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*RESEARCH PAPER*

# Response of brown sarson (*Brassica campestris* var. brown sarson) to integrated nutrient management in mid hill conditions of Himachal Pradesh

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**Abstract :** A field experiment was conducted during *Rabi* 2011-12 at the experimental farm of Department of Agronomy, Forages and Grassland Management CSKHPKV, Palampur Himachal Pradesh to study the "Response of brown sarson (*Brassica campestris* var. brown sarson) to integrated nutrient management in mid hill conditions of Himachal Pradesh". The treatments comprising of all possible combinations of three biofertilizers *viz., Azotobacter*, *Azotobacter* + PSB and no inoculation and four fertility levels *viz.,* 100% RDF, FYM 5.0 t $ha^{-1}$ + 50% RDF, Vermicompost 5.0 t $ha^{-1}$ + 50% RDF and control were tested in Factorial Randomized Block Design, replicated three times. Significantly highest plant height was recorded with the application of *Azotobacter* + PSB over *Azotobacter* alone and no inoculation at 90, 120 DAS and at harvest. Among different fertility levels, application of 100 per cent RDF being statistically at par with vermicompost 5.0 t $ha^{-1}$ + 50% RDF produced significantly taller plants as compared to other treatments. Results revealed that growth, yield attributes, seed and straw yields of brown sarson were significantly increased with the application of biofertilizers and different fertility levels over control. The treatment receiving *Azotobacter* + PSB significantly increased the seed and straw yields followed by *Azotobacter* and no inoculation. Effect of fertility levels on seed and straw yields showed that 100 per cent RDF resulted in significantly higher seed and straw yield as compared to other fertility levels and control treatment. However, 100 per cent RDF treatment remained at par with vermicompost 5.0 t $ha^{-1}$ + 50% RDF. The application of biofertilizers and fertility levels could not exhibit any significant effect on harvest index. The increase in seed yield with *Azotobacter* + PSB was 20.3% over *Azotobacter* alone.

**Key Words :** Bio-fertilizer, Rapeseed, Siliqua, Vermicompost, Treatment, Straw yield

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## INTRODUCTION

Oilseed crops are the backbone of Indian agricultural economy and occupy an important position in daily diet being a rich source of fats and vitamins. India is the fourth largest oilseed producer in the world next to USA, China and Brazil. Hence, oilseeds play the second important role in the Indian agricultural economy, next only to food grains in terms of area and production. They occupy a distinct position after cereals constituting 14.87

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per cent gross cropped area of the country. They occupy an area of 27.86 m ha with 27.98 mt of production and registering the productivity level of 1004 kg $ha^{-1}$. About 14 million persons are engaged in production and another one million in processing of oilseeds. Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max* L. Merr.) and palm (*Elaeis guineensis* Jacq.). Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6 per cent in the total oilseeds production and ranks second after groundnut sharing 27.8 per cent in the India's oilseed economy (Shekhawat *et al.*, 2012). The estimated area, production and average yield of rapeseed-mustard in the world is 30.74 m ha, 59.93 mt and 1,950 kg $ha^{-1}$, respectively (AICRP, 2010). India is the second largest rapeseed-mustard growing country in the world after China. The crop is grown over an area of 6.19 m ha with an annual production of 7.37 mt and productivity of 1142 kg $ha^{-1}$ (AICRP, 2010). Rapeseed-mustard crops in India are grown in diverse agro climatic conditions ranging from north-eastern, north-western hills to southern parts under irrigated or rainfed, timely or late sown, saline soils and mixed cropping. In Himachal Pradesh, the crop is grown over an area of 8.4 thousand hectares with a total production of 3.6 thousand tonnes. The average productivity of the crop in Himachal Pradesh is 430 kg $ha^{-1}$ as compared to 1142 and 1950 kg $ha^{-1}$ in national and world level, respectively (Anonymous, 2010).

Rapeseed-mustard oil being rich source of the unsaturated fatty acids is primarily used for human consumption as desirable edible oil. The oil obtained from rapeseed and mustard is rich in unsaturated and low in saturated fatty acids. In addition to the oil, most plant parts of rapeseed-mustard such as seed, sprouts, leaves, and tender parts are also of great use to human health, and consumed as spices and vegetables. These plant parts are rich in dietary fibre (1.08 g per 100 g on fresh weight basis), omega-3 fatty acids (0.20 g per 100 g on fresh weight basis), vitamin $B_3$ (0.60 mg per 100 g on fresh weight basis), calcium (38.92 mg per 100 g on fresh weight basis) and protein (1.88 g per 100 g on fresh weight basis) (Anonymous, 2004). The oil and fats serve as important raw materials for manufacture of paints, soaps, varnishes, hair oil, lubricants, textile auxiliaries and pharmaceuticals. The cake is used as cattle feed.

Under rapeseed-mustard group, three crops *viz.*, brown sarson, toria and raya are being cultivated in Himachal Pradesh. Amongst them, sarson leads in terms of cultivated area followed by toria and raya. Rapeseed and mustard crops are mostly grown under rainfed conditions resulting in lesser productivity as compared to the irrigated conditions. Under irrigated conditions its cultivation as a pure crop is taken up to a limited extent. Mixed cropping with wheat is a common practice leading to low per hectare productivity in the State. Out of many reasons of low productivity of sarson, low and imbalanced fertilizer application is most important in the state. Therefore, balanced nutrient management is the most critical input for obtaining optimum yield in rapeseed-mustard all over India (Sankar *et al.*, 2002). Available evidences indicate that even balanced use of chemical fertilizer alone cannot improve the productivity under continuous cropping system whereas, incorporation of farm yard manure, biofertilizer as well as vermicompost regulated the quality, improved crop yield and physical status of the soil (Kabeeranthuma *et al.*, 1993). Moreover, the ever escalating prices of chemical fertilizers and their detrimental effects on soil and environmental health, strongly emphasize the need of alternate source of nutrients especially biofertilizers, vermicompost and FYM etc. Further, to supply all the nutrients in required quantities through organic sources and biofertilizers is not an easy proposition. The integrated nutrient supply system involving the combined use of chemical, organic sources and bio-fertilizer has been thought to be best option for meeting out the nutrient requirement of the crop.

Therefore, partial substitution of nutritional requirement of rapeseed-mustard with organics such as vermicompost and FYM besides biofertilizers is the need of hour in sustaining yield (Hedge *et al.*, 2004). Hence, the present study was conducted to work out the integrated nutrient requirement involving organics, inorganics and bio-fertilizers in brown sarson under mid hill conditions of Himachal Pradesh (Palampur) with following objective:

– Effect of different nutrient management practices on growth, yield and profitability of brown sarson.

## MATERIAL AND METHODS

The field experiment entitled, "Response of brown sarson (*Brassica campestris* var. brown sarson) to integrated nutrient management in mid hill conditions of Himachal Pradesh" was conducted during *Rabi* season

**Table A : Physico-chemical properties of experimental soil**

| Determination | Values | Method employed |
|---|---|---|
| Sand (%) | 26 | International pipette method (Piper, 1966) |
| Silt (%) | 42 | |
| Clay (%) | 30.4 | |
| Texture class | Silty clay loam | |
| **Chemical properties** | | |
| pH | 5.6 | 1:2.5 soil water suspension using glass electrode pH meter (Jackson, 1967) |
| Organic Carbon (%) | 0.82 | Walkley and Black's rapid titration (Piper, 1966) |
| Available N (kg $ha^{-1}$) | 266 | Alkaline permanganate method (Subbiah and Asija, 1956) |
| Available P (kg $ha^{-1}$) | 30.1 | Olsen's method (Olsen *et al.*, 1954) |
| Available K (kg $ha^{-1}$) | 187 | Ammonium acetate extraction method (AOAC, 1970) |

of 2011-12 at research farm of Department of Agronomy, Forages and Grassland Management, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (H.P.). The experimental farm is located at 32°6' N latitude, 76°3' E longitude and an altitude of 1290 meters amsl. The site falls in the sub-temperate mid hill zone of Himachal Pradesh.

| Treatments | |
|---|---|
| $T_1$ | *Azotobacter* + 100% RDF |
| $T_2$ | *Azotobacter* + FYM 5.0 t $ha^{-1}$ + 50% RDF |
| $T_3$ | *Azotobacter* + vermicompost 5.0 t $ha^{-1}$ + 50% RDF |
| $T_4$ | *Azotobacter* + control (No NPK) |
| $T_5$ | *Azotobacter* + PSB + 100% RDF |
| $T_6$ | *Azotobacter* + PSB + FYM 5.0 t $ha^{-1}$ + 50% RDF |
| $T_7$ | *Azotobacter* + PSB + vermicompost 5.0 t $ha^{-1}$ + 50% RDF |
| $T_8$ | *Azotobacter* + PSB + control |
| $T_9$ | 100% RDF |
| $T_{10}$ | FYM 5.0 t $ha^{-1}$ + 50% RDF |
| $T_{11}$ | Vermicompost 5.0 t $ha^{-1}$ + 50% RDF |
| $T_{12}$ | Control (No-inoculation + No NPK) |

### Climate and weather :

The place is characterized by severe winters and mild summers. On an average, about 2600 mm rainfall is received annually and out of which 80 per cent is received during June to September and rest between October to May. During the period of experimentation (November, 2011 to March, 2012), mean minimum temperature ranged from 2.4 °C in December to 14.9 °C in March. The mean maximum temperature during these corresponding months remained at 9.8 °C and 28.4 °C, respectively. In *Rabi* 2011-12, a total rainfall of 320 mm was received. Relative humidity ranged from 42.0 to 87.0 per cent during the entire cropping season.

### Soil characteristics :

Before the sowing of crop in the experiment, a composite soil sample (0-15 cm depth) was collected. The soil sample was air dried, ground and passed through 2 mm sieve and analyzed for different physico-chemical properties of soil (Table A).

A perusal of data given in Table 1 revealed that the soil of the experimental site was acidic in reaction and silty-clay loam in texture. On the basis of chemical values the soil was categorized as medium in organic carbon, high in available phosphorus and medium in available nitrogen and potassium.

## RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

### Plant height :

The data on average plant height (cm) of brown sarson at different time intervals have been presented in Table 1. The data showed that up to 60 days after sowing biofertilizers did not play any significant role in affecting the plant height of brown sarson. However, at 90 days after sowing combined application of *Azotobacter* + PSB produced significantly taller plants as compared to *Azotobacter* and no-inoculation, though later treatments remained at par with each other. At 120 days after sowing *Azotobacter* remained at par with *Azotobacter* + PSB, but at harvest *Azotobacter* + PSB surpassed it producing significantly taller plants, mainly due to slow release of nutrients in initial stages.

Among fertility levels (Table 1) the treatment effect at 30 days after sowing showed that vermicompost 5.0 t $ha^{-1}$ + 50% RDF remaining at par with 100 per cent RDF gave significantly taller plants followed by FYM 5 t $ha^{-1}$ + 50% RDF. At stages from 60 to 120 days after sowing no significant difference among fertility levels was observed, except in control smallest plants were produced. However, at harvest, 100 per cent RDF resulted in significantly taller plants remaining at par with vermicompost 5 t $ha^{-1}$ + 50% RDF. Statistically, the vermicompost 5 t $ha^{-1}$ and FYM 5 t $ha^{-1}$ along with 50 per cent NPK were at par with each other giving similar plant height. Non-significant effect during initial stages might be due to less release of plant nutrients compared to later stages of crop growth. Similar findings also reported by Pal *et al.* (2008) and Singh *et al.* (2011).

**Effect on yield and yield attributes :**

It is evident from data presented in Table 2 that different biofertilizers and fertility levels involving chemical fertilizers as well as organics have significantly influenced all recorded yield contributing characters *viz.* number of primary branches, number of secondary branches, number of seeds per siliqua and number of siliquae per plant.

**Number of primary branches :**

The data pertaining to effect of treatments on number of primary branches (Table 2) indicated that among biofertilizers, *Azotobacter* + PSB resulted in significantly higher number of primary branches as compared to *Azotobacter.* The later remained at par with no inoculation showing that *Azotobacter* along with PSB could mobilize plant nutrients in more efficient way.

Among fertility treatments vermicompost 5.0 t $ha^{-1}$ + 50% RDF remaining at par with FYM 5 t $ha^{-1}$ +50% RDF and 100 per cent RDF produced higher number of primary branches $plant^{-1}$ compared to no NPK application. Significantly lowest number of primary branches was recorded under treatment where no fertilizer or organics were applied.

**Number of secondary branches :**

The data presented in Table 3 on number of secondary branches $plant^{-1}$ revealed that among biofertilizer treatments, *Azotobacter* + PSB resulted in significantly higher number of secondary branches but it remained at par with *Azotobacter*. Both biofertilizer treatments were statistically superior to the control. No-inoculation has resulted in significantly lowest number of secondary branches.

As far as fertility treatments are concerned, the data shown in Table 2 indicated similar trend was observed as far as number of primary branches. Higher numerical values of number of secondary branches were recorded with application of 100 per cent RDF but statistically it was at par with other treatments except, control treatment where significantly lower primary branches were recorded. The higher number of primary branches so obtained in treatments gave rise to higher secondary branches. Similar findings also reported Gayathri *et al.* (2004).

**Number of seeds per siliqua :**

A perusal of data presented in Table 2 showed that among biofertilizers, *Azotobacter* + PSB resulted in

**Table 1 : Effect of different treatments on plant height (cm) of brown sarson**

| Treatments | Plant height (cm) | | | | |
|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | 120 DAS | At harvest |
| **Biofertilizers** | | | | | |
| *Azotobacter* | 6.3 | 27.5 | 77.0 | 101.3 | 113.2 |
| *Azotobacter* + PSB | 6.6 | 28.8 | 83.2 | 104.5 | 117.8 |
| No-inoculation | 5.9 | 27.9 | 75.7 | 97.8 | 110.4 |
| C.D. (P=0.05) | NS | NS | 3.8 | 3.4 | 2.5 |
| **Fertility levels** | | | | | |
| 100% RDF | 6.9 | 28.8 | 81.4 | 104.4 | 118.4 |
| FYM 5.0 t $ha^{-1}$ + 50% RDF | 6.2 | 28.2 | 80.0 | 101.0 | 115.1 |
| Vermicompost 5.0 t $ha^{-1}$ + 50% RDF | 7.2 | 29.3 | 81.6 | 103.8 | 116.7 |
| Control | 4.7 | 25.9 | 71.5 | 95.6 | 104.9 |
| C.D. (P=0.05) | 0.8 | 1.6 | 4.4 | 3.98 | 2.9 |

DAS = Days after sowing; PSB = Phosphate solubilizing bacteria; RDF = Recommended dose of fertilizers; FYM = Farm yard manure
NS=Non-significant

significantly higher number of seeds per siliqua followed by *Azotobacter* alone and no-inoculation. Whereas, *Azotobacter* and no-inoculation remained at par with each other in producing number of seeds per siliqua.

The same Table 2 depicting the effect of different fertility levels indicated that significantly higher total number of seeds per siliqua were recorded with the application of vermicompost 5.0 t $ha^{-1}$ + 50% RDF. However, this treatment remained statistically at par with all the other treatments *viz.*, FYM 5 t $ha^{-1}$ + 50% RDF and 100 per cent RDF under study, except, control treatment where significantly lowest seeds per siliqua were recorded.

## Number of siliquae per plant :

The data pertaining to number of siliquae per plant have been presented in Table 2. The observations indicated that seed inoculation with *Azotobacter* + PSB significantly increased the number of siliquae per plant giving higher values compared to *Azotobacter* alone and no inoculation. However, *Azotobacter* alone had no significant advantage over no inoculation inspite of the higher numerical values.

Under fertility levels of chemical fertilizers and organics, the data have been presented in Table 2. The data revealed that significantly higher number of siliquae per plant were recorded with the application of 100 per cent RDF. However, this treatment remained statistically at par with vermicompost 5 t $ha^{-1}$ + 50% RDF. The later, further was found to be statistically at par with FYM 5 t $ha^{-1}$ + 50% RDF. All treatments were found superior to control. Similar results were also reported by Shukla *et al.* (2002).

## Seed yield :

The data on seed yield as influenced by biofertilizers

**Table 2 : Effect of different treatments on yield attributes of brown sarson**

| Treatments | No. of primary Branches per plant | No. of secondary branches per plant | No. of seeds per siliqua | No. of siliquae ($plant^{-1}$) |
|---|---|---|---|---|
| **Biofertilizers** | | | | |
| *Azotobacter* | 4.7 | 4.3 | 7.6 | 115.1 |
| *Azotobacter* + PSB | 6.1 | 4.9 | 8.8 | 132.3 |
| No-inoculation | 4.7 | 3.6 | 7.3 | 109.1 |
| C.D. (P=0.05) | 0.6 | 0.6 | 0.9 | 11.0 |
| **Fertility levels** | | | | |
| 100% RDF | 5.6 | 4.9 | 8.4 | 130.4 |
| FYM 5.0 t $ha^{-1}$ + 50% RDF | 5.4 | 4.5 | 8.3 | 117.8 |
| Vermicompost 5.0 t $ha^{-1}$ + 50% RDF | 5.6 | 4.4 | 8.7 | 124.1 |
| Control | 4.2 | 3.3 | 6.1 | 101.9 |
| C.D. (P=0.05) | 0.7 | 0.7 | 1.0 | 12.7 |

PSB = Phosphate solubilizing bacteria; RDF = Recommended dose of fertilizers; FYM = Farm yard manure

**Table 3 : Effect of different treatments on seed, straw yield (kg $ha^{-1}$) and harvest index of brown sarson**

| Treatments | Seed yield (kg $ha^{-1}$) | Straw yield (kg $ha^{-1}$) | Harvest index |
|---|---|---|---|
| **Biofertilizers** | | | |
| *Azotobacter* | 827.3 | 4195.6 | 0.16 |
| *Azotobacter* + PSB | 995.1 | 4586.2 | 0.16 |
| No-inoculation | 797.8 | 3364.3 | 0.19 |
| C.D. (P=0.05) | 102.5 | 320.3 | NS |
| **Fertility levels** | | | |
| 100% RDF | 1083.4 | 5116.0 | 0.17 |
| FYM 5.0 t $ha^{-1}$ + 50% RDF | 938.4 | 4119.0 | 0.19 |
| Vermicompost 5.0 t $ha^{-1}$ + 50% RDF | 1031.3 | 4571.6 | 0.19 |
| Control | 440.5 | 2388.1 | 0.16 |
| C.D. (P=0.05) | 118.4 | 369.9 | NS |

PSB = Phosphate solubilizing bacteria; RDF = Recommended dose of fertilizers; FYM = Farm yard manure
NS=Non-significant

inoculation and different fertility levels through chemical fertilizers and organics have been presented in the Table 3. A perusal of above data showed that inoculation with biofertilizers showed the positive influence on the seed yield of brown sarson. Inoculation of seeds with *Azotobacter* though increased the seed yield of brown sarson over no inoculation, but the differences were not statistically significant in the study. However, when *Azotobacter* was inoculated along with PSB to the seeds of brown sarson the seed yield was significantly increased over the *Azotobacter* alone as well as where no inoculation was done. The increase in seed yield to the tune of 3.7 per cent was observed with the application of *Azotobacter* alone over the treatment receiving no biofertilizer. Since there was an increase in seed yield of brown sarson with *Azotobacter* alone but the further increase in the seed yield was made significant with the synergetic effect of *Azotobacter* and Phosphate solublising bacteria recording an increase to the tune of 24.7 per cent over the no inoculation, thus, registering the significant differences between the treatments. Further, in comparison to inoculation with *Azotobacter* alone, the combined application of *Azotobacter* + PSB made an increase to the tune of 20.3 per cent over the application of *Azotobacter* alone. The positive influence of increasing the seed yield of brown sarson with the inoculation of seeds with biofertilizers was the result of significantly higher yield contributing characters under these treatments. Hence, the significant higher value of yield contributing characters manifested there positive effect on the seed yield of brown sarson, thereby recording higher yield under biofertilizer treatments.

Narula *et al*. (1993) observed that the seed treatment with *Azotobacter* @ 10 g $kg^{-1}$ seed before sowing in addition to rest of the supplementary ingredients further increased the seed yield.

The observations on seed yield of sarson as varied by different fertility levels have been presented in Table 3. Application of recommended dose of NPK (100% RDF) resulted in significantly higher seed yield of sarson. However, when 100 per cent NPK was reduced to 50 per cent NPK and in addition to it vermicompost 5 t $ha^{-1}$ was applied, the seed yield obtained was statistically at par with 100 per cent RDF. However, curtailing 50 per cent NPK and adding FYM 5.0 t $ha^{-1}$ could not match the yield statistically with 100 per cent RDF. Whereas, treatment differences between FYM 5 t $ha^{-1}$ and vermicompost 5 t $ha^{-1}$ along with 50 per cent NPK were found to be non significant. But all the treatments were significantly superior to the control treatment where no fertilizer or organics were applied. Hence, it was observed that application of 100 per cent RDF registered an increase of 146 per cent in the seed yield over the control. Similarly by curtailing 50 per cent of NPK but adding vermicompost 5 t $ha^{-1}$ registered an increase of yield to the tune of 134 per cent over the control indicating the advantage of application of vermicompost. However, application of FYM 5.0 t $ha^{-1}$ in replacement of vermicompost enhanced the seed yield up to 113 per cent over the control. The positive influences as recorded in yield contributing characters under these treatments were manifested in the seed yield of sarson by Tripathi *et al.* (2010) and Saha *et al.* (2010) .

**Straw yield :**

The data pertaining to straw yield as affected by biofertilizers inoculation and different fertility levels have been presented in the Table 3. Significantly higher straw yield was observed with *Azotobacter* + PSB. It was followed by the treatment of *Azotobacter* alone. Under control treatment significantly lowest straw yield was recorded. The observations on straw yield as affected by different fertility levels as depicted in Table 3 revealed that almost similar trend for straw yield was observed as for seed yield. Significantly highest straw yield was recorded under 100 per cent RDF followed by vermicompost 5.0 t $ha^{-1}$ + 50 per cent RDF and FYM 5.0 t $ha^{-1}$ + 50 per cent RDF.

**Harvest index :**

The data regarding the effect of biofertilizers and different fertility levels on harvest index have been summarized in the Table 3. It was apparent from data that the biofertilizers and fertility levels could not exhibit any significant effect on harvest index of the sarson crop under study.

**Conclusion :**

From the findings of the study it was concluded that significantly highest plant height was recorded with the application of *Azotobacter* + PSB over *Azotobacter* alone and no inoculation at 90, 120 DAS and at harvest. Among different fertility levels, application of 100 per cent RDF being statistically at par with vermicompost 5.0 t $ha^{-1}$ + 50% RDF produced significantly taller plants as compared to other treatments. The results observed that brown sarson (*B. campestris* var. brown sarson) crop inoculated with *Azotobacter* + PSB gave significantly higher seed yield. The treatment receiving *Azotobacter* + PSB significantly increased the seed and straw yields followed by *Azotobacter* and no inoculation. Effect of fertility levels on seed and straw yields showed that 100 per cent RDF resulted in significantly higher seed and straw yield as compared to other fertility levels and control treatment. However, 100 per cent RDF treatment remained at par with vermicompost 5.0 t $ha^{-1}$ + 50% RDF. The application of biofertilizers and fertility levels could not exhibit any significant effect on harvest index.

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