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ALLOMETRIC PARAMETERS ASSESSMENT IN CANOLA UNDER DIFFERENT MACRO AND MICRONUTRIENT REGIMES

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Abstract

Nutrient management strategies are an excellent resource for optimizing canola production in Pakistan's arid and semi-arid regions. The current study was conducted to investigate the effect of nitrogen (N), phosphorus (P), zinc (Zn), and boron (B) on canola genotypes and determine optimal fertilizer levels. The two-season field experiment was conducted in a randomized complete block design (RCBD) with two promising canola genotypes (R00-125/14 and W97-75/16) and parents (Rainbow and Westar) under different combinations of N, P, B, and Zn. The results evinced that the varietal and fertilizer treatments produced significant differences regarding yield and yield contributing traits. In the case of the interactive effect of varieties and fertilizer treatments, R00-125/14 produced the maximum seed yield of 3377.7 kg ha^{-1} under the treatment N_{90}-P_{45}-Zn_{06}-$B_{1.0}$. The second-highest seed yield (3083.3 kg ha^{-1}) was recorded in the same variety under N_{90}-P_{45}-Zn_{03}-$B_{1.5}$. The minimum seed yield (1471.4 kg ha^{-1}) was obtained in W97-75/16 under N_{90}-P_{45}-Zn_{09}-$B_{1.5}$. The overall performance of the genotypes for yield and yield components indicated that all the characteristics significantly varied in mutants as well as the parent material under different treatments. The results of the study indicated that optimal fertilizer application can help enhance canola yield in Pakistan.

Key words: Canola, Chemical fertilizer, Nitrogen, Phosphorus, Zinc, Boron, Genotypes.

Introduction

Pakistan is dealing with edible oil shortage and imports a large amount of edible oil from other countries every year. There are numerous opportunities to improve canola production, thereby reducing the gap between consumption and edible oil production (Hu *et al*., 2017). Local oil production accounts for only 29% of total oil consumption. The remaining 71% of oil is imported from different countries to fulfill the national requirement (Anon., 2020). Pakistan also faces the issue of low canola yields due to ineffective macro and micronutrients management. Thus, nutrient management strategies are valuable for optimizing canola production in the country's arid and semi-arid regions (Selim, 2020). The overall crop yields are significantly influenced by the effective and balanced fertilizer application during the growing season.

Balanced fertilizer application influences crop yield and quality and helps sustain soil productivity (Bindraban *et al.*, 2015). The chemical fertilizers (N, P, Zn, and B) influence the biochemical, physiological, and morphological mechanisms of the canola plant (Hosseini *et al.*, 2007). Nitrogen significantly influences the yield and growth parameters, including pods per plant, flowering potential, and seed yield. On the other hand, phosphorus enhances the seed size and oil content percentage in canola (Razaq *et al.*, 2017). It is also an essential part of DNA and RNA (Sharma *et al.*, 2012; Razaq *et al.*, 2017). The micro fertilizer zinc is an integral part of auxin synthesis, which enhances stem length and is involved in growth regulation. It is also required for carbohydrate synthesis, starch-to-sugar conversion, and chlorophyll synthesis in plants (Wissuwa *et al.*, 2006). Boron is also involved in various functions in plants, including cell wall formation, energy and sugar movement from source to sink, biological membrane integrity, pollination, and seed formation (Shireen *et al.*, 2018). Thus, canola production is severely influenced by macro and micronutrients.

N, P, Zn, and B fertilizers significantly impact canola yield, yield components, and physiological indices such as plant height, branch number, pod per plant, days to maturity, and seed yield per hectare. In this context, the current study was conducted to investigate the effect of N, P, B, and Zn on canola genotypes and determine optimal fertilizer levels.

Materials and Methods

Experiment site and cultivation conditions: Two seasons field experiment was conducted at the Experimental Farm of Nuclear Institute of Agriculture, Tandojam, Pakistan, during 2016-17 and 2017-18.

Experimental design, plant material, and treatments: The experiment was laid out in randomized complete block design (RCBD) with three replications to find out the effect of different chemical fertilizers (N, P, Zn, and B) on two canola mutants (R00-125/14 and W97-75/16) and their parents (Rainbow and Westar). The recommended dose of $N_{90}P_{45}$ kg ha^{-1} was applied through the broadcasting method while the three concentrations of zinc (3, 6, 9 kg ha^{-1}) and boron (0.5, 1.0, and 1.5 kg ha^{-1}) were applied via foliar application.

Observations: Ten plants were randomly selected from each treatment to collect data for height. Similarly, days to maturity were also recorded. The 1000 seed weight was measured by randomly collecting and weighing seed samples from each plot, and seed yield (kg ha^{-1}) was determined by harvesting central five rows from each plot, followed by drying and weighing.

Statistical analysis

The data of the abovementioned traits were subjected to analysis under RCBD design using Statistix software version 8 (Analytical Software, 2005). The level of significance among the different combinations and traits was evaluated via the LSD (Least significant difference) test (Gomez and Gomez, 1984).

Results and Discussions

Seed yield and yield-related parameters: The seed yield of canola was significantly influenced by interactions of the macro (N and P) and micro (Zn and B) fertilizers and canola cultivars.

Days to maturity: On average (varietal mean), the early days to maturity were recorded in genotype W97-75/16 (126.35 days) followed by R00-125/14 (127.37 days) and Rainbow (127.75 days). On contrary, late days to maturity were observed in Westar (128.25 days: Table 1). The mean results of different chemical fertilizer applications showed that early days to maturity (120.37 and 120.54 days) were observed under the treatment N_{90}-P_{45}-Zn_{03}-$B_{1.0}$ and N_{90}-P_{45}-Zn_{00}-B_{00}, respectively. In comparison, late maturity was recorded (137.83 days) in the case of N_{00}-P_{00}-Zn_{00}-B_{00}.

The interaction of genotypes and chemical fertilizers showed that early days to maturity (118.33 and 118.83 days) were observed under N_{90}-P_{45}-Zn_{03}-$B_{1.0}$ and N_{90}-P_{45}-Zn_{03}-B_{00} in genotypes R00-125/14 and Rainbow, respectively. On the other hand, the late days to maturity (142.83 days and 140.50) were recorded in genotypes R00-125/14 and Rainbow (parent) under N_{00}-P_{00}-Zn_{00}-B_{00} and N_{90}-P_{45}-Zn_{03}-$B_{1.5}$, respectively. Early days to maturity in canola facilitate the completion of seed development. The outcomes of the study were in agreement with the previous findings of Kutcher *et al*., (2005), who found that the parameter of days to maturity was influenced by the time and rate of fertilizer application. They also reported that chemical fertilizers influence the morpho-physiological and yield attributes of canola plants.

Plant height: On average (varietal mean), the maximum plant height was observed (135.92 cm) in Westar, followed by W97-75/16 (130.78) and Rainbow (Parent) (130.09) genotypes. Contrarily, the lowest plant height (122.94 cm) was recorded in genotype R00-125/14 (Table 2). The mean results of different chemical fertilizers indicated that maximum plant height (173.48 cm) was produced under N_{90}-P_{45}-Zn_{06}-$B_{1.0}$ followed by N_{90}-P_{45}-Zn_{09}-$B_{.1.0}$ (163.18 cm). The minimum (average) plant height was 119.08 and 119.60 cm under N_{00}-P_{00}-Zn_{00}-B_{00} and N_{90}-P_{45}-Zn_{00}-B_{00} treatments, respectively.

The interactive effect of different chemical fertilizers and varieties showed that maximum plant height was recorded (175.75 cm) with the application of N_{90}-P_{45}-Zn_{06}-$B_{1.0}$ in R00-125/14 followed by 174.12 and 169.65 cm under N_{90}-P_{45}-Zn_{09}-$B_{1.5}$ and N_{90}-P_{45}-Zn_{00}-B_{00} in Westar and Rainbow, respectively, while the minimum plant height (106.90 cm) was recorded under the application of N_{00}-P_{00}-Zn_{00}-B_{00} in R00-125/14. In agreement with our results, Özer (2003) also reported increased plant height due to optimal fertilizer levels.

Table 1. Effect of different chemical fertilizer applications on days to maturity in (*Brassica napus* L.) canola genotypes.

Treatments*N-P-Zn-B (kg ha^{-1})	R00-125/14	W97-75/16	Rainbow (Parent)	Westar (Parent)	Mean
N_{00}-P_{00}-Zn_{00}-B_{00}	142.83 a	132.00 g-k	121.67 xy	121.00 v-a	137.83 a
N_{90}-P_{45}-Zn_{00}-B_{00}	132.50 f-j	120.67 w-a	119.67 x-a	121.83 t-x	120.54 hi
N_{90}-P_{45}-Zn_{03}-B_{00}	135.50 d-e	120.67 w-a	118.83 z-a	133.67 e-j	121.63 gh
N_{90}-P_{45}-Zn_{06}-B_{00}	121.00 v-a	121.83 t-x	128.00 l-m	119.00 z-a	122.75 fg
N_{90}-P_{45}-Zn_{09}-B_{00}	121.67 t-y	121.17 u-z	121.50 t-y	132.83 f-j	122.83 fg
N_{90}-P_{45}-Zn_{00}-$B_{0.5}$	123.67 p-t	122.33 s-w	121.67 t-y	123.83 o-t	123.00 f
N_{90}-P_{45}-Zn_{00}-$B_{1.0}$	123.83 o-t	122.50 r-w	122.67 q-w	123.83 o-t	123.00 f
N_{90}-P_{45}-Zn_{00}-$B_{1.5}$	124.83 n-r	123.33 p-v	123.33 p-v	126.67 m-n	123.67 ef
N_{90}-P_{45}-Zn_{03}-$B_{0.5}$	125.33 n-p	124.67 n-s	123.67 p-t	126.17 m-o	124.79 de
N_{90}-P_{45}-Zn_{06}-$B_{0.5}$	125.00 n-q	125.17 n-p	124.33 n-s	121.67 t-y	125.13 d
N_{90}-P_{45}-Zn_{09}-$B_{0.5}$	125.33 n-p	131.50 j-k	139.50 b-c	123.50 p-u	133.63 b
N_{90}-P_{45}-Zn_{03}-$B_{1.0}$	118.33 z-a	119.83 z-a	133.33 e-j	134.17 e-h	120.37 i
N_{90}-P_{45}-Zn_{06}-$B_{1.0}$	119.33 a-c	134.17 e-h	134. 83 d-f	132.17 g-k	137.17 a
N_{90}-P_{45}-Zn_{09}-$B_{1.0}$	134.83 d-f	133.50 e-j	134.00 e-i	130.00 k-l	131.71 c
N_{90}-P_{45}-Zn_{03}-$B_{1.5}$	128.33 l-m	131.67 i-k	140.50 a-b	134.33 e-g	132.42 bc
N_{90}-P_{45}-Zn_{06}-$B_{1.5}$	130.00 k-l	131.83 h-k	133.50 e-j	138.50 b-c	132.42 bc
N_{90}-P_{45}-Zn_{09}-$B_{1.5}$	131.50 j-k	132.17 g-k	133.83 e-j	137.17 c-d	133.50 b
Mean	127.37 b	126.35 c	127.75 ab	128.25 a	

*Nitrogen (N), Phosphorus (P), Zinc (Zn), Boron (B)

Table 2. Effect of different chemical fertilizer applications on plant height (cm) in canola (*Brassica napus* L.) genotypes.

Treatments*N-P-Zn-B (kg ha^{-1})	R00-125/14	W97-75/16	Rainbow (Parent)	Westar (Parent)	Mean
N_{00}-P_{00}-Zn_{00}-B_{00}	106.90 y	125.72 k-s	109.92 w-y	141.65 f-g	119.08 f
N_{90}-P_{45}-Zn_{00}-B_{00}	160.93 b-d	167.17 a-c	169.65 a-b	143.15 e-g	119.60 ef
N_{90}-P_{45}-Zn_{03}-B_{00}	117.27 p-x	151.92 d-e	126.57 i-p	123.98 k-s	120.33 ef
N_{90}-P_{45}-Zn_{06}-B_{00}	113.50 u-y	125.45 j-q	123.87 k-s	131.88 h-k	120.96 d-f
N_{90}-P_{45}-Zn_{09}-B_{00}	166.38 a-c	122.55 k-u	129.92 h-l	130.33 h-l	121.93 d-f
N_{90}-P_{45}-Zn_{00}-$B_{0.5}$	111.85 v-y	124.08 k-s	129.75 h-m	130.78 h-k	123.22 d-f
N_{90}-P_{45}-Zn_{00}-$B_{1.0}$	115.23 s-y	119.50 n-v	147.67 e-f	118.62 n-w	123.37 d-f
N_{90}-P_{45}-Zn_{00}-$B_{1.5}$	112.85 v-y	133.93 g-j	127.13 h-o	127.83 h-n	123.56 d-f
N_{90}-P_{45}-Zn_{03}-$B_{0.5}$	115.90 q-y	136.07 g-i	123.23 k-t	120.32 m-v	123.89 de
N_{90}-P_{45}-Zn_{06}-$B_{0.5}$	118.83 n-w	129.88 h-l	129.45 h-m	122.95 k-u	124.07 de
N_{90}-P_{45}-Zn_{09}-$B_{0.5}$	117.18 p-x	124.08 k-s	124.43 j-s	136.28 g-h	124.12 de
N_{90}-P_{45}-Zn_{03}-$B_{1.0}$	113.95 t-y	126.70 i-p	122.62 k-u	131.45 h-k	153.20 c
N_{90}-P_{45}-Zn_{06}-$B_{1.0}$	175.75 a	115.68 r-y	114.20 t-y	128.12 h-n	173.48 a
N_{90}-P_{45}-Zn_{09}-$B_{1.0}$	108.20 x-y	118.00 o-w	158.82 c-d	136.58 g-h	163.18 b
N_{90}-P_{45}-Zn_{03}-$B_{1.5}$	116.53 q-x	116.20 q-y	120.95 l- v	152.28 d-e	124.14d e
N_{90}-P_{45}-Zn_{06}-$B_{1.5}$	111.45 v-y	116.73 q-x	125.03 j-r	160.33 b-d	125.28 d
N_{90}-P_{45}-Zn_{09}-$B_{1.5}$	112.57 v-y	119.65 n-v	124.28 k-s	174.12 a	125.45 d
Mean	122.94 c	130.78 b	130.09 b	135.92 a	

*Nitrogen (N), Phosphorus (P), Zinc (Zn), Boron (B)

Table 3. Effect of different chemical fertilizer applications on 1000 seed weight (g) in canola (*Brassica napus* L.) genotypes.

Treatments*N-P-Zn-B (kg ha^{-1})	R00-125/14	W97-75/16	Rainbow (Parent)	Westar (Parent)	Mean
N_{00}-P_{00}-Zn_{00}-B_{00}	2.99 i	3.74 gh	2.57 j	4.30 z-d	3.27 h
N_{90}-P_{45}-Zn_{00}-B_{00}	3.60 h	3.19 i	3.93 fg	4.80 l-r	3.83 g
N_{90}-P_{45}-Zn_{03}-B_{00}	3.63 h	4.04 e f	3.59 h	4.87 i-p	4.17 f
N_{90}-P_{45}-Zn_{06}-B_{00}	4.16 c-f	4.33 y-d	4.01 ef	4.75 m-s	4.17 f
N_{90}-P_{45}-Zn_{09}-B_{00}	4.46 u-z	4.73 n-t	4.40 x-c	5.08 d-j	4.42 e
N_{90}-P_{45}-Zn_{00}-$B_{0.5}$	4.13 def	4.73 n-t	4.66 p-v	4.95 h-n	4.46 e
N_{90}-P_{45}-Zn_{00}-$B_{1.0}$	4.44 w-a	4.81 k-q	4.58 q-x	5.26 b-e	4.69 d
N_{90}-P_{45}-Zn_{00}-$B_{1.5}$	4.52 s-z	4.84 j-p	5.10 d-i	5.39 ab	4.70 d
N_{90}-P_{45}-Zn_{03}-$B_{0.5}$	4.74 n-t	4.84 j-p	4.99 f-m	5.06 e-k	4.74 d
N_{90}-P_{45}-Zn_{06}-$B_{0.5}$	4.99 f-m	4.91 h-o	5.38 ab	4.77 m-r	4.77 d
N_{90}-P_{45}-Zn_{09}-$B_{0.5}$	4.96 g-n	5.23 b-f	5.41 ab	4.41 w-b	4.94 c
N_{90}-P_{45}-Zn_{03}-$B_{1.0}$	5.05 e-k	5.24 b-e	5.13 c-h	4.56 r-y	5.17 a
N_{90}-P_{45}-Zn_{06}-$B_{1.0}$	5.58 a	5.11 d-i	5.36 a-c	4.49 t-z	5.08 ab
N_{90}-P_{45}-Zn_{09}-$B_{1.0}$	5.05 e-k	5.20 b-g	4.73 n-t	4.21 a-e	5.13 a
N_{90}-P_{45}-Zn_{03}-$B_{1.5}$	4.69 o-u	5.22 b-f	4.99 f-m	4.37 x-d	4.96 bc
N_{90}-P_{45}-Zn_{06}-$B_{1.5}$	4.75 m-s	5.30 b-d	4.65 p-w	4.17 b-e	4.97 bc
N_{90}-P_{45}-Zn_{09}-$B_{1.5}$	4.87 i-p	5.04 e-l	4.35 x-d	3.21 i	5.08 bc
Mean	4.51 c	4.74 a	4.67 b	4.53 c	

*Nitrogen (N), Phosphorus (P), Zinc (Zn), Boron (B)

Table 4. Effect of different chemical fertilizer applications on seed yield (kg ha^{-1}) in canola (*Brassica napus* L.) genotypes.

Treatments*N-P-Zn-B (kg ha^{-1})	R00-125/14	W97-75/16	Rainbow (Parent)	Westar (Parent)	Mean
N_{00}-P_{00}-Zn_{00}-B_{00}	2540.7 e-m	2140.7 p-y	2387.0 j-t	2066.6 t-y	2283.8 ef
N_{90}-P_{45}-Zn_{00}-B_{00}	2929.6 b-d	2316.2 j-u	2125.9 p-y	2187.0 l-y	2389.7 b-e
N_{90}-P_{45}-Zn_{03}-B_{00}	2468.5 f-p	2322.2 j-u	2124.0 p-y	2262.9 k-w	2294.4 d-f
N_{90}-P_{45}-Zn_{06}-B_{00}	2638.9 c-j	2640.7 c-j	2010.7 u-y	2061.1 t-y	2337.8 c-e
N_{90}-P_{45}-Zn_{09}-B_{00}	2996.2 bc	2409.2 h-t	2168.5 n-y	2285.2 j-u	2464.8 b-d
N_{90}-P_{45}-Zn_{00}-$B_{0.5}$	2798.1 b-g	2425.9 h-s	2187.2 l-y	2244.4 k-x	2413.9 b-e
N_{90}-P_{45}-Zn_{00}-$B_{1.0}$	2859.6 b-e	2420.3 h-t	2179.6 n-y	2450.0 f-q	2477.4 a-c
N_{90}-P_{45}-Zn_{00}-$B_{1.5}$	3074.0 ab	2401.8 i-t	2190.7 l-y	2207.4 l-y	2468.5 b-d
N_{90}-P_{45}-Zn_{03}-$B_{0.5}$	2544.2 e-l	2950.1 b-d	2122.2 p-y	2985.1 bc	2650.4 a
N_{90}-P_{45}-Zn_{06}-$B_{0.5}$	2809.2 b-f	2598.1 d-k	2181.4 m-y	2094.4 q-y	2420.8 b-e
N_{90}-P_{45}-Zn_{09}-$B_{0.5}$	2451.8 f-q	2088.8 r-y	2946.3 b-d	2159.2 o-y	2411.5 b-e
N_{90}-P_{45}-Zn_{03}-$B_{1.0}$	2755.5 b-i	2183. m-y	2520.3 e-n	2190.7 l-y	2412.4 b-e
N_{90}-P_{45}-Zn_{06}-$B_{1.0}$	3377.7 a	2512.9 e-o	2122.2 p-y	2216.6 l-y	2557.4 ab
N_{90}-P_{45}-Zn_{09}-$B_{1.0}$	2946.2 b-d	2442.5 g-r	2122.2 p-y	1898.1 xy	2352.3 c-e
N_{90}-P_{45}-Zn_{03}-$B_{1.5}$	3083.3 ab	2220.3 l-y	2070.3 s-y	1911.1 w-y	2321.3 c-f
N_{90}-P_{45}-Zn_{06}-$B_{1.5}$	2766.7 b-h	2170.3 n-y	2274.1 k-v	1918.5 v-y	2282.4 ef
N_{90}-P_{45}-Zn_{09}-$B_{1.5}$	2955.8 b-d	1471.4 z	2266.6 k-w	1879.6 y	2143.4 f
Mean	2823.3 a	2336.2 b	2235.2 c	2177.5 c	

*Nitrogen (N), Phosphorus (P), Zinc (Zn), Boron (B)

1000 seed weight: The maximum (varietal) average 1000 seed weight was recorded as 4.74 g in W97-75/16 (Table 3). The mean results of different fertilizer levels showed that the maximum 1000 seed weight (5.17 g) was produced by N_{90}-P_{45}-Zn_{03}-$B_{1.0}$ followed by N_{90}-P_{45}-Zn_{09}-$B_{1.0}$ (5.13 g). The interactive effect of chemical fertilizer and genotypes indicated that the maximum 1000 seed weight (5.58 g) was produced by R00-125/14 under N_{90}-P_{45}-Zn_{06}-$B_{1.0}$ treatment, followed by Westar under the application of N_{90}-P_{45}-Zn_{00}-$B_{1.5}$ (5.39 g). The lowest 1000 seed weight (2.57 g) was produced by Rainbow (parent) under the treatment of N_{00}-P_{00}-Zn_{00}-B_{00}. Shafi *et al.*, (1992) observed that seed weight is controlled by the environment, genetic makeup, and soil fertility—especially soil nitrogen and phosphorus. Similarly, the present findings are also supported by the previous study of Manzoor *et al.*, (2019).

Seed yield: The maximum varietal mean seed yield was produced by mutant R00-125/14 (2823.3 kg ha^{-1}) while the minimum (2177.5 kg ha^{-1}) by Westar (parent; Table 4). The mean results of different applications of chemical fertilizers illustrated that N_{90}-P_{45}-Zn_{03}-$B_{0.5}$ offered the highest average yield of 2650.4 kg ha^{-1}. The interactive effect of chemical fertilizer and genotypes indicated that R00-125/14 produced the maximum seed yield of 3377.7 kg ha^{-1} under the treatment N_{90}-P_{45}-Zn_{06}-$B_{1.0}$. The second-highest seed yield (3083.3 kg ha^{-1}) was recorded by the same variety under N_{90}-P_{45}-Zn_{03}-$B_{1.5}$. The minimum seed yield was obtained in W97-75/16 under N_{90}-P_{45}-Zn_{09}-$B_{1.5}$ (1471.4 kg ha^{-1}). Our findings were parallel to the report of Ahmad *et al.*, (2007), who mentioned that the optimal rate of chemical fertilizers can enhance canola seed yield. Moreover, the present findings are also supported by several previous studies regarding the impact of varietal differences and fertilizer treatments on canola (Tian *et al.*, 2016; Yousaf *et al.*, 2017; Bindraban *et al.*, 2020).

Conclusion

Canola is an emerging and unique oilseed crop due to its low erucic acid and glucosinolate contents. The overall performance of the genotypes for yield and yield components in this study indicated that all the characteristics significantly varied in mutants as well as the parent material under different treatments. The results of the study indicated that optimal fertilizer application N_{90}-P_{45}-Zn_{06}-$B_{1.0}$. can help enhance canola yield in Pakistan.

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