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Effect of potassium and zinc application on growth and yield attributes of mustard (*Brassica juncea* L.)

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Abstract

A field experiment was carried out at the Crop Research Centre, Jigyasa University, Dehradun, during the Rabi season 2022–2023 to assess the impact of applying potassium and zinc on development and yield of mustard (*Brassica juncea* L.). The experiment was laid down in Randomised Block Design with three replications and sixteen treatments, including varying potassium (30, 40, and 50 kg/ha) and zinc (5, 10, 15, 20, and 25 kg/ha) levels as well as 100% RDF as a control. The findings showed that the application of potassium and zinc had a substantial impact on growth, yield characteristics and yield of Mustard. The maximum plant height (193.45 cm), plant dry weight (35.25 g), crop growth rate (19.70 g/m²/day), and relative growth rate (0.0425 g/g/day) were reported for the treatment T₁₃ (50 kg K/ha + 15 kg Zn/ha). The same treatment also produced the highest yield qualities, such as the number of siliques per plant (302.20) and the number of seeds per silique (17.60). In comparison to the control (100% RDF), T₁₃ produced considerably greater seed yield (2685 kg/ha), stover yield (6143 kg/ha), and harvest index (30.41%). The same treatment had the highest gross return (₹1,36,910/ha), net return (₹93,070/ha), and benefit-cost ratio (2.11). Thus, it can be concluded that the combined application of 50 kg K/ha and 15 kg Zn/ha is the most effective and economically viable nutrient management practice for enhancing growth, yield, and profitability of mustard under the agro-climatic conditions of Dehradun.

Keywords: Mustard (*Brassica juncea* L.), potassium, zinc, growth attributes, yield, nutrient management, crop productivity, benefit-cost ratio

1. Introduction

One of the most significant oilseed crops in the Brassicaceae family, Indian mustard (*Brassica juncea* L.) is widely grown in India under a variety of agroclimatic conditions. It contributes significantly to the agricultural economy and plays an important part in the production of edible oil. Despite its significance, yield of mustard is comparatively low because of inadequate crop management techniques, nutritional shortages, and uneven fertilisation (Bastia *et al.*, 2020) ^[4]. Final crop production is mostly determined by growth and yield characteristics including plant height, number of branches, leaf area, siliques per plant, and seeds per silique. These characteristics are extremely sensitive to the availability of nutrients, especially zinc and potassium, which are necessary for a number of physiological and biochemical functions in plants.

Potassium is an important macro nutrient essential for protein synthesis, photosynthesis, enzyme activation, and helps in translocation of water and minerals. Additionally, it controls stomatal opening and closing, which enhances plants' ability to withstand stress and use water more efficiently. Sufficient potassium feeding improves the development of yield-contributing traits and fortifies plant structure (Subba Rao & Srinivasarao, 2010) ^[32]. An important micronutrient, zinc (Zn) is involved in protein metabolism, enzyme activation, and auxin production. It has a major impact on photosynthesis, growth regulation, and the production of chlorophyll. According to Singh *et al.* (2005) ^[30], applying zinc has been shown to boost plant height, branch count, and yield characteristics such seeds per silique and siliques per plant in mustard. Zinc also improves photosynthates' transfer to reproductive organs, which boosts agricultural productivity (Deo & Khandelwal, 2009) ^[12]. Crop growth and development are restricted in many Indian soils due to zinc deficiencies and inadequate potassium levels. Because high-yielding

cultivars progressively deplete soil micronutrients, balanced fertilisation is crucial. Therefore, potassium and zinc if applied together judiciously can boost mustard's development parameters and production features. Keeping in view the importance of nutrient management, the present study was undertaken to evaluate the effect of potassium and zinc on growth and yield attributes of mustard (*Brassica juncea* L.).

2. Review of Literature

The development and yield characteristics of mustard are greatly impacted by the application of zinc and potassium. According to Pradhan *et al.* (2023) ^[25], a combined treatment of 50 kg K/ha + 15 kg Zn/ha produced the highest plant height (193.45 cm), plant dry weight (35.25 g), siliquae per plant (302.20), and seeds per siliqua (17.60) under sandy loam soil conditions. Atkari *et al.* (2022) ^[3] found that potassium application at 45 kg/ha greatly increased plant height, branch count, dry matter accumulation and number of siliquae. Azotobacter + PSB plus 40 kg K/ha also enhanced siliqua per plant (134.53) and seeds per siliqua (31.67), according to Tripathi *et al.* (2022) ^[33].

According to Ajnar *et al.* (2021) ^[1], the combined application of RDF, sulphur, vermicompost, and biofertilizers greatly increased test weight, siliqua per plant, and seeds per plant. Additionally, Jana *et al.* (2021) ^[16] found that RDF + foliar DAP @ 2% increased plant height, leaf area index, dry matter accumulation, and seed count. Additionally, Singh *et al.* (2005) ^[30] found that due to increased metabolic activity, zinc administration up to 6 kg/ha considerably boosted plant height, number of branches, and yield parameters. Similar to this, Deo and Khandelwal (2009) ^[12] found that applying zinc increased growth metrics because of its function in protein synthesis and enzyme activation. Furthermore, Choudhary *et al.* (2008) ^[11] noted that mustard growth indices and reproductive features are greatly enhanced by balanced fertilisation that includes micronutrients. Applying zinc greatly enhances mustard's growth and yield characteristics. According to Jannat *et al.* (2023) ^[17], maximum plant height (140.57 cm), branches (5.84), pods per plant (87.57), and seeds per pod (31.53) were achieved with a combined basal and foliar application of Zn and B (100% basal + 25% Zn foliar). According to Jaswal *et al.* (2023) ^[18], foliar spraying RDF + 1% urea + 0.5% ZnSO₄ + 0.5% FeSO₄ at 45 DAS greatly improved growth metrics and yield. Beulah *et al.* (2022) ^[6] found higher plant height (202.36 cm), branches (11.18), and dry weight (32.96 g) when Zn was applied @ 15 kg/ha under 40 cm spacing. Yanthan *et al.* (2021) ^[36] and Mhonhung *et al.* (2021) ^[23] reported that combined application of Zn and B significantly increased siliqua per plant (86.07), seeds per siliqua (40.27), and test weight (3.85 g). Similarly, Behara *et al.* (2021) ^[5] observed superior plant height (136.02 cm), dry weight (34.37 g), siliqua per plant (113), and seeds per siliqua (32.5) with Zn @ 10 kg/ha + S @ 30 kg/ha.

Additionally, Zn @ 10 kg/ha combined with sulphur greatly increased the leaf area index and chlorophyll content, according to Verma *et al.* (2018) ^[34]. Sangwan *et al.* (2017) ^[29] found that foliar Zn (0.5% ZnSO₄) greatly increased growth and yield qualities under dryland circumstances. Kumar *et al.* (2018) ^[22] also noted better plant height, branches, siliqua per plant, and test weight with integrated use of RDF + FYM + Zn + S. Additionally, Sahito *et al.* (2014) ^[28] found that applying up to 8 kg/ha of zinc increased growth metrics. In general, mustard's vegetative development and production characteristics are improved by balanced nutrition management that incorporates potassium, zinc, and integrated sources.

3. Materials and Methods

A field experiment was carried out during the Rabi season of 2022–2023 at the Department of Agriculture's experimental farm at Jigyasa University (formerly Himgiri Zee University), Dehradun, Uttarakhand. The location of the site was 650 meters above mean sea level, at latitude of 30°19' N and longitude 78°04' E. The soil had a sandy loam texture, a pH of 7.49, and 0.40% organic carbon. Soil Sampling was done prior to sowing from four distinct locations at a depth of 0 to 15 cm. The samples were combined to create a composite sample, which was then examined for physico-chemical characteristics. Temperatures throughout the crop season varied from 4.0°C to 14.0°C (min.) and from 19.8°C to 34.4°C (max.). The experiment was set up using a Randomised Block Design (RBD) with three replications and sixteen treatments. Observations were recorded from five tagged plants per plot at different growth stages (20, 40, 60, 80, 100 DAS and at harvest) on quantitative characters viz. Plant height (cm), Plant dry weight (g/plant), Crop Growth Rate (CGR), Relative Growth Rate (RGR), Number of siliquae per plant, Number of seeds per siliqua, Test weight (g).

4. Results and Discussion

At every growth stage, potassium and zinc had a substantial impact on plant height (Table 1). The T₁₃ treatment (50 kg K/ha + 15 kg Zn/ha) recorded the highest plant height (14.95 cm) at 20 DAS, (55.93 cm) at 40 DAS, (84.59 cm) at 60 DAS, (134.16 cm) at 80 DAS, (179.45 cm) at 100 DAS, and (193.45 cm) at harvest, while the lowest (162.89 cm) at harvest was recorded under T₁₆ (100% RDF). Potassium plays a vital role in enzyme activation, osmotic regulation, and stomatal functioning, thereby enhancing cell expansion and water relations, while zinc is essential for auxin synthesis, protein metabolism, and membrane integrity. This coordinated action promotes cell division and elongation, resulting in increased plant height, as also reported by Ismail Cakmak (2019) ^[10] and Hafeez *et al.* (2020) ^[13]. Plant dry weight was greatly impacted by treatments and rose steadily with crop age (Table 1). The dry weight under T₁₃ (50 kg K/ha + 15 kg Zn/ha) ranged from 0.85 g (20 DAS) to 35.25 g (at harvest), whereas the dry weight under T₁₆ (100% RDF) was the lowest (31.87 g at harvest). Potassium facilitates the translocation of photosynthates from source to sink, whereas zinc enhances chlorophyll synthesis and carbonic anhydrase activity, thereby improving carbon fixation. The lower dry weight under RDF alone (T₁₆) highlights the importance of micronutrient supplementation for optimal biomass production. Similar findings were reported by Raza *et al.* (2020) ^[26] and Imran *et al.* (2021) ^[14], who emphasized the role of balanced fertilization in enhancing crop growth. CGR rose during the early to mid-growth phases before falling.

Under T₁₃ (50 kg K/ha + 15 kg Zn/ha), the highest CGR was measured at intervals of 7.19, 10.82, 19.70, and 10.53 g/m²/day. T₁₆ (100% RDF) had the lowest CGR (Table 2). The highest CGR under T₁₃ suggests efficient conversion of intercepted radiation into biomass due to optimal nutrient supply. As crop age increased, the relative growth rate exhibited a decreasing tendency. T₁₃ had the highest RGR (0.0425, 0.0179, 0.0137, and 0.0055 g/g/day at successive intervals), whereas T₁₆ (100% RDF) had the lowest values. This suggests that a diet rich in potassium and zinc improves growth efficiency, particularly in the early phases of growth. Potassium enhances ATP production and enzyme activity, while zinc improves nitrogen metabolism and protein synthesis, leading to higher growth rates (Ali *et al.*,

2022) [2]. Likewise, Relative Growth Rate (RGR) decreased with crop age due to increased structural biomass; however, higher RGR values in early stages under T₁₃ indicate better metabolic efficiency and nutrient utilization, as supported by Singh *et al.* (2021) [31].

Zinc and potassium had a substantial impact on the number of siliqua per plant (Table 2 and Fig. 1). The highest number of siliqua (302.20) was found under T₁₃ (50 kg K/ha + 15 kg Zn/ha), whereas the lowest number (266.53) was found under 100% RDF (T₁₆). Higher nutrition levels were found to significantly enhance the number of seeds per siliqua. T₁₃ had the greatest value (17.60), while T₁₆ had the lowest (13.87). The higher values under T₁₃ can be attributed to improved reproductive development, enhanced pollen viability, and efficient assimilate translocation to reproductive organs. Zinc plays a critical role in flowering and fertilization processes, while potassium ensures effective carbohydrate transport,

resulting in improved sink development. These findings are in agreement with Bhati *et al.* (2014) [7], Kour *et al.* (2017) [20], and Khan *et al.* (2022) [19]. Better reproductive development and increased metabolic activity under balanced potassium and zinc nutrition are the causes of this improvement. It was discovered that the test weight was not significant. However, the highest value (3.73 g) was recorded under T₁₃, and the lowest (3.23 g) under T₁₆. Although test weight was statistically non-significant, higher values under T₁₃ suggest improved seed filling due to better nutrient availability. Potassium is particularly important in starch synthesis and grain development, while zinc supports enzymatic activities involved in seed maturation (Yadav *et al.*, 2020) [35]. Overall, the study highlights that balanced application of potassium and zinc enhances growth efficiency, biomass accumulation, and reproductive performance, ultimately leading to improved crop productivity compared to RDF alone.

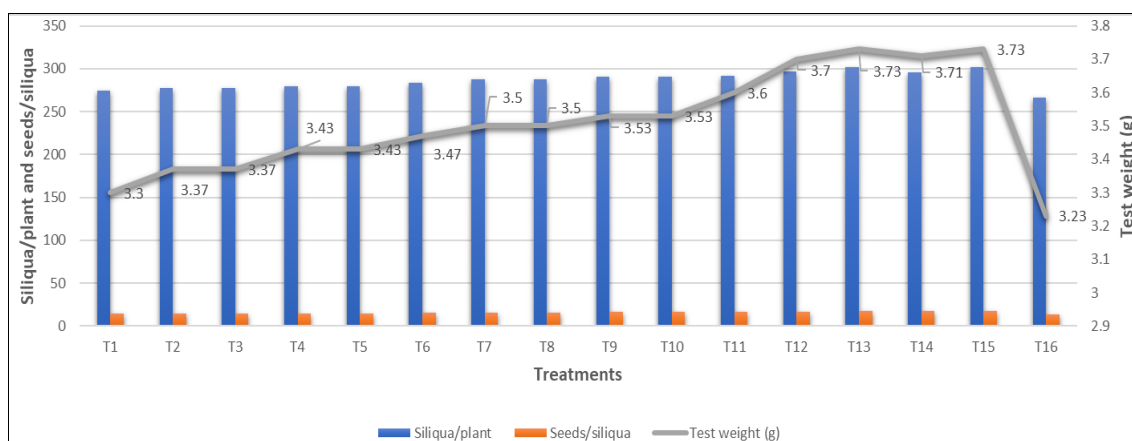


Fig 1: The influence of potassium and zinc on siliqua/plant, seeds/siliqua and test weight in mustard

Table 1: The effect of potassium and zinc on Plant height and dry weight of mustard

Treatments	Height 20 DAS	Height 40 DAS	Height 60 DAS	Height 80 DAS	Height 100 DAS	Height Harvest	Dry Wt 20 DAS	Dry Wt 40 DAS	Dry Wt 60 DAS	Dry Wt 80 DAS	Dry Wt 100 DAS	Dry Wt Harvest
T ₁	11.60	38.51	60.93	113.95	150.74	164.74	0.69	4.73	10.80	20.42	26.20	32.00
T ₂	11.96	40.51	63.69	116.71	157.07	171.07	0.71	4.75	10.97	20.72	26.50	32.32
T ₃	12.33	41.91	68.09	117.94	161.77	175.77	0.71	4.75	10.97	20.72	26.50	32.32
T ₄	12.33	41.91	68.09	117.94	161.77	175.77	0.72	4.90	11.17	21.38	26.95	32.71
T ₅	12.63	44.78	71.92	120.29	156.29	170.29	0.72	4.90	11.17	21.38	26.95	32.71
T ₆	13.15	47.50	73.81	121.87	167.33	181.33	0.74	4.69	10.55	21.65	27.51	33.25
T ₇	13.15	47.50	73.81	121.87	167.33	181.33	0.77	4.75	10.78	21.69	27.70	33.75
T ₈	13.51	49.59	76.78	123.76	170.43	184.43	0.77	4.75	10.78	21.69	27.70	33.75
T ₉	13.51	49.59	76.78	123.76	170.43	184.43	0.78	4.80	11.12	22.83	28.53	34.13
T ₁₀	13.65	50.95	80.01	126.77	174.01	188.01	0.79	5.04	11.29	22.97	28.80	34.29
T ₁₁	13.65	50.95	80.01	126.77	174.01	188.01	0.79	5.04	11.29	22.97	28.80	34.29
T ₁₂	14.07	51.91	82.08	131.36	176.13	190.13	0.80	5.10	11.41	23.19	28.98	34.80
T ₁₃	14.95	55.93	84.59	134.16	179.45	193.45	0.85	5.16	11.65	23.47	29.78	35.25
T ₁₄	14.07	51.91	82.08	131.36	176.13	190.13	0.80	5.10	11.41	23.19	28.98	34.80
T ₁₅	13.95	52.93	83.59	133.16	177.45	192.45	0.75	4.16	10.65	22.47	28.78	34.25
T ₁₆	11.49	35.74	57.40	109.71	148.89	162.89	0.67	4.71	10.76	20.24	26.09	31.87
SEm ±	0.29	2.19	1.84	1.77	1.33	1.33	0.02	0.06	0.08	0.12	0.38	0.33
CD (p=0.05)	0.85	6.50	5.46	5.25	3.94	3.94	0.07	0.16	0.25	0.36	1.14	0.97

T₁: 30 kg K/ha + 5 kg Zn/ha; T₂: 30 kg K/ha + 10 kg Zn/ha; T₃: 30 kg K/ha + 15 kg Zn/ha; T₄: 30 kg K/ha + 20 kg Zn/ha; T₅: 30 kg K/ha + 25 kg Zn/ha; T₆: 40 kg K/ha + 5 kg Zn/ha; T₇: 40 kg K/ha + 10 kg Zn/ha; T₈: 40 kg K/ha + 15 kg Zn/ha; T₉: 40 kg K/ha + 20 kg Zn/ha; T₁₀: 40 kg K/ha + 25 kg Zn/ha; T₁₁: 50 kg K/ha + 5 kg Zn/ha; T₁₂: 50 kg K/ha + 10 kg Zn/ha; T₁₃: 50 kg K/ha + 15 kg Zn/ha; T₁₄: 50 kg K/ha + 20 kg Zn/ha; T₁₅: 50 kg K/ha + 25 kg Zn/ha; T₁₆: 100% RDF

Table 2: The effect of potassium and zinc on Crop Growth rate, relative growth rate, siliqua/plant, seeds/siliqua and test weight of mustard

Treatments	CGR 20-40	CGR 40-60	CGR 60-80	CGR 80-100	RGR 20-40	RGR 40-60	RGR 60-80	RGR 80-100	Siliqua/plant	Seeds/siliqua	Test weight (g)
T ₁	6.74	10.12	16.02	9.63	0.0418	0.0179	0.0138	0.0054	274.27	14.30	3.30
T ₂	6.73	10.36	16.25	9.64	0.0413	0.0182	0.0138	0.0053	277.53	14.43	3.37
T ₃	6.73	10.36	16.25	9.64	0.0413	0.0182	0.0138	0.0053	277.53	14.43	3.37
T ₄	6.97	10.45	17.02	9.28	0.0418	0.0179	0.0141	0.0050	279.27	14.67	3.43
T ₅	6.58	9.77	18.51	9.76	0.0402	0.0176	0.0156	0.0052	279.27	14.67	3.43
T ₆	6.63	10.05	18.19	10.00	0.0394	0.0178	0.0152	0.0053	283.47	15.33	3.47
T ₇	6.63	10.05	18.19	10.00	0.0394	0.0178	0.0152	0.0053	287.47	15.67	3.50
T ₈	6.70	10.54	19.51	9.50	0.0395	0.0183	0.0156	0.0048	287.47	15.67	3.50
T ₉	6.70	10.54	19.51	9.50	0.0395	0.0183	0.0156	0.0048	290.93	16.33	3.53
T ₁₀	7.08	10.42	19.47	9.71	0.0402	0.0175	0.0154	0.0049	290.93	16.33	3.53
T ₁₁	7.08	10.42	19.47	9.71	0.0402	0.0175	0.0154	0.0049	291.60	16.73	3.60
T ₁₂	7.16	10.53	19.63	9.66	0.0403	0.0175	0.0154	0.0048	297.20	17.00	3.70
T ₁₃	7.19	10.82	19.70	10.53	0.0425	0.0179	0.0137	0.0055	302.20	17.60	3.73
T ₁₄	7.16	10.53	19.63	9.66	0.0403	0.0175	0.0154	0.0048	296.20	17.40	3.71
T ₁₅	6.19	9.82	18.70	9.53	0.0392	0.0176	0.0153	0.0047	302.20	17.55	3.73
T ₁₆	6.74	10.08	15.80	9.75	0.0393	0.0177	0.0152	0.0051	266.53	13.87	3.23
SEm ±	0.10	0.12	0.20	0.79	0.0001	0.0001	0.002	0.005	2.63	0.40	0.11
CD (p=0.05)	0.29	0.36	0.58	0.0001	0.0001	0.0001	0.0001	0.0001	7.82	1.20	0.001

T₁: 30 kg K/ha + 5 kg Zn/ha; T₂: 30 kg K/ha + 10 kg Zn/ha; T₃: 30 kg K/ha + 15 kg Zn/ha; T₄: 30 kg K/ha + 20 kg Zn/ha; T₅: 30 kg K/ha + 25 kg Zn/ha; T₆: 40 kg K/ha + 5 kg Zn/ha; T₇: 40 kg K/ha + 10 kg Zn/ha; T₈: 40 kg K/ha + 15 kg Zn/ha; T₉: 40 kg K/ha + 20 kg Zn/ha; T₁₀: 40 kg K/ha + 25 kg Zn/ha; T₁₁: 50 kg K/ha + 5 kg Zn/ha; T₁₂: 50 kg K/ha + 10 kg Zn/ha; T₁₃: 50 kg K/ha + 15 kg Zn/ha; T₁₄: 50 kg K/ha + 20 kg Zn/ha; T₁₅: 50 kg K/ha + 25 kg Zn/ha; T₁₆: 100% RDF

5. Conclusion

The study comes to the conclusion that applying 50 kg K/ha + 15 kg Zn/ha together greatly improved mustard yield attributes and growth metrics. Better nutrition absorption, increased physiological activity, and effective assimilate translocation were the causes of this improvement. Therefore, this therapy can be suggested to improve crop output and growth characteristics.

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