

## RESPONSES OF MUSTARD GENOTYPES TO DIFFERENT FERTILIZER DOSES GROWN UNDER IRRIGATED CONDITIONS OF SEMI-ARID REGION OF NORTHWESTERN HARYANA, INDIA

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### Abstract

The experiment was done to determine the latest genotypes' performance in semi-arid irrigated areas when sowed punctually. The only oilseed crop in Haryana during rabi season is mustard. The split-plot design used five genotypes (RH 1975, RH 1974, RH 749, Kranti, and DRMRIJ31) in the main plots and three fertilizer levels {100% RDF: (80 : 30 : 20 kg N, P and K/ha), 125% RDF, and 150% RDF} in the subplots with three replications. RH1975 mustard had the maximum seed output (2916 kg/ha), surpassing RH 749, Kranti, and DRMRIJ31. The mustard seed yield of RH 1975 was 27.43, 22.02, and 21.06% higher than Kranti, DRMRIJ31, and RH 749, respectively whereas RH 1974 was 24.10, 18.44, and 17.43% higher. Fertilizer increased seed production to 150 % RDF regardless of genotype. Mustard seed's protein content rose from 100% RDF (16.71%) to 150% RDF (17.60%). The genotype RH1975 was found to have a significantly greater concentration of NPK in the stover (0.523, 0.268, and 1.49%) and in the seed (2.82, 0.398, and 0.870%) highest RWC was 82.42%.

### Introduction

Globally, rapeseed and mustard crops are cultivated on 43.35 million hectares, yielding 89.77 million tonnes of production and 2.07 tonnes of productivity per hectare during 2024-25 (Kumar *et al.* 2025). Canada leads the world in area, followed by India, the European Union leads in production, and Chile leads in productivity; the other nations with productivity above 3.0 tonnes/ha in 2023-2024 are the United Kingdom, Switzerland, and the European Union (USDA 2024). Over time, the area used for this crop during the rabi season has increased. In the state of Haryana, mustard is the sole important oilseed crop. The area devoted to the other oilseed crops is small or negligible. Between 2000 and 2021, the area planted to mustard grew from 4.08 lakh hectares to 8.80 lakh hectares (Anonymous 2024). This crop is grown on 4.2 lakh hectares in Haryana, yielding 6.9 lakh tons and 1609 kg/ha of productivity (Shweta *et al.* 2022a).

India produced 39.67 million tonnes of oilseeds from 30.19 million hectares during 2023-2024, with rapeseed–mustard contributing 30.41% of total oilseed production and 33.43% of the cultivated area (Anonymous 2023). Despite its importance, India remains dependent on edible oil imports, highlighting the need to enhance domestic oilseed productivity. In Haryana, mustard is the major rabi oilseed crop, but productivity is constrained under semi-arid conditions, particularly by poor-quality water irrigation (Shanker *et al.* 2016). Therefore, identification of high-performing genotypes and optimization of fertilizer use are essential for improving mustard productivity and nutrient utilization under irrigated conditions. The study further aimed to identify the genotype with superior yield performance, physiological attributes and nutrient accumulation and to determine the fertilizer level that optimizes productivity and quality of mustard under irrigated conditions.

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### Materials and Methods

During the 2022-2023 rabi season, a field experiment was carried out at the CCS Haryana Agricultural University Research Farm in Hisar, Haryana, India (29°10' N, 75°46' E, elevation 215.2 m). With dramatic temperature swings from below-freezing temperatures in the winter to 45°C in the summer, the area has a semi-arid climate. About 450 mm of rain falls there each year, with 70-80% of that falling during the monsoon season (July-September). During the crop season, the study found that the weekly average maximum and minimum temperatures ranged from 14.6°C (January) to 32.2°C (October) and 3.6°C (January) to 16.5°C (November), respectively. The range of relative humidity (RH) was 84.7 to 100% in the morning and 46.4 to 85% in the evening.

Five Indian mustard genotypes (RH 1975, RH 1974, RH 749, Kranti, and DRMRIJ31) were planted in the main plots of the experiment, which was set up in a split-plot design with three replications. Three fertilizer levels (100, 125, and 150% of the prescribed amount of N P and K) were planted in sub-plots. 80 kg N, 30 kg P<sub>2</sub>O<sub>5</sub>, and 20 kg K<sub>2</sub>O/ha were the suggested dosages. Phosphorus and potassium were applied as a base, while nitrogen was applied in two splits, half at sowing and half at flowering time. On 22 October 2022, mustard genotypes were sown with a row spacing of 30 cm. After thinning, plant-to-plant spacing was kept at 15 cm. At 30 DAS, a single canal irrigation was given, and conventional agronomic procedures were practiced. The crop was harvested on 15 March 2023.

Samples of grain and straw were harvested from each plot as the mustard crop was being threshed. They were first allowed to air dry before being oven-dried at 45 ± 20°C until their weight remained consistent. For analysis, information on yield, yield characteristics, and quality factors was documented. A small grinder was used to finely grind the oven-dried samples, which were then placed in paper bags for additional analysis. A 4 : 1 di-acid mixture of sulfuric and perchloric acid was used to digest the straw samples. The concentrations of N, P, and K in the digested plant material were measured using flame photometry.

Leaf relative water content (LRWC) was measured using the formula of Shweta *et al.* (2022b) and Shweta *et al.* (2021). The dimethyl sulfoxide (DMSO) method was used to measure the total amount of chlorophyll (Prakash *et al.* 2022). The following formula was used to obtain the harvest index:  $HI = (\text{Economic yield} / \text{Biological yield}) \times 100$ .

Content of protein was computed by multiplying the amount of nitrogen in grain by a conversion ratio of 6.25 (Meena *et al.* 2018). For statistical analysis the OPSTAT software (Sheoran *et al.* 2020) was used to analyse the data for ANOVA.

### Results and Discussion

Genotypes have an impact on mustard plant height (Table 1). Significantly taller plants comparable to RH 1974 were documented by DRMRIJ 31. Across all genotypes, Kranti plants were noticeably smaller. RH1975's plant height was comparable to that of RH 749. Fertilizer dosages did not significantly alter plant height. With the exception of primary branches that were noticeably larger under 150% RDF, genotypes and fertilizer levels did not significantly affect the variation in main shoot, primary branches, or siliqua length. The height of the main shoot ranges from 82 to 86 cm, while the number of primary branches stays between 4.0 and 4.6. Secondary branches were significantly impacted by different genotypes, and DRMRIJ31 has significantly fewer secondary branches (9.16), comparable to RH749 (10.77), than other genotypes. Because of their varying nitrogen levels, secondary branches were not significant. Fertilizer dosages and genotypes had a major impact on test weight. RH1975 (6.03 g) was a very bold seed, followed by RH 1974 (5.64 g), RH 749 (5.38 g), Kranti (5.34 g), and DRMRIJ31 (5.19 g). By raising the

fertilizer dosage from 100 RDF (5.39 g) to 150 RDF (5.68 g), the test weight rose. Improved metabolic activities and increased photosynthesis could be the cause of this (Saneoka *et al.* 2004, Beenish *et al.* 2018, Rimi *et al.* 2020).

**Table 1. Yield attributes of mustard genotypes under different fertilizer levels under timely sown irrigated conditions.**

| Treatments       | Plant height (cm) | Main shoot (cm) | Primary branches | Secondary branches | Siliqua length (cm) | Siliqua/ main | Seeds/ siliqua | Test weight (g) |
|------------------|-------------------|-----------------|------------------|--------------------|---------------------|---------------|----------------|-----------------|
| Genotypes        |                   |                 |                  |                    |                     |               |                |                 |
| RH1975           | 188               | 86              | 4.6              | 12.02              | 5.46                | 56.6          | 13.90          | 6.03            |
| RH1974           | 193               | 84              | 4.5              | 12.16              | 5.01                | 54.9          | 12.88          | 5.64            |
| RH749            | 190               | 84              | 4.5              | 10.77              | 5.28                | 64.7          | 12.22          | 5.38            |
| Kranti           | 176               | 82              | 4.6              | 12.48              | 5.28                | 48.2          | 11.44          | 5.34            |
| DRMRIJ31         | 200               | 86              | 4.0              | 9.16               | 5.13                | 55.0          | 13.14          | 5.19            |
| C.D.(p=0.05)     | 9                 | NS              | NS               | 1.89               | NS                  | 6.3           | 1.44           | 0.10            |
| Fertilizer doses |                   |                 |                  |                    |                     |               |                |                 |
| F1-100% RDF      | 191               | 86              | 4.2              | 10.90              | 5.54                | 54.5          | 10.97          | 5.39            |
| F2-125%RDF       | 186               | 85              | 4.4              | 11.62              | 5.12                | 58.5          | 14.15          | 5.48            |
| F3-150 %RDF      | 191               | 82              | 4.7              | 11.43              | 5.03                | 54.7          | 13.03          | 5.68            |
| C.D. (p=0.05)    | NS                | NS              | 0.4              | NS                 | NS                  | NS            | 1.84           | 0.16            |

NS= not significant.

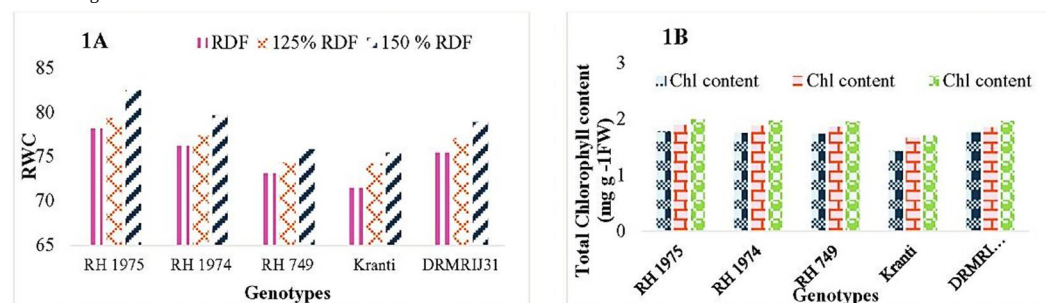


Fig. 1. Relative water content (A) and total chlorophyll content (B) in different mustard varieties influenced by fertilizer levels under timely sown irrigated conditions.

Under irrigated conditions, it was demonstrated that increased fertilizer dosages corresponded with elevated RWC (Fig. 1A) and total chlorophyll content (Fig.1B). The highest recorded RWC was 82.42% in RH 1975, while the lowest was 75.43% in Kranti at 150 % RDF. A comparable pattern was noted when 125% RDF was applied. The findings coincide with those of Priyanka *et al.* (2022). Likewise, as fertilizer levels increased, so did the overall chlorophyll concentration. At 150% RDF imposition, RH 1975 had the maximum chlorophyll content (1.98 mg/g fw), followed by RH 1974 (1.97 mg/g fw), DRMRIJ31 (1.96 mg/g fw), and RH 749 (1.95 mg/g fw). Total chlorophyll content values at 125% RDF imposition and 150% RDF imposition were not statistically significant. It is commonly known that nitrogen improves osmolyte production and N assimilation. In both water stress and normal situations, studies have shown that applying 120 kg K/ha to mustard and groundnut crops increases their relative water content (RWC) as compared to the control ( $K_0$ ) (Wang *et al.* 2013). It has been demonstrated that applying potassium increases plant RWC and aids in preserving water balance in both normal and drought situations (Namvar and Khandan 2015). Role of K in controlling stomatal resistance, improving water usage

efficiency, and lowering transpiration is responsible for this impact. The application of 200 kg N/ha produced the highest chlorophyll content, while the lack of N fertilizer produced the lowest amounts. Chlorophyll synthesis was encouraged, the leaf area index (LAI) was improved, and their retention was extended until the end of the growth period when N consumption was increased. Furthermore, it has been discovered that applying N and S together increases RWC; the chlorophyll content was reported to be 5.27% higher than the control. Additionally, higher N levels promote protein synthesis, thicken cell walls, enable the protoplasm to absorb more water, and enhance RWC (Sharma *et al.* 2019).

Different genotypes had a substantial impact on biological, stover, and seed output (Table 2). Table 2 showed that genotype RH 1975 (2916 kg/ha) will have a much greater seed output than genotypes RH1974 (2788 kg/ha), RH749 (2302 kg/ha), DRMRIJ31 (2274 kg/ha), and Kranti (2116 kg/ha) to RDF (2249 kg/ha). Substantially greater output was found under 150% RDF (2672 kg/ha) and 125% RDF (2516 kg/ha), in compared to with various fertilizer dosages. The seed yield rose from 18.81 to 100% RDF after 150% RDF treatment. The pattern for stover and biological yield was like that of seed yield. DRMRIJ31 (20.37%), RH749 (20.84%), Kranti (20.44%), RH1975 (20.41%), and RH 1974 (19.72%) were the next highest harvest index values. Improved chlorophyll content and metabolic activities were the cause of the rise in mustard seed yield and biological yield with higher nutritional dosages (Priyanka *et al.* 2022).

**Table 2. Seed, stover, biological and protein yield (kg ha<sup>-1</sup>), of mustard genotypes under different fertilizer levels under timely sown irrigated conditions.**

| Treatments       | Seed yield (kg/ha) | Stover yield (kg/ha) | Biological yield (kg/ha) | HI (%) | Protein content (%) | Protein yield (q/ha) |
|------------------|--------------------|----------------------|--------------------------|--------|---------------------|----------------------|
| Genotypes        |                    |                      |                          |        |                     |                      |
| RH1975           | 2916               | 11450                | 14365                    | 20.41  | 17.63               | 5.14                 |
| RH1974           | 2788               | 11432                | 14220                    | 19.72  | 17.41               | 4.85                 |
| RH749            | 2302               | 8896                 | 11198                    | 20.84  | 17.15               | 3.95                 |
| Kranti           | 2116               | 8246                 | 10361                    | 20.44  | 16.87               | 3.57                 |
| DRMRIJ31         | 2274               | 9010                 | 11284                    | 20.37  | 16.75               | 3.81                 |
| C.D. (p=0.05)    | 236                | 1170                 | 1364                     | NS     | 0.41                | 0.41                 |
| Fertilizer doses |                    |                      |                          |        |                     |                      |
| F1- 100 % RDF    | 2249               | 8489                 | 10738                    | 21.06  | 16.71               | 3.76                 |
| F2- 125 % RDF    | 2516               | 9805                 | 12321                    | 20.58  | 17.17               | 4.33                 |
| F3- 150 % RDF    | 2672               | 11126                | 13789                    | 19.44  | 17.60               | 4.71                 |
| C.D. (p=0.05)    | 215                | 1512                 | 1678                     | NS     | 0.32                | 0.42                 |

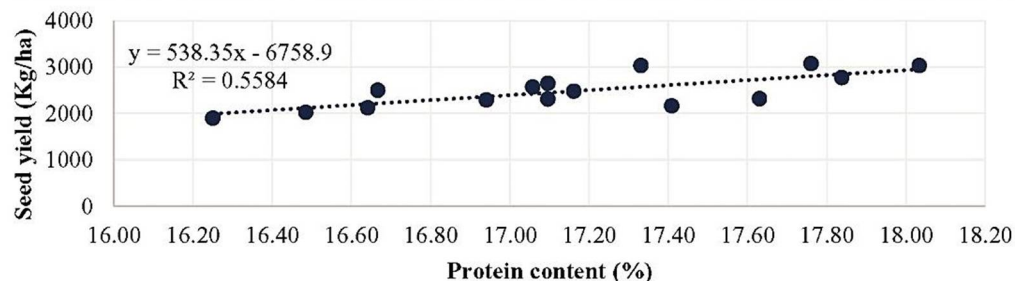


Fig. 2. Regression analysis of seed yield and protein content of mustard.

Fertilizer dosages and genotypes dramatically affected mustard seed protein. Table 2 projected that RH1975 (17.63%) had more protein than RH 1974 (17.41%). As fertilizer dosages increased, mustard seed protein grew from 100% RDF (16.71%) to 150% RDF (17.60%).

Fertilizer dosages have an impact on the nutritional content of mustard seed and straw of various genotypes (Figs 4a, b). The genotype RH1975 was found to have a significantly greater concentration of NPK in the stover (0.523, 0.268, and 1.49%) and in the seed (2.82, 0.398, and 0.870%). In contrast, K in Kranti was 0.810 and 1.40% in seed and stover, respectively, and minimum N, P in DRMRIJ31 was 2.68 and 0.357 % in seed and 0.487 and 0.228% in stover. Data indicated that the NPK content of seed and stover was greatly influenced by varying fertilizer dosages. 150% RDF was much greater than other doses (2.82, 0.381, and 0.874% in seed and 0.519, 0.253, and 1.53% in stover NPK, respectively). This could be because mineral fertilizers contained more nutrients that are soluble in water and easily absorbed by plants. Numerous researchers corroborated the findings as did the protein content (Khan *et al.* 2005, Meena *et al.* 2016, Meena *et al.* 2018).

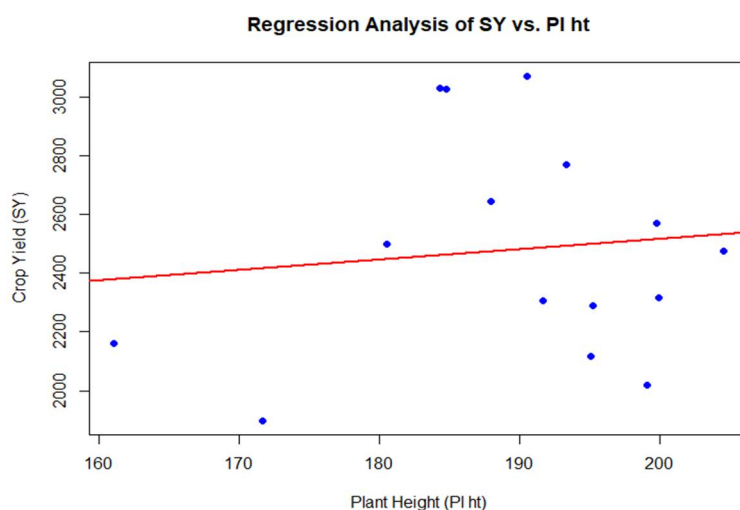


Fig. 3. Regression analysis of seed yield (kg/ha) vs. plant height (cm).

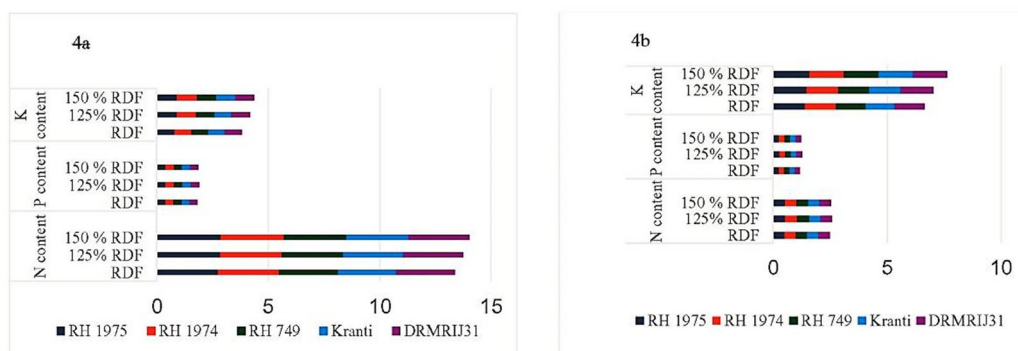


Fig. 4. Effects of genotypes under different fertilizer levels on N, P and P content of mustard (a), and seed and mustard stover (b).

Fig. 3 shows a regression analysis of mustard seed yield (kg/ha) and protein content. Protein concentration enhances seed yield, indicating a favorable association.  $y=538.35x-6758.9$ , indicated that 538.35 is the slope, meaning that for every 1% increase in protein content, the seed yield increases by 538.35 kg/ha. This value (0.5584 or 55.84%) indicates the proportion of variation in seed yield that can be explained by protein content. A moderate correlation is observed, meaning protein content influences seed yield but is not the sole factor. However, the relationship is not perfect ( $R^2 = 0.5584$ ), meaning other agronomic factors (e.g., soil fertility, irrigation, variety, or climate conditions) also play a role.

This regression analysis can help in decision-making for agronomic practices to balance yield and nutritional quality in mustard.

From the study concluded that genotype RH 1975 recorded maximum seed yield (2916 kg/ha), biological yield (14365 kg/ha) and physiological parameters followed by RH 1974 (2788 kg/ha), RH 749 (2302 kg/ha), DRMRIJ 31 (2274 kg/ha), and Kranti (2116 kg/ha). Genotype RH 1975 had the highest nutrient content (N, P and K) in seed and stover with reaching to 125% RDF being at par with 150% RDF followed by RH 1974, RH 749, Kranti and DRMRIJ31, respectively.

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