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Impact of Biofertilizers and Zinc Foliar Spray on Mustard Growth, chlorophyll content and Yield

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Abstract

Mustard (*Brassica juncea* L.) is a significant oilseed crop, valued for its oil content and culinary uses. This study investigated the effects of biofertilizers and zinc foliar application on mustard growth and yield. Field experiment was conducted during the Rabi 2021-22 season at the experimental farm of Lovely Professional University, Phagwara, Punjab. The experiment employed a Randomized Block Design (RBD) with seven treatments replicated thrice. Treatments included: T0 (Recommended Dose of Fertilizers - RDF), T1 (RDF + $ZnSO_4$), T2 (RDF + Azotobacter), T3 (RDF + PSB), T4 (RDF + PSB + $ZnSO_4$), T5 (RDF + Azotobacter + $ZnSO_4$), and T6 (Absolute Control). Results indicated that treatment T4 (RDF + PSB + $ZnSO_4$) (200.86) exhibited superior performance, showing increased plant height at various growth stages, number of functional leaves, fresh weight, dry weight, number of siliquae per plant, pod length, and Grain yield. Additionally, treatment T5 (RDF + Azotobacter + $ZnSO_4$) (0.81 and10.18) resulted in significant dry weight at 30 and 60 days after sowing (DAS) respectively. The combined treatment significantly boosted chlorophyll content over individual treatments and the control. Thus, integrating biofertilizers with zinc foliar spray effectively enhances mustard growth, yield, and physiological performance, reducing reliance on chemical fertilizers and minimizing environmental impacts. Further research is needed to optimize application rates and understand the underlying mechanisms for broader use in mustard cultivation.

Key words: Azotobacter, Biofertilizers, Phosphorus Solubilizing Bacteria (PSB), Nutrient uptake, Nitrogen use efficiency, SPAD index, Siliqua

Introduction

After food grains oilseeds emerge as one of the most crucial agricultural commodities, serving as both a nutritional staple and a vital ingredient in various industrial applications for the ever-expanding global population. Despite being the fourth-largest oilseed producer globally, India continues to rely heavily on imports to meet its vegetable oil demands, with imports reaching 164.7 lakh tonnes, equivalent to Rs.1.38 lakh crore rupees in the 2022-23 period. The significant vegetable oil import bill places strain on the country's foreign reserves and balance of payments, prompting the urgent need to enhance domestic production and productivity of oilseed crops. Among oilseed crops, mustard stands as the second most significant edible oilseed crop worldwide, trailing only soybean. Globally, mustard is cultivated across 36.59 million hectares (m ha), yielding approximately 72.37 million tonnes (mt) of seeds with a productivity rate of 1980 Kg/ha in the 2018-19 period (FAOSTAT 2021).

In India, mustard cultivation spans diverse agro-climatic conditions, ranging from the elevated terrains of the northeast and northwest to lowlands under rainfed, timely sown, saline soils, and mixed cropping systems. Presently, mustard cultivation is extending to new ecosystems, contributing to roughly 27.8% (11.75 million tonnes) of the total oilseed production in India (Singh *et al.,* 2017). However, this output is derived from only 25% (9.17 million hectares) of the total oilseed cultivated area in India, with an average productivity of 1230 kg/ha, which is significantly lower than the global average productivity (DACNET, 2023).

Efficient and sustainable nutrient management stands as a pivotal agronomic factor for boosting mustard productivity. Since the onset of the green revolution, the reliance on inorganic fertilizers has escalated, resulting in an imbalanced application of Nitrogen (N) compared to Phosphorus (P) and Potash (K) in India, with a ratio of 7.7:3.1:1, and in Punjab, with a ratio of 31.4:8:1https://www.impriindia.com/insights/policy-update/india-agriculture-evolution/. This skewed usage pattern not only diminishes nutrient use efficiency but also amplifies input costs. Additionally, it exacerbates air, water, and soil pollution, contributing to global warming. In India, nitrogen use efficiency hovers below 45%, while phosphorus and potassium efficiencies linger below 15% and 70%, respectively and micronutrient efficiencies below 5%. As a result, it is crucial to prioritize improving the efficiency of NPK and micronutrient utilization significantly to tackle these urgent agricultural challenges. Low organic matter addition due to intensive clean cultivation practices and the rapid losses of soil-applied nitrogen through processes such as denitrification, volatalization, leaching, and runoff losses causing widespread nitrogen deficiency and fixation ability of phosphorus leading to severe phosphorus deficiency in Indian soils.

The lower nutrient use efficiency, particularly in nitrogen and phosphorus, underscores the necessity for balanced fertilizer application. Bio fertilizers are recognised as the important component of integrated nutrient management for sustainable crop production. *Azotobacter* is a free-living biological nitrogen-fixing bacteria that assimilates atmospheric nitrogen. It fixes 10-20 kg of nitrogen per hectare per year thereby enhancing soil fertility and increasing the availability of nitrogen for crop growth and consequently decreases the dependency on inorganic fertilizers which contributes to sustainable agricultural practices. Utilizing *Pseudomonas* sp., *Bacillus* sp. etc. as a phosphate solubilizing bacteria (PSB) improve the phosphorus availability in rootzone and enhance the efficiency of applied and soil fixed phosphorus utilization and reduce the inorganic fertilizers use, thereby mitigating imbalances in fertilizer application which further improve productivity in sustainable way (Sharma *et al*., 2014). Additionally, among micronutrients zinc deficiency is notably prevalent in Indian soils. Zinc plays a critical role in mustard productivity and quality. Soil application of zinc often results in poor use efficiency. However, foliar application of zinc sulphate ($ZnSO_4$) in mustard presents a promising approach to improve zinc utilization efficiency and to correct zinc deficiencies in standing crop, improve yield and quality, mitigate stress conditions, and promote sustainable crop production

MATERIALS AND METHODS

Field Experiment was conducted at experimental farm of Lovely Professional University, Punjab during the Rabi session of 2021. The farm is located at exactly between geographical co-ordinates of 31.24 North latitude and 75.6909 east latitude at an altitude of 252m above mean sea level. The region falls under the agro-ecological sub-region known as the Northern Plain, hot sub-humid eco-region of Punjab, and the agro-climatic zone identified as the Trans-Gangetic Plain region. The area comes under the semi-arid zone with an annual rainfall of 527.1 mm annually. Except for a brief period during the South-West monsoon season, the district's climate is characterised by general dryness. The maximum and minimum temperature recorded during the crop period is 34^0C and 9^0C respectively. The maximum and minimum Rainfall recorded during the crop period is 15.21mm and 8.25mm respectively.

The experiment conducted with RBD design and replicated trice which consisted 7 integrated nutrient management treatments : T0 (Recommended Dose of Fertilizers - RDF), T1 (RDF + $ZnSO_4$), T2 (RDF + Azotobacter), T3 (RDF + PSB), T4 (RDF + PSB + $ZnSO_4$), T5 (RDF + Azotobacter + $ZnSO_4$), and T6 (Absolute Control) Experimental soil having slightly alkali pH 7.9, EC value 0.33 ds/m, organic carbon low 0.278 %, available nitrogen low 162.84 Kg/ha, phosphorus medium 17.12 Kg/ha and potassium medium 241.34 Kg/ha, zinc 0.2-0.5 ppm.

Field was ploughed twice with tractor mounted disk harrow. Seeds of mustard variety Pusa bold used for sowing. Seeds are treated with *Azotobacter and PSB* followed by treated seeds are dried in a shade for 2 hrs before sowing. Fertilizer applied as for treatments. Urea, SSP, and MOP were used to apply the appropriate nutrient rates (N, P, and K @ 80, 40, and 40 kg ha^{-1}). SSP and MOP were applied at the time of sowing, whereas nitrogen was provided in 3 splits *i.e.* at sowing and at 30 and 60 days after sowing and 6 kg/ha zinc was applied using zinc sulphate (Heptahydrate) in 2 splits as foliar spray i.e., 45 DAS and 75 DAS with the help of knapsack sprayer. All the standard agronomic practices were followed as recommended. biometric observations were recorded at intervals of 30DAS, 60DAS, and 90DAS, while yield attributes were recorded at maturity as for standard methodology. Chlorophyll contents were measured by a portable soil plant analysis development meter (SPAD 502 plus Chlorophyll Meter) during active growth stages of plants. Three fully expanded leaves from top, middle and bottom per plant were selected. Each leaf was punched at three different places in between the leaf margin and the mid rib and the average of three SPAD values were taken as SPAD index as the final value (Hallikeri *et al.*, 2011).

RESULTS AND DISCUSSION

GROWTH PARAMETERS

Plant Height:

Plant height is a key indicator of crop growth and development, reflecting the effectiveness of various treatments and environmental factors. In this study, the integration of Azotobacter, phosphate-solubilizing bacteria (PSB), and zinc foliar application, along with recommended fertilizer doses (RDF), significantly influenced mustard plant height at 30, 60, and 90 days, and at harvest.

The maximum plant height was observed with treatment T4 (RDF + PSB + $ZnSO_4$) (13.50 cm) (Table 1). This treatment consistently showed the highest plant height at all measured intervals, including at harvest. Treatments T5 (RDF + Azotobacter + $ZnSO_4$) and T3 (RDF + PSB) also demonstrated comparable effects to T4, indicating that the combined application of PSB and zinc significantly enhances plant growth. (Premi *et al.*, 2012; Meena *et* *al*., 2014; Dhruw *et al*., 2017). The observed increase in plant height with T4 can be attributed to several factors. The application of PSB aids in the efficient utilization of phosphorus, promoting better root development, water transportation, and nutrient uptake. Improved root systems facilitate enhanced plant growth and stability. Additionally, the foliar spray of zinc may have contributed to the biosynthesis of indole-3-acetic acid (IAA) growth hormones, which are critical for cell enlargement, division, and multiplication. This hormonal activity ultimately leads to greater plant height and overall growth. These studies support the conclusion that integrated nutrient management practices involving Azotobacter, PSB, and zinc are effective in promoting the growth and development of mustard plants.

Number of Functional Leaves:

Functional leaves are crucial for photosynthesis and significantly impact crop yields. This study examined the effects of Azotobacter, phosphate-solubilizing bacteria (PSB), zinc foliar application, and recommended fertilizer doses (RDF) on the number of functional leaves in mustard plants. The highest count of functional leaves was consistently observed in treatment T4 (RDF + PSB + $ZnSO_4$), (6.43, 26.40, and 73.40) at 30, 60, and 90 days after sowing (DAS), respectively (Table 1). Treatments T4 and T5 (RDF + Azotobacter + $ZnSO_4$) showed significant increases in functional leaf count compared to other treatments.

The observed increase in functional leaf count with T4 and T5 can be attributed to several factors. The application of Azotobacter and PSB likely enhanced nutrient availability and uptake, promoting the development of healthy leaves capable of efficient photosynthesis. Additionally, the inclusion of zinc foliar application may have improved leaf metabolism and chlorophyll synthesis, further enhancing the photosynthetic capacity of the plants (Premi *et al*., 2012; Meena *et al*., 2014; Dhruw *et al*., 2017). The synergistic effects of these treatments with RDF may have optimized nutrient balance and overall plant growth, ultimately leading to the observed increase in functional leaf count. These findings demonstrate that integrated nutrient management practices involving biofertilizers and zinc can effectively enhance the photosynthetic potential and yield of mustard crops (Premi *et al*., 2012; Meena *et al*., 2014; Dhruw *et al*., 2017).

Number of Branches per Plant:

The evaluation of branches per plant holds significant importance in assessing the growth and productivity of mustard crops. This metric is markedly influenced by the application of Azotobacter, phosphate-solubilizing bacteria (PSB), and zinc foliar application, in conjunction with recommended fertilizer doses. Treatment T4 (RDF + PSB + $ZnSO_4$) exhibited the highest number of branches (20.16), followed by T5 (RDF + Azotobacter + $ZnSO_4$) (19.53), while the lowest count was recorded in T6 (absolute control) (14.90) (Table 1). The observed variation in branch numbers directly correlates with the application of Azotobacter, phosphate-solubilizing bacteria (PSB), and zinc, indicating a synergistic effect leading to a significant increase in branch count per plant. Previous research, such as that by Kansotia *et al*., (2015), suggests that seed inoculation with Azotobacter and PSB promotes the growth of both primary and secondary branches, thus enhancing overall plant vigor.

Additionally, the incorporation of zinc foliar application alongside recommended fertilizer doses likely contributed to enhanced branching, given zinc's essential role in various physiological processes, including the regulation of growth hormones and enzyme activities (Dey and Sinha, 2012; Yadav, 2016). The number of branches per plant serves as a vital determinant of mustard crop growth and productivity, highlighting the significance of integrated nutrient management practices in augmenting branching and ultimately enhancing mustard crop yield.

Fresh weight and Dry matter Accumulation:

The application of Azotobacter, phosphate-solubilizing bacteria (PSB), zinc foliar spray, and recommended fertilizers significantly influenced both fresh weight and dry matter accumulation in mustard plants. At various stages of growth (30, 60, and 90 days after sowing), distinct treatments demonstrated varying effects on these parameters. At 90 days, treatments T3 (RDF+PSB) and T4 (RDF + PSB + $ZnSO_4$) recorded the highest fresh weights (108.39 g and 157.36 g respectively), compared to other treatments. Similarly, the maximum dry matter accumulation was observed in treatment T4 (RDF + PSB + $ZnSO_4$) at 29.77 g (Table 2).

These significant increases in fresh weight and dry matter accumulation in specific treatments could be attributed to various factors. For instance, the application of PSB and zinc, either individually or in combination, might have enhanced nutrient availability and uptake efficiency, thereby promoting plant growth and biomass accumulation. Additionally, the synergistic effects of Azotobacter and PSB, along with zinc supplementation, could have further optimized plant physiological processes, leading to increased biomass production. These findings align with previous research conducted by Singh and Pandey (2018), which reported similar trends in dry matter accumulation, supporting the notion that the combination of specific treatments, such as PSB, Azotobacter, and zinc, can effectively enhance biomass production in mustard crops (Quddus et al., 2011).

Chlorophyll Content:

In this study, chlorophyll content in leaves emerged as a crucial indicator of active photosynthesis, reflecting the efficiency of plant processes. The application of Azotobacter, phosphate-solubilizing bacteria (PSB), zinc foliar spray, and recommended fertilizer doses significantly influenced chlorophyll content. Notably, treatments T4 and T5 exhibited the highest SPAD chlorophyll Index (42.43) (48.33) compared to other treatments at 60 and 90 days after sowing (DAS). These findings align with previous research by Kumar *et al.,* (2017) and Shorna *et al.,* (2020), indicating superior chlorophyll content in plants treated with biofertilizers and zinc compared to other treatments. This consistency across studies underscores the effectiveness of integrated nutrient management practices involving biofertilizers and zinc in enhancing chlorophyll content and, consequently, photosynthetic efficiency.

The observed increase in SPAD chlorophyll index in treatments T4 and T5 can be attributed to several factors. Primarily, the application of zinc sulphate, combined with seed inoculation with biofertilizers, likely enhanced nutrient uptake and utilization efficiency, thereby promoting chlorophyll synthesis and overall photosynthetic activity. This combined effect of biofertilizers and zinc supplementation optimally supports chlorophyll content in mustard plants.

YIELD PARAMETERS

Number of Siliqua per Plant:

The number of siliquae per plant exhibited significant variation in response to the application of Azotobacter, phosphate-solubilizing bacteria (PSB), zinc foliar application, and recommended fertilizer doses. Notably, treatment T4 (RDF+PSB+ $ZnSO_4$) recorded the highest count of siliquae per plant (179.66) (Table 3), surpassing other treatments at harvest. This increase can be attributed to the significant enhancement in overall plant growth associated with treatment T4, potentially driven by an increased photosynthetic rate. The improved photosynthesis likely resulted in greater availability of photosynthates, metabolites, and nutrients, facilitating the development of reproductive structures and consequently leading to a higher number of siliquae per plant. These findings closely align with previous studies by

Meena et al. (2019) and Solanki et al. (2015), further validating the observed effects of integrated nutrient management practices on siliqua formation in mustard plants. The consistent increase in siliquae per plant in treatment T4 underscores the effectiveness of integrated nutrient management in enhancing reproductive structure development.

Number of Seeds per Siliqua:

The number of seeds per siliqua exhibited significant variation due to the application of Azotobacter, phosphate-solubilizing bacteria (PSB), zinc foliar application, and recommended fertilizer doses. Treatment T4 (RDF+PSB+ $ZnSO_4$) recorded the highest number of seeds per siliqua, (16.66) (Table 3), surpassing other treatments at harvest. These findings align with previous research, including Dhruw *et al*., (2017) study, emphasizing the importance of integrated nutrient management practices in optimizing mustard crop yield. This notable increase underscores the substantial impact of biofertilizers and zinc management on seed development, potentially leading to enhanced number of seed per siliqua.

Siliqua Length:

Siliqua length underwent notable changes owing to the application of Azotobacter, phosphate-solubilizing bacteria (PSB), zinc foliar application, and recommended fertilizer doses. Significant variations were evident across the treatments, with the absolute control (T6) exhibiting the shortest siliqua length, followed by the treatment with only recommended fertilizer (T0). In contrast, treatment T4 (RDF+PSB+ $ZnSO_4$) displayed substantially longer siliquae (6.33 cm). These findings align with prior research conducted by Dhruw *et al*. (2017), indicating consistency in the effects of integrated nutrient management on siliqua length. This study reaffirms the significant influence of treatment compositions on siliqua length, emphasizing the effectiveness of treatments like T4 (RDF+PSB+ $ZnSO_4$) in enhancing this parameter compared to control groups.

Grain Yield:

The highest grain yield was observed in treatment RDF+PSB+ZnSO4 (T4) (29.33 q/ha), surpassing other treatments at harvest (Table 3). These findings are consistent with studies by Chandan *et al*., (2018) and Deshmukh *et al*., (2019), emphasizing the pivotal role of zinc in enhancing yield through improved seedling Vigor and reproductive development. This increase in yield can be attributed to the combined application of biofertilizers and zinc, which enhanced mustard yield by promoting robust seedling growth. Biofertilizer-inoculated treatments demonstrated significantly higher yields compared to uninoculated treatments Zinc played a crucial role in this process by facilitating the biosynthesis of indole acetic acid and initiating primordia for reproductive parts, thereby directing photosynthates towards them. This led to improved flowering and fruiting, ultimately boosting grain yield.

Conclusion

This study underscores the efficacy of integrated nutrient management practices, particularly the combined use of biofertilizers and zinc foliar spray, in augmenting mustard growth, yield, and physiological performance. By reducing dependency on chemical fertilizers and minimizing environmental impacts, this approach presents a sustainable solution for enhancing crop productivity. Further research is warranted to fine-tune application rates and elucidate the underlying mechanisms driving these beneficial effects. Such insights will facilitate broader implementation of integrated nutrient management strategies in mustard cultivation systems, contributing to agricultural sustainability and food security.

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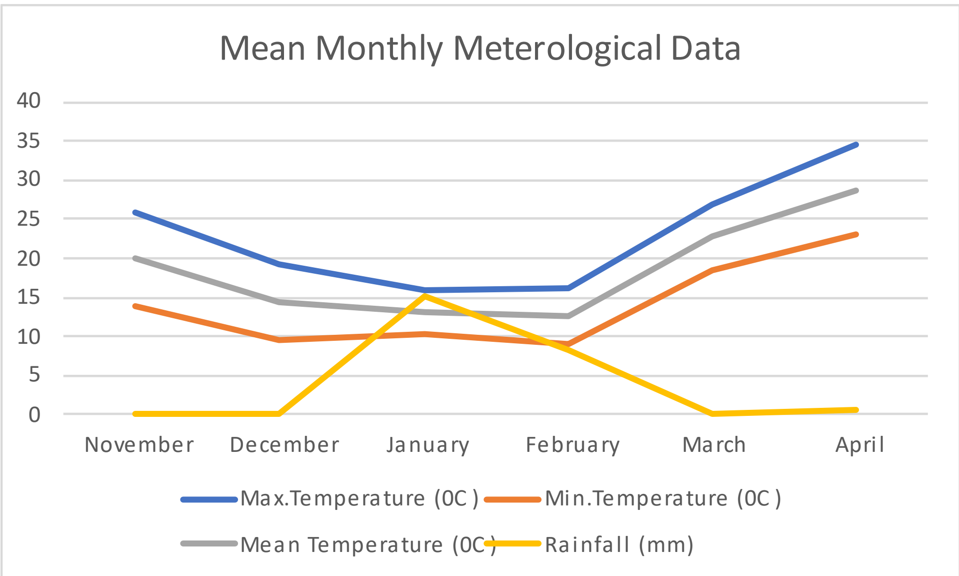

Fig 1: Mean monthly meteorological data from November 2021 to April 2022

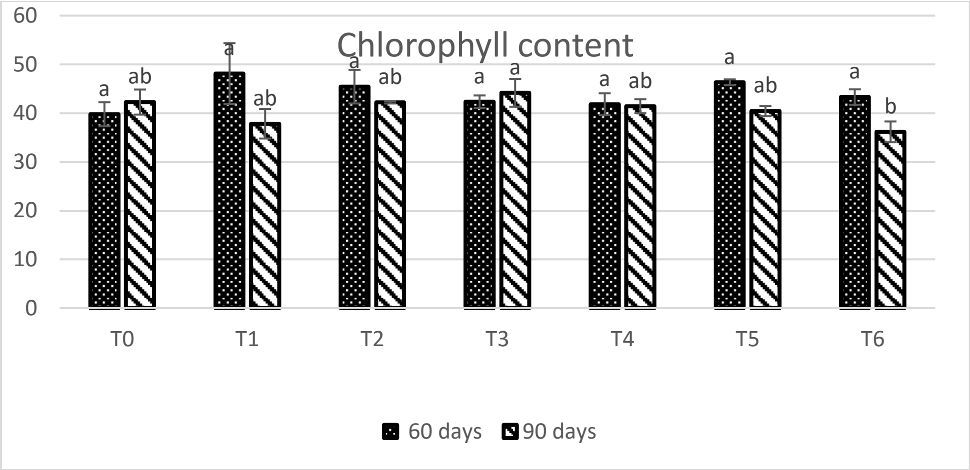

Fig 2: Chlorophyll content at 60 days and 90 days

Table 1. Impact of Biofertilizers and Zinc Foliar Spray on Mustard Growth, chlorophyll content and Yield of Mustard on Plant height (cm) at 30, 60, 90 and 120DAS , No. of branches at 60 and 90 DAS and No of functional leaves at 30, 60 and 90 DAS

	Plant height				No. of branches		No of functional leaves		
Treatment	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
T0 (RDF)	$12.1667^{d}\pm 0.28868$	$73.3667^{ab}\pm 4.76060$	$170.7867^{b}\pm 2.09393$	$187.9667^{b}\pm 3.2516$	$4.9667^{a}\pm 1.9629$	$19.1000^{ab}\pm 0.5567$	$5.1667^{b}\pm 0.76376$	$24.0000^{b}\pm 2.10713$	$64.8333^{a}\pm 8.05750$
T1(RDF+ $ZnSO_4$)	$13.1667^{bc}\pm 0.28868$	$72.0333^{ab}\pm 6.68606$	$173.8333^{ab}\pm 0.76376$	$191.9333^{ab}\pm 8.0524$	$5.4333^{a}\pm 0.5131$	$15.4667^{ab}\pm 2.7061$	$5.5000^{ab}\pm 0.86603$	$24.2000^{b}\pm 2.77849$	$63.9000^{a}\pm 15.18585$
T2(RDF+Azotobacter)	$13.0000^{bc}\pm 0.50000$	$78.2333^{ab}\pm 10.72210$	$169.1000^{bc}\pm 4.45309$	$192.3833^{ab}\pm 3.1346$	$5.6333^{a}\pm 0.6506$	$16.8333^{ab}\pm 3.7872$	$5.1000^{b}\pm 0.65574$	$26.0200^{ab}\pm .55245$	$59.1467^{a}\pm 9.21654$
T3(RDF +PSB)	$12.1667^{d}\pm 0.228868$	$79.7667^{a}\pm 3.18957$	$172.6667^{ab}\pm 1.15902$	$190.3333^{b}\pm 2.9005$	$5.4000^{a}\pm 0.3464$	$15.0333^{a}\pm 2.0550$	$5.3333^{b}\pm 0.41633$	$27.6000^{ab}\pm 2.30651$	$64.6000^{a}\pm 6.95414$
T4(RDF+PSB+ $ZnSO_4$)	$13.5000^{ab}\pm 0.50000$	$70.3333^{ab}\pm 6.00111$	$176.8667^{a}\pm 2.20530$	$200.8667^{a}\pm 8.6639$	$6.1667^{a}\pm 0.6806$	$20.1667^{ab}\pm 2.8360$	$6.4333^{a}\pm 0.40415$	$26.4000^{ab}\pm 1.92873$	$73.4000^{a}\pm 5.76541$
T5(RDF+Azotobacter+ $ZnSO_4$)	$14.1667^{a}\pm 0.288868$	$76.2667^{ab}\pm 5.75355$	$173.9333^{ab}\pm 1.85831$	$196.1333^{ab}\pm 3.9803$	$6.0667^{a}\pm 1.3613$	$19.5333^{ab}\pm 1.3613$	$5.8333^{ab}\pm 0.35119$	$28.1333^{a}\pm 1.41422$	$61.5333^{a}\pm 4.11987$
T6(Absolute control)	$12.5000^{cd}\pm 0.50000$	$66.8000^{b}\pm 0.26458$	$164.7667^{c}\pm 3.87986$	$173.4333^{c}\pm 2.5579$	$4.8667^{a}\pm 0.3511$	$14.9000^{b}\pm 3.3181$	$5.2333^{b}\pm 0.20817$	$23.8667^{b}\pm 1.85831$	$57.2333^{a}\pm 3.23161$
CD (5%)	NS	11.00	7.66	9.15	1.76	4.54	NS	3.45	14.70
SE	0.23	3.63	1.54	3.02	0.58	1.50	0.33	1.14	4.85

CV	3.04	8.40	1.55	2.74	18.10	15.00	10.32	7.65	13.22

Table 2: Impact of Biofertilizers and Zinc Foliar Spray on Mustard Growth, chlorophyll content and Yield of Mustard on fresh weight (gm) and Dry weight(gm):

	Fresh weight			**Dry weight**		
Treatments	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
T0 (RDF)	$4.8667^{bc}\pm.80829$	$54.6667^{b}\pm9.88956$	$105.1933^{b}\pm21.55739$	$0.6100^{ab}\pm.08185$	$8.7333^{a}\pm.211197$	$18.9233^{b}\pm7.61260$
T1 ($ZnSO_4$+RDF)	$4.5000^{c}\pm.50000$	$50.4333^{ab}\pm23.55724$	$153.3700^{a}\pm5.50664$	$0.6267^{ab}\pm.25482$	$8.5567^{a}\pm.72845$	$20.3767^{b}\pm6.01628$
T2(Azotobacter +RDF)	$5.6000^{ab}\pm.40000$	$49.9000^{ab}\pm21.24453$	$125.6600^{ab}\pm11.60071$	$0.7233^{ab}\pm.09074$	$8.5900^{a}\pm.98148$	$21.4967^{ab}\pm1.85087$
T3 (PSB+RDF)	$6.0667^{a}\pm.37859$	$57.1667^{ab}\pm7.93494$	$108.3900^{b}\pm12.32366$	$0.7600^{a}\pm.07000$	$9.4700^{a}\pm2.963322$	$20.0567^{b}\pm3.35068$
T4(PSB+$ZnSO_4$ + RDF)	$5.9667^{ab}\pm.90738$	$72.5500^{a}\pm20.80847$	$157.3567^{a}\pm32.48242$	$0.7567^{ab}\pm.13577$	$10.1533^{a}\pm1.25085$	$29.7700^{a}\pm4.97462$
T5(Azotobacter +$ZnSO_4$+RDF)	$5.9333^{ab}\pm.45092$	$69.8667^{a}\pm17.45690$	$145.0500^{a}\pm13.64294$	$0.8133^{ab}\pm.11930$	$10.1833^{a}\pm1.98389$	$26.5300^{ab}\pm2.232579$

T6(Absolute control)	4.3333^{abc}±.35119	50.6667^{ab}±8.57341	95.8967^{b}±31.88918	0.5767^{b}±.6807	8.2533^{a}±1.95439	18.0933^{b}±2.41471
CD (5%)	NS	29.04	31.42	0.23	2.93	7.96
SE	0.36	9.58	10.36	0.08	0.97	2.63
CV	11.57	28.67	14.04	18.99	18.34	20.50

Table:3 Impact of Biofertilizers and Zinc Foliar Spray on Mustard Growth, chlorophyll content and Yield of Mustard on Siliqua plant^{-1}, Seeds siliqua^{-1} and Siliqua length:

Treatments	**Siliqua plant^{-1}**	**Seeds siliqua^{-1}**	**Siliqua length**	**Grain yield (q/ha)**
T0 (RDF)	156.6667^{bc}±19.1298	14.6667^{bc}±1.1547	5.0000^{b}±.45826	20.67^{bc}±3.05505
T1(RDF+ $ZnSO_4$)	165.6667^{ab}±12.013	13.3333^{c}±1.52753	5.3000^{ab}±.5000	24.00^{abc}±6.08276
T2(RDF+Azotobacter)	159.3333^{ab}±6.4291	14.6667^{bc}±.57735	5.3333^{ab}±.7.946	22.67^{abc}±.3.51188
T3(RDF +PSB)	170.0000^{ab}±9.8488	14.0000^{bc}±1.0000	5.5333^{ab}±.3055	22.00^{bc}±3.00000
T4(RDF+PSB+$ZnSO_4$)	179.6667^{a}±5.03322	16.6667^{a}±.57735	6.3333^{a}±.40415	29.33^{a}±3.51188
T5(RDF+Azotobacter+$ZnSO_4$)	171.6667^{ab}±11.930	15.3333^{ab}±.57735	5.6000^{ab}±.5567	26.33^{ab}±2.51661
T6(Absolute control)	138.6667^{c}±5.50757	14.0000^{bc}±1.0000	4.9000^{b}±.80000	17.33^{c}±1.52752
CD (5%)	13.84	1.71	0.08	6.23
SE	4.56	0.56	0.02	2.05
CV	4.93	6.65	1.26	15.35