along with one third dose of nitrogen was applied as basal. The remaining dose of nitrogen was given by urea at vegetative and flowering stage in two equal splits. The recommended dose of fertilizer is 120 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1}.

List 1: Plant Analysis

Sr. No.	Nutrient	Analytical method
1	Nitrogen	Digestion of plant sample by concentrated H_2SO_4 in the presence of digestion mixture (K_2SO_4:$CuSO_4$:Selenium powder in 10:1:0.1 ratio) and later determination following Kjeldahl's and distillation method (Jackson 1973).
2	Phosphorus	Plant samples were digested in diacid mixture (HNO_3:$HClO_4$ = 9:4 ratio) and further determination by Vanadomolybdate acid yellow colour method (Jackson 1973).
3	Potassium	Digestion of plant samples in diacid mixture (HNO_3:$HClO_4$ = 9:4 ratio) and estimation by flame photometer (Black 1965).
4	Zinc	Atomic Absorption Spectrophotometry method (Jackson 1967).

$$\text{Nutrient uptake in seed (kg / ha)} = \frac{\text{concentration of nutrient in seed (\%)} \times \text{seed yield (kg / ha)}}{100}$$

$$\text{Nutrientuptakeinstraw (kg / ha)} = \frac{\text{concentrationofnutrientinstraw(\%)} \times \text{strawyield (kg / ha)}}{100}$$

Total nutrient uptake (kg/ha) = Nutrient uptake in seed (kg ha^{-1}) + Nutrient uptake in straw (kg ha^{-1})

Statistical analysis

The statistical analysis for Split plot design conducted by adopting the ANOVA techniques as explained by Cocharan and Cox (1957). The critical difference (CD) values among treatments were worked out at 5% level of probability wherever F values were found significant. Data analysis was undertaken in OPSTAT software. http://14.139.232.166/opstat.

Result and Discussion

Nutrient content

Significantly higher content of primary nutrients (N, P and K) and zinc micro nutrient in both seed and straw were recorded with application of 100% RDF over 75% RDF and control (no fertilizer) except nitrogen content in seed. The present results are in conformity with Pradhan *et al.* (2016) where they reported that application of adequate amount of nutrients produced healthier and vigorous plant growth as evident by taller plants, more number of branches and dry matter production that accompanied better nutrient content.

In general, seed inoculation with biofertilizers significantly improved the nutrient content in seed and straw of *gobhi sarson*. Seed inoculation with *Azotobacter* significantly recorded higher N, P & K content per cent (seed & straw) being at par with PSMO except P content in straw over control (no inoculation). ZSB treatment recorded significantly more zinc content (seed & straw) being at par with NPK consortia + ZSB over no inoculation which may be ascribed to zinc solubilization. *Azotobacter* has ability to fix atmospheric nitrogen, PSMO and KMB increased the availability of P & K by organic acid production and solubilization, microbial consortia also enhanced nutrient availability and ZSB synthesize chelate zinc through carboxyl & hydroxyl groups to enhance Zn solubility and mineral uptake by plant. This is in accordance with the findings of Singh*et al.*(2024), Nisha *et al.*(2014) and Olaniyan *et al.*(2022).

Nutrient uptake

Nutrient uptake significantly increased from control (no fertilizer) to 75% RDF and further to 100% RDF. Due to more nutrient content as well as higher yield, significantly more uptake of primary nutrients & zinc was more with 100% RDF over 75% RDF and control except P uptake in straw. Application of 100% RDF recorded nutrient uptake of N (139.5 kg), P (27.3 kg), K (122.3 kg) and Zn (304.4 g) per hectare over 75% RDF & control. This might be due to adequate supply of nutrients to the crop through chemical fertilizers which was able to meet out the nutritional requirement of the crop Kumar *et al.*(2017) and Sharma *et al.* (2023).

In general, seed inoculation with biofertilizers increased the N, P, K and Zn uptake by *gobhi sarson* seed and straw as well as total (seed + straw) crop over no inoculation. *Azotobacter* recorded significantly more total (seed + straw) nutrient uptake (128.0 kg N, 24.5 kg P, 118.1 kg K) followed by PSMO & NPK consortia + ZSB. Higher nutrient content of zinc in ZSB & NPK consortia + ZSB resulted in total (seed +straw) zinc uptake on par with *Azotobacter* though the seed yield was more with latter. Biofertilizers *viz*., *Azotobacter*, PSMO etc. increased the nutrient uptake by production of growth hormones that allowed better root development & acquisition of more nutrients from the soil. The results are in agreement with Naik *et al.* (2024) and Sharma*et al.*(2024a).

Table 1: Effect of fertility levels and microbial consortia on nitrogen, phosphorus, potassium and zinc content of *gobhi sarson*

Treatment		Nitrogen (%)		Phosphorus (%)		Potassium (%)		Zinc (mg kg^{-1})	
		Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
Fertility Levels									
F_1	Control	3.35	0.62	0.49	0.14	0.50	1.18	28.64	23.95
F_2	75% NPK	3.68	0.72	0.54	0.17	0.59	1.29	32.11	26.93
F_3	100% NPK	3.90	0.81	0.58	0.19	0.65	1.35	34.31	29.36
	SEm±	0.06	0.01	0.01	0.004	0.01	0.01	0.50	0.33
	LSD ($p=0.05$)	0.25	0.04	0.03	0.014	0.05	0.04	2.04	1.32
Microbial consortia									
T_1	*Azotobacter*	3.84	0.76	0.56	0.183	0.63	1.33	32.12	27.11
T_2	PSMO	3.70	0.73	0.55	0.185	0.61	1.32	31.40	26.15
T_3	KMB	3.58	0.70	0.53	0.16	0.57	1.24	30.04	24.72
T_4	ZSB	3.60	0.71	0.54	0.17	0.58	1.26	34.63	29.77
T_5	NPK consortia + ZSB	3.63	0.72	0.54	0.17	0.59	1.30	33.73	28.88
T_6	Control	3.50	0.69	0.50	0.16	0.52	1.20	28.22	23.87
	SEm±	0.07	0.01	0.002	0.004	0.01	0.01	0.40	0.31
	LSD ($p=0.05$)	0.21	0.04	0.01	0.007	0.02	0.02	1.15	0.92

Table 2: Effect of fertility levels and microbial consortia on nitrogen, phosphorus, potassium and zinc uptake of *gobhi sarson*

Treatment		Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})			Zinc (g ha^{-1})		
		Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
Fertility levels													
F_1	Control (no fertilizer)	28.4	37.9	66.3	4.1	8.8	12.9	4.3	71.7	76.1	24.4	145.8	170.2
F_2	75% RDF	64.9	55.0	120.0	9.5	13.4	23.0	10.5	98.3	108.9	56.6	205.2	261.8
F_3	100% RDF	73.1	66.4	139.5	10.9	16.3	27.3	12.2	110.1	122.3	64.3	240.0	304.4
	SEm±	1.1	1.5	2.4	0.2	0.7	0.8	0.3	3.0	3.3	1.7	6.0	7.2
	LSD *(p=0.05)*	4.6	6.2	9.8	1.0	2.8	3.4	1.2	12.1	13.3	6.8	24.4	29.1
Microbial consortia													
T_1	*Azotobacter*	66.4	61.6	128.0	9.6	14.9	24.5	10.9	107.1	118.1	55.2	218.3	273.5
T_2	PSMO	60.7	56.3	117.1	9.1	14.3	23.4	10.2	100.8	111.1	51.5	200.9	252.4
T_3	KMB	50.2	49.7	100.0	7.4	11.7	19.2	8.0	86.8	94.9	42.2	173.6	215.8
T_4	ZSB	53.4	50.8	104.2	8.0	12.3	20.3	8.7	89.7	98.5	51.6	213.3	264.8
T_5	NPK consortia + ZSB	56.4	53.1	109.6	8.5	12.9	21.5	9.3	94.8	104.2	52.6	213.8	266.4
T_6	Control (no biofertilizer)	45.7	46.9	92.6	6.6	10.8	17.5	6.9	81.0	88.0	37.6	162.1	199.7
	SEm±	1.4	1.3	2.5	0.1	0.3	0.3	0.1	1.3	1.4	0.7	3.8	3.8
	LSD (p=0.05)	4.1	3.9	7.3	0.3	0.8	0.8	0.4	4.0	4.0	2.0	11.2	11.1

Conclusion

The result of the study concluded that application of 100% RDF resulted in higher nutrient content and uptakeof NPK and Zn by *gobhi sarson* over control. Whereas, different biofertilizers showed significant effect on nutrient content as well asuptake of primary nutrients (NPK) and micronutrient (Zn). However, *Azotobacter* was found to be the most efficient biofertilizer followed by PSMO.

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