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Research Paper

Economic Evaluation of the Effect of S Fertilization with Seed Biopriming on Indian Mustard (cv. Giriraj) Production under Middle Gangetic Plains of Uttar Pradesh, India

Sonam Singh and Amitava Rakshit*

Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Science, Banaras Hindu University, Varanasi, Uttar Pradesh India

*Corresponding author: amitavar@bhu.ac.in **(ORCID ID:** 0000-0002-9406-8262)

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ABSTRACT

A two-year field experiment was carried out during rabi season of 2018-19 and 2019-20 at the research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi on a sandy loam soil to evaluate the economic feasibility of seed bio-priming with sulphur (S) fertilization for mustard production in middle gangetic plains. The experiment was laid out in randomized block design (RBD) with three replications. The treatments were consisting of four levels of S (0, 20, 30 and 40 kg S ha^{-1}) through bentonite S and three seed priming sources (un-primed, *Bacillus subtilis* and *Pseudomonas fluorescence*). The results showed that, application of T_{11} (40 kg S ha^{-1} + *Bacillus subtilis*) results in highest gross return (105791 and 116209 INR ha^{-1}), net return (70182 and 79282 INR ha^{-1}) and B: C ratio (1.97 and 2.15) in the first and second year of study, respectively. Application of 30 kg S ha^{-1} + *Bacillus subtilis* gives higher gross return, net return and B: C ratio compared to application of 40 kg S ha^{-1} (recommended dose of S) without seed bio-priming. It was concluded that application of 40 kg S ha^{-1} + *Bacillus subtilis* was best technique for better net return in mustard production and may be recommended to farmers.

HIGHLIGHTS

- Adoption of seed priming technology along with S fertilization by mustard growers proved to be more efficient in terms of economic compared to solo application of fertilizer.

Keywords: Sulphur, seed priming, gross return, net return and B: C ratio

Quality food production and economic feasibility are the biggest concern of researchers in the recent time. Improving crop productivity with application of synthetic chemicals like fertilizers, pesticides, fungicides, etc. has led to increased soil pollution and loss of soil biodiversity. Synthetic chemicals are costly and cause serious health issues by entering into the food chain (Javed *et al*. 2019 and Baweja *et al*. 2020). Replacing chemical fertilizers is not a viable option as it will widen the gap between food production and demand. Sulphur (S) is important nutrients for oilseeds production as it influences productivity and quality of product (Piri and Sharma, 2006; Kumar *et al*. 2011 and Patel *et al*. 2019). Continuous use of concentrated nitrogen (N), phosphorus (P) and potassium (K) containing fertilizers lead to nutrient deficiency like S (Saha *et al*. 2010). Despite being the fifth biggest oilseed crop-producing country in the world, India is also one of the leading importers of vegetable oils today (Jat *et al.* 2021). According to NMOOP (2018), India imports 60% of its vegetable oil demand which is consumed annually and the cost of this import is

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approximately ₹ 73,048 crores. Nutrient deficiency (S in this case) is a major cause of low mustard productivity which forces Indian government to import vegetable oil. Food grain and oilseed are two important sectors with fertilizer consumption more than 70% of total Indian fertilizer consumption (Srinivasarao, 2021). The forecast suggests, 48.68 MT and 57.32 MT of total fertilizer demand by 2025 and 2030, respectively. Further, the rate of consumption is going to increase from 148 to 277 kg ha^{-1} by 2030. Increasing fertilizer consumption is going to put a huge burden on the Indian economy and their effect on the environment is naturally going to be magnified (Jadhav and Ramappa, 2021).

Sulphur is critical element of integrated nutrient management because it improves the efficiency of other nutrients in soil beside its critical role in plant metabolism (Gupta and Jain, 2008). However, S fertilizers are majorly imported for agriculture because S reserves are very limited in India. Sulphur import form countries like Canada, China, etc. makes S fertilizer costly (GOI, 2020). Costly imported fertilizers increase the cost of production and thus small farmers avoid their application (Dhinakaran and Kesavan, 2020). There is a need of adopting climate-smart and renewable energy sources to reduce the burden of the agriculture sector on the Indian economy and for a healthy life. Although, elemental sulphur containing fertilizers like bentonite S have the ability of releasing S steadily in soil and thus their input requirement is less (Mehmood *et al*. 2019 and Fontaine *et al*. 2021). Sulphur is very important element for Brassicaceae family crops. In vegetable oil, rapeseed and mustard production rank second after soybean production (Shivran *et al.* 2020). Sulphur deficiency is known to affect productivity and quality of mustard seed. Biopriming is the practice where seeds were inoculated with live bacterial strains before sowing. Multifunctional role of biopriming results in enhanced plant growth, plant resilient system, nutrient use efficiency and plant adaptability under stress condition (Kumar *et al*. 2020 and Sarkar *et al*. 2021). Therefore, the present experiment was undertaken to study the effect of bio-priming and graded S fertilization on economic of mustard production.

MATERIALS AND METHODS

A field experiment was conducted during rabi season of 2018-19 and 2019-20 in the research farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experimental soil was sandy loam in texture, low in available N, medium in available P, available K and low in available S. The experiment was conducted with four levels of S (0, 20, 30 and 40 kg S ha^{-1}) and three seed priming agents (un-primed, *Bacillus subtilis* and *Pseudomonas fluorescence)* in randomized block design with three replications. For seed bio-priming, sterilized mustard seed (cv. Giriraj) were treated liquid culture containing 2% carboxymethyl cellulose (adhesive agent) and live bacterial strains for 2 h. Pre-treated air-dried mustard seeds at the rate of 6 kg ha^{-1} were sown in rows having 30 cm spacing. Bentonite S fertilizer is applied as S source, 10 days before sowing and recommended dose of NPK (120:60:40) through urea, diammonium phosphate and muriate of potash is applied as basal dose.

Economic analysis

The cost of production was calculated considering the prevailing market price of variable inputs and output (unit cost). Net return is calculated by subtracting total expenditure during crop production from gross income.

$$\textit{Net return} = \textit{Gross return} - \textit{Cost of cultivation}$$

where,

Gross return = Market price × Total quantity of marketed product

Cost of cultivation = Total variable cost + Total fixed cost

Benefit: cost (B: C) ratio was estimated using the following formula:

$$\text{B: C} = \frac{\text{Net return (Rs ha}^{-1})}{\text{Cost of production (Rs ha}^{-1})}$$

Statistical analysis

Experimental data were tested for analysis of variance (ANOVA) and mean value of all the treatments compared through Duncan's multiple range test (DMRT) (P = 0.05 significance level).

Computer Statistical Package for Social Science (SPSS) software was used for homogeneity test of all the collected data.

RESULTS AND DISCUSSION

Suitability of agriculture technology for farmers is determined by their economic feasibility in terms of gross return, net return and B: C ratio. The economic data provided in table 1 shows that application of seed biopriming and S fertilization have significantly influence on gross return, net return and B: C ratio. Highest gross return (105791 and 116209 INR ha^{-1}) during first and second year was registered in T_{11} (40 kg S ha^{-1} + *B. subtilis*). Application of 40 kg S ha^{-1} + *P. fluorescens* (T_{12}) provide gross return of 103512 INR ha^{-1} in the first year and 113486 INR ha^{-1} in the second year which was statistically at par with T_{11}. Compared with recommended dose of S for mustard (40 kg S ha^{-1}), application of 30 kg S ha^{-1} along with *B. subtilis* as seed priming agents provide 3.8% more gross return on pooled basis. Maximum net return (70182 and 78282 INR ha^{-1}) is recorded with application T_{11} (40 kg S ha^{-1} + *B. subtilis*) in the first and second year, respectively. According to pooled data, application of 40 kg S ha^{-1} + *B. subtilis* increase the net return by 33.8% compared to control (T_1). However, application of T_{12} (40 kg S ha^{-1} + *P. fluorescens*) show at par results with T_{11} (40 kg S ha^{-1} + *B. subtilis*) in both the season. Treatment of seed with bioagents in addition with S fertilization results in greater net return compared to solo application of S fertilizers. On pooled basis, net return in different treatments were found in the order of T_{11} (40 kg S ha^{-1} + *B. subtilis*) ≥ T_{12} (40 kg S ha^{-1} + *P. fluorescens*) ≥ T_8 (30 kg S ha^{-1} + *B. subtilis*) ≥ T_9 (30 kg S ha^{-1} + *P. fluorescens*) ≥ T_{10} (40 kg S ha^{-1}) ≥ T_5 (20 kg S ha^{-1} + *B. subtilis*) ≥ T_6 (20 kg S ha^{-1} + *P. fluorescens*) ≥ T_7 (30 kg S ha^{-1}) ≥ T_2 (10 kg S ha^{-1} + *B. subtilis*) ≥ T_3 (10 kg S ha^{-1} + *P. fluorescens*) ≥ T_4 (20 kg S ha^{-1}) ≥ T_1 (0 kg S ha^{-1}). Highest B: C ratio is recorded in T_{11} (1.97 and 2.15) followed by T_{12} (1.91 and 2.07) ≥ T_8 (1.86 and 2.06) ≥ T_9 (1.80 and 1.96) ≥ T_{10} (1.79 and 1.96) in the first and second year, respectively. The performance of *B. subtilis* in improving gross return, net return and B: C ratio was significantly higher than other priming sources but at par results were observed in *P. fluorescens*. Higher gross return with seed treatment was due to increase in stover and grain yield which provide greater return. Similar findings were reported by Om *et al.* (2013)

Table 1: Effects of seed bio-priming and varied levels of S fertilization on economic of mustard

Treatments	Gross return (INR ha^{-1})			Net return (INR ha^{-1})			B: C ratio		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1 (0 kg S ha^{-1} +No priming)	82145^{i}	95856^{g}	89001^{i}	49632^{h}	62098^{e}	55865^{g}	1.53^{g}	1.84^{d}	1.68^{e}
T_2 (0 kg S ha^{-1} + *Bacillus subtilis*)	89419^{gh}	101553^{defg}	95486^{gh}	56138^{efg}	66991^{cde}	61565^{ef}	1.69^{def}	1.94^{bcd}	1.81^{de}
T_3 (0 kg S ha^{-1} + *Pseudomonas florescence*)	87364^{h}	99328^{fg}	93346^{h}	54084^{fgh}	64766de	59425^{fg}	1.63^{efg}	1.87^{cd}	1.75^{de}
T_4 (20 kg S ha^{-1} + No priming)	86532^{hi}	100676^{efg}	93604^{h}	52533^{gh}	65395^{cde}	58964^{fg}	1.55^{fg}	1.85^{d}	1.70^{e}
T_5 (20 kg S ha^{-1} + *Bacillus subtilis*)	95014^{def}	106279^{cde}	100646^{def}	60249^{cde}	70195^{bcd}	65222de	1.73^{cde}	1.95^{bcd}	1.84^{cd}
T_6 (20 kg S ha^{-1} + *Pseudomonas florescence*)	93207^{efg}	104177^{def}	98692^{efg}	58442^{def}	68093^{cde}	63267^{def}	1.68^{defg}	1.89^{bcd}	1.78^{de}
T_7 (30 kg S ha^{-1} + No priming)	90723^{fgh}	103042^{def}	96882^{fgh}	56302^{efg}	67340^{cde}	61821^{ef}	1.64^{efg}	1.89^{bcd}	1.76^{de}
T_8 (30 kg S ha^{-1} + *Bacillus subtilis*)	100486^{bc}	111534^{abc}	106010^{bc}	65298^{abc}	75029^{ab}	70164^{bc}	1.86^{abc}	2.06^{abc}	1.96^{abc}
T_9 (30 kg S ha^{-1} + *Pseudomonas florescence*)	98649^{bcd}	108227^{bcd}	103438^{cd}	63462^{bcd}	71722^{bc}	67592^{cd}	1.80^{bcd}	1.96^{bcd}	1.88^{bcd}
T_{10} (40 kg S ha^{-1} + No priming)	97323^{cde}	106787^{cde}	102055^{cde}	62480^{cd}	70663^{bc}	66572^{cd}	1.79^{bcd}	1.96^{bcd}	1.87^{bcd}
T_{11} (40 kg S ha^{-1} + *Bacillus subtilis*)	105791^{a}	116209^{a}	111000^{a}	70182^{a}	79282^{a}	74732^{a}	1.97^{a}	2.15^{a}	2.06^{a}
T_{12} (40 kg S ha^{-1} + *Pseudomonas florescence*)	103512^{ab}	113486^{ab}	108499^{ab}	67903^{ab}	76559^{ab}	72231^{ab}	1.91^{ab}	2.07^{ab}	1.99^{ab}
SEm ±	1667.61	1667.61	1518.14	2018.35	2018.35	1518.14	0.05	0.06	0.04
CD (P = 0.05)	4890.9	4890.9	4452.56	5919.63	5919.63	4452.56	0.14	0.17	0.13

and Sandhya *et al*. (2021). The present findings are in line with findings of Mookherjee *et al.* (2014) who reported that application of chemical fertilizer with *Azotobacter* and PSB in yellow sarson provide highest return rupee^{-1} compared to solo application of fertilizers. Similarly, Singh and Singh (2014) reported that inoculation of Indian mustard with PSM and *Azospirillum* increased the gross return, net return and B: C ratio.

CONCLUSION

It is inferred from the present study that inoculation of mustard seed with *Bacillus subtilis* along with 40 kg S ha^{-1} through bentonite S can significantly increase gross return and net return compared to solo application of S fertilizers. Furthermore, B: C ratio for mustard crop production is also improved with 40 kg S ha^{-1} + *Bacillus subtilis* (T_{11}). Study also reveals that application of 30 kg S ha^{-1} + *Bacillus subtilis* (T_8) provide better net return when compared to application of recommended dose of S which is 40 kg S ha^{-1} (T_{10}). The implication of this is that, though the benefit-cost ratio is positive at all biopriming intervention compared to sole application of Sulphur only, the best returns would be achieved at an application rate of 40 kg S ha^{-1} along with seed biopriming with *B. subtilis*. The local mustard farmers with a stagnated yield in Indo-Gangetic plain and are looking for options must include this practice in their existing plant nutrition schedule.

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