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Evaluation of Mustard (Brassica spp.) Genotypes for Yield and Oil Content in Tandojam, Sindh, Pakistan

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ABSTRACT

The evaluation of mustard (Brassica spp.) genotypes under specific agro-climatic conditions is essential to optimize productivity and oilseed quality. This study assessed the yield performance of ten mustard genotypes, including a commercial check variety, under the agro-climatic conditions of Tandojam, Sindh, Pakistan. The research was conducted at the Experimentation Station of the Oilseeds Research Institute, A.R.C. Tandojam, with the objective of identifying high-yielding genotypes suited for the region. Significant differences were observed among genotypes for seed yield and related traits. The commercial check variety, Mehran Raya, demonstrated superior yield performance with a plant height of 179.29 cm, 7.11 branches plant-1, 330.49 pods per plant, 20.63 seeds per pod, seed index of 4.92 g, a seed yield of 2086.70 kg ha-1 and an oil content of 35.35%. Notably, the genotype TJB-30 recorded the highest oil content at 37.83%, surpassing the check variety. The observed differences in yield and oil content were attributed to genetic diversity, environmental conditions, and cultivation practices. The findings highlight Mehran Raya's potential as a high-yielding mustard variety, suitable for cultivation in Tandojam, while TJB-30 shows promise for improving oil content. Mehran Raya exhibited superior yield, and TJB-30 demonstrated potential for enhanced oil quality. However, further research is necessary to assess their stability and adaptability across various environments, ensuring these genotypes' long-term suitability for sustainable oilseed production and contributing to regional food security. This study provides valuable insights for the selection of mustard genotypes tailored to the agro-climatic conditions of Tandojam, supporting efforts to enhance oilseed production in Pakistan.

INTRODUCTION

Mustard (Brassica spp.) is a crucial oilseed crop with significant global and economic importance, ranking third in vegetable oil production behind soybean and palm oil. It is prized for its quick growing season and ability to thrive in cooler climates, offering a high oil content of 28–32% and protein content of 28–36%. Mustard is grown for various purposes, including as a source of edible oil, fodder, and for its medicinal properties. In Pakistan, mustard is traditionally cultivated during the Rabi season and adapts well to a range of agro-climatic zones. However, despite its potential, the productivity of mustard in Pakistan remains low, with an average yield of 812 kg ha^{-1}, significantly lower than the global average of 1,560 kg ha^{-1}. This low yield is attributed to challenges such as suboptimal genotypes, environmental stresses, and pest pressures. Furthermore, Pakistan's dependence on edible oil imports underscores the need to boost domestic production. Currently, Pakistan faces a persistent shortfall in edible oil, relying on imports to meet about 80% of its domestic needs, which places a heavy burden on foreign exchange (Abro et al., 2019). Thus, enhancing the production of oilseed crops, particularly mustard, presents an opportunity to improve local edible oil production and decrease import dependence (Tahira et al., 2021).

Although many research institutions in Pakistan have developed mustard varieties with high oil content, their potential remains largely unexplored due to a lack of comprehensive research. Genotypes can exhibit

varying performance levels in different agro-climatic regions, and their yield potential is not consistent across all environments (Sher et al., 2019). Factors such as temperature, daylight duration, soil fertility, and water availability significantly influence a genotype's performance in new settings (Singh et al., 2019). Mustard crops are particularly sensitive to climatic variables; even minor changes can profoundly affect production. High temperatures during early crop establishment, cold spells, fog, and intermittent rains during the flowering to pod formation stage can lead to substantial yield losses due to physiological disorders and increased vulnerability to pest attacks (Kumar et al., 2018; Solangi et al., 2020). Only stable genotypes can provide good yields with a reduced risk of production loss, which allows researchers to offer general recommendations for various environments.

However, mustard cultivation confronts numerous environmental challenges that can significantly affect yield, quality, and overall sustainability.

These challenges include climatic factors, soil health issues, pest and disease pressures, as well as broader environmental concerns such as climate change and biodiversity loss. Understanding and addressing these challenges is crucial to maintaining the resilience and productivity of mustard crops in a changing environment. Mustard is particularly sensitive to temperature fluctuations, with extremes impacting germination, flowering, and seed development. Changes in temperature patterns, including heatwaves and cold spells, can disrupt the growth cycle and diminish overall yields (Fahad et al., 2017). Furthermore, shifting climate patterns, such as changes in temperature and precipitation, can directly affect mustard cultivation. Therefore, adaptation strategies, including the development of climate-resilient varieties, are essential for mitigating the effects of climate change (FAO, 2020). Agricultural intensification and monoculture practices lead to biodiversity loss, disrupting ecosystem balance. Preserving biodiversity in and around mustard fields is crucial for effective pest control and overall ecosystem health.

Mustard cultivation faces a range of environmental challenges that necessitate integrated and sustainable solutions. Tackling these issues is vital for the long-term viability of mustard crops and for ensuring global food security (Kremen et al., 2016). Therefore, this study aims to evaluate mustard genotypes for yield and oil content in the agro-climatic conditions of Tandojam, Sindh. By identifying stable, high-performing genotypes, this research seeks to overcome production challenges and support the sustainable development of mustard cultivation in Pakistan.

MATERIALS AND METHODS

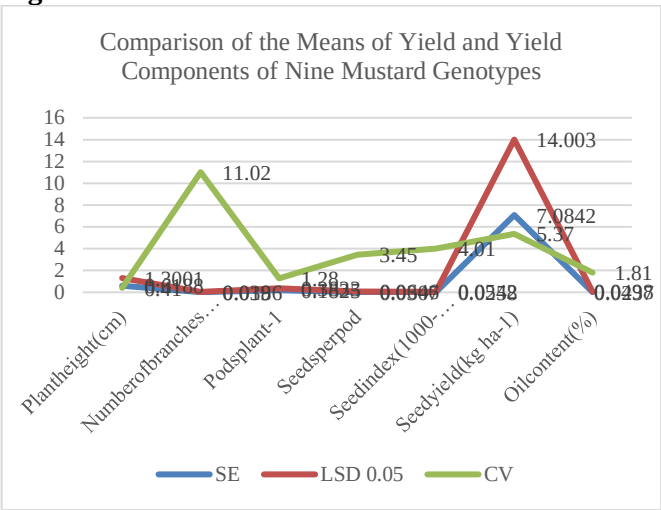
The present study was conducted at the Oilseeds Research Institute, A.R.C. Tandojam Agriculture Farm, to evaluate of mustard (Brassica spp.) genotypes for yield and oil content in Tandojam, Sindh, Pakistan, during Rabi 2022. The field experiment was laid out in a randomized block design (RBD) with three replications. Nine genotypes were planted with a spacing of 10 cm between rows and 45 cm between plants. The net plot size was 5 x 4 m^2. Nitrogen and phosphorus were applied at75 and 50 kg ha^{-1} respectively. All P_2 O_5 and one third of the nitrogen were applied at the time of sowing while the remaining doses of nitrogen fertilizer were applied at the 1st and 2nd irrigation. A total number of three irrigations were applied to this crop. All other agronomic practices were kept normal and uniform for all treatments. Data were recorded on plant height at harvest (cm), number of branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, seed index (1000), seed yield (kg ha^{-1}), and oil content (%). The data were subjected to statistical analysis using Statistics 8.1 software (Statistics, 2006). Differences among the treatments were compared using the least significant difference (LSD) test where necessary.

Table 1

Comparison of the Means of Yield and Yield Components of Nine Mustard Genotypes

Genotypes	Plantheight (cm)	Number of Branches $plant^{-1}$	Pods $plant^{-1}$	Seeds Per pod	Seed index (1000-seeds weight, g)	Seed yield (kg ha^{-1})	Oil content (%)
V_1=TJB-29	198.00 a	6.11 b	303.99 c	12.90 h	3.83 e	1646.30 h	32.04 i
V_2=TJB-22	164.27 h	5.11 f	289.24 e	17.38 d	3.32 h	1805.00 b	32.97f
V_3=TJB-177	199.20 a	5.45 e	287.49 f	11.90 j	3.62 g	1548.30 j	37.76 b
V_4=TJB-27	170.75 g	4.42 h	242.92 i	14.99 g	4.74 b	1680.00 g	32.61 g
V_5=TJB-159	192.99 c	5.49 e	292.36 d	19.69 c	3.74 f	1905.0 c	37.57 c
V_6=TJB-153	173.59 f	4.70 g	261.65 h	17.03 f	4.43 c	1695.0 f	37.49 d
V_7=TJB-30	193.59 c	5.64 d	286.47 g	17.11 e	3.73 f	1740.0 c	37.83 a
V_8=TJB-41	196.00 b	6.02 c	308.89 b	20.12 b	4.45 c	1990.0 b	37.73 b
V_9=TJB-140	183.18 d	5.46 e	287.74 f	11.40 i	3.97 d	1608.0 i	32.48 h
V_{10}=Mehran Raya (Check)	179.29 e	7.10 a	330.49 a	20.62 a	4.95 a	2086.70 a	35. 43 e
SE	0.6188	0.0186	0.1825	0.0307	0.0258	7.0842	0.0237
LSD 0.05	1.3001	0.0390	0.3833	0.0646	0.0542	14.003	0.0498
CV	0.41	11.02	1.28	3.45	4.01	5.37	1.81

Figure 1



RESULT AND DISCUSSION

The evaluation of mustard (Brassica spp.) genotypes under the agro-climatic conditions of Tandojam, Sindh, revealed significant variation in yield and oil content among the tested genotypes, demonstrating the critical role of genetic and environmental factors in crop performance. The commercial check variety, Mehran Raya, exhibited the highest seed yield of 2086.70 kg ha^{-1}, coupled with desirable agronomic traits, such as plant height (179.29 cm), branches $plant^{-1}$ (7.11), pods $plant^{-1}$ (330.49), seeds pod^{-1} (20.63), and a seed index of 4.92 g. Its oil content of 35.35% further highlights its suitability as a high-yielding and high-quality oilseed variety for the region. These results are in favor of Sodani et al. (2017), Sondhiya et al. (2019) and Yousaf et al. (2016).

The superior performance of Mehran Raya can be attributed to its adaptation to local environmental conditions, genetic potential, and agronomic stability. The genotype's balanced traits, such as robust branching and pod production, contributed to its high seed yield, which aligns with findings from previous studies emphasizing the importance of branching and pod density in yield determination (Kumar et al., 2018). Additionally, the relatively high oil content supports its potential as a dual-purpose variety for yield and oil production, addressing the growing demand for edible oil in Pakistan.

The genotype TJB-30, which recorded the highest oil content (37.83%), surpassing the check variety, is noteworthy. This result highlights the genetic potential of TJB-30 for improving oil quality traits, which is crucial for reducing Pakistan's dependency on edible oil imports. The higher oil content observed in TJB-30 suggests that this genotype could be an ideal candidate for breeding programs aimed at enhancing oil yield without compromising seed production.

The observed variability among genotypes is consistent with earlier research, indicating that mustard exhibits significant genetic diversity in yield-related traits and oil quality under different agro-climatic conditions (Singh et al., 2019; Solangi et al., 2020). These differences underscore the importance of region-specific genotype evaluation, as environmental factors, including temperature, rainfall, soil fertility, and cultivation practices, influence phenological development, seed filling, and oil synthesis(Hagos et al., 2020).

. The agro-climatic conditions of Tandojam, characterized by moderate winter temperatures and adequate irrigation, likely played a role in maximizing the yield potential of certain genotypes.

Despite the overall promising results, the relatively lower performance of other genotypes compared to Mehran Raya indicates that not all mustard varieties are equally suited for the climatic conditions of Tandojam. Variability in traits such as branch number, pod count, and seed weight among genotypes reflects the complex interaction between genotype and environment (G × E). This emphasizes the need for further multi-environment trials to identify stable and high-performing genotypes across diverse growing conditions. These observations are supported by other researchers (Aghsaei et al., 2020; Peng et al., 2020).

The findings of this study also highlight the potential for integrating high-yielding genotypes like Mehran Raya and high-oil-content genotypes like TJB-30 into mustard breeding programs. Such integration could lead to the development of improved varieties combining high yield and superior oil quality, thereby addressing the dual challenges of enhancing domestic edible oil production and reducing reliance on imports. The evaluation of mustard genotypes under Tandojam's agro-climatic conditions has provided valuable insights into their yield potential and oil content. The superior performance of Mehran Raya underscores its suitability for cultivation in the region, while TJB-30 demonstrates promise for improving oil quality. These findings can guide the selection and development of mustard genotypes tailored to regional needs, supporting sustainable oilseed production and contributing to food security in Pakistan. Further research is recommended to assess these genotypes across multiple environments to confirm their stability and adaptability.

CONCLUSION

In conclusion, this study highlights the significant variation in yield and oil content among mustard genotypes evaluated under the agro-climatic conditions of Tandojam, Sindh. The commercial check variety, Mehran Raya, emerged as the top performer in terms of seed yield, while TJB-30 exhibited the highest oil content, showcasing its potential for improving oil yield. The genetic diversity observed emphasizes the importance of region-specific genotype evaluation, as

environmental factors such as temperature, rainfall, and soil fertility influenced crop performance. While Mehran Raya demonstrated high yield and adaptability, TJB-30's potential for enhanced oil quality makes it a valuable candidate for breeding programs. Further multi-environment trials are essential to identify stable genotypes across diverse conditions. These findings contribute to the goal of improving mustard production in Pakistan, addressing both yield and oil content to support sustainable agricultural practices and reduce dependency on edible oil imports.

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