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Corn Growth, Yield and Weed Composition as Influenced by Different Nitrogen Rates and Plant Densities

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ABSTRACT

Sufficient nitrogen application is the main factor in plant growth and yield development processes. Therefore, a field research was conducted during 2020 at Field 15, Faculty of Agriculture, Universiti Putra Malaysia in Serdang, Selangor, to quantify the effect of four nitrogen rates N_1 (120 kg N/ha), N_2 (140 kg N/ha), N_3 (160 kg N/ha) and N_4 (180 kg N/ha) and two planting densities D_1 (75 x 20 cm) and D_2 (65 x 20 cm) on growth and yield attributes of corn variety (GWG 888) and weed composition. The results showed that both factors (nitrogen rates and planting densities) significantly influenced corn growth, yield and weed composition. It was observed that N_3 (160 kg N/ha) produced the maximum plant height, number of leaves, cob number, cob length and dry mater yield. The maximum number of the weed species and weed population were obtained with 180 kg N/ha. Higher plant density (65 x 20 cm) decreased plant height and leaf; however, it significantly enhanced dry matter yield. The findings suggested that the use of 160 kg N/ha was appropriate nitrogen rate at 75 x 20 cm, which improved corn growth and yield.

Key words: Corn, nitrogen rates, plant densities, weeds, growth, yield

INTRODUCTION

Corn (*Zea mays*) is the third major cereal grain crop after wheat and rice. It is used by humans as daily food, as well as livestock feed and raw material for industry (Erenstein *et al*., 2022). Low corn production is due to several limitations, but fertilizer use is regarded as one of the key factors that can increase corn yield per unit area (Wang and Hu, 2021). Moreover, one of the basic issues in corn production is the management of nitrogen (N). The use of nitrogen (N) fertilizers has been successful in increasing plant productivity, agronomic attributes and crop yields (Olaiya *et al*., 2020). In general, the yield of corn grain increases with the addition of N in low fertility soils until the yield reaches the peak, after that N would have no impact or causes reduction in yield (Yue *et al*., 2022).
Agricultural practices along with seed rates, plant density and application of fertilizer are known to influence the environment of the crop, which affects growth and eventually the yield. To ensure adequate growth and yield, optimum plant population and N levels should be retained to utilize full natural resources, including nutrients, sunlight and soil moisture (Pant and Sah, 2020). The use of N by corn allows the use of acceptable sources of sufficient amount at appropriate timing and adequate rates of application. Therefore, the optimum corn yield was estimated by using 140 to 250 kg N/ha. It was observed that, with application of 160 kg N/ha, the highest average leaves area, plant height, weight of 1000-kernels, biological production, grain yield and harvest index (42%) were obtained (Anwar *et al*., 2018). Lamptey *et al.* (2018) reported major impact on the quality of the forage corn when N was applied. Increasing the N application rate increases crude protein, whereas decreasing acid detergent fiber and neutral detergent fiber. Besides, optimum plant population density ensures proper plant growth either in its surface and sub-surface parts, use solar radiation and nutrients differently (Mahdi and Ismail, 2015). Increased

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plant population density is one of the important factors to improve solar radiation capture inside the canopy. Though, the capacity of converting absorbed solar radiation into corn production is reduced with a high plant population density due to joint shading in the plants (Yang *et al.*, 2019).

The corn yield and yield components are greatly influenced by planting practices, plant population and corn hybrids, however, the response of corn hybrids is different from varying planting densities (Fromme *et al.*, 2019). The practices of crop nutrient management can serve as the main part of better weed management programs. Balanced fertilizer encourages crop production, leading in a closing crop stand and light limitations for the underlying weed populations, thus reducing the diversity of weed species (Wickramasinghe *et al.*, 2023). However, corn production is declined due to low soil fertility and lower plant density in some countries such as Afghanistan. Thus, to enhance the growth and yield of corn, it is essential to increase nitrogen rates and plant density. Therefore, the experiment was conducted to ensure whether the current recommended nitrogen rate and plant density for corn plant are enough or need to increase.

MATERIALS AND METHODS

A field experiment was conducted during 2020 at Field 15, Faculty of Agriculture, University Putra Malaysia in Serdang, Selangor to investigate the effect of four nitrogen rates and two planting densities on growth and yield attributes of forage corn variety (GWG 888) and weed composition. The seeds of GWG 888 commercialized by the Green World Genetics Sdn. Bhd. were obtained from Thailand.

The experimental site was ploughed prior to seed sowing. The soil was then rotovated to achieve an adequate size for planting. A total of two seeds were planted per hill. Later seedlings were thinned to a single plant per hill. Each subplot consisted of three rows, separated by 35 cm inter row and 50 cm buffer zone between subplots. Irrigation was immediately given after seed sowing to ensure proper germination and plant stand using drip irrigation system.

The experiment was conducted under four replications in a split-plot design, comprising four nitrogen rates as the subplot and two planting densities as the main plot. Thus, thee total area used for the experiment was 39 x 14.6 m.

Observation on growth parameters was made at middle rows to prevent border effects from nearby plots. The field data were collected at 4, 6, 8, 10 and 12 weeks after planting. Plant height, number of leaves, cob number and cob length of plant were measured using standard ruler and digital balance. At 13 WAP, plants were harvested above ground for nutrients analysis. Plants were dried in the oven until the weight was constant. The dry weight of plants was measured. The concentration of N and P was measured using an auto-analyzer machine Lachat Instrument 8000 series, and the concentration of K was measured by ICE 3000 series atomic absorption spectrometer (AAS) (Nazli *et al.*, 2019).

The weed composition was determined at 12 weeks after sowing using three quadrates in each plot. All weeds present in quadrate were collected, sorted, counted by species and converted to number/m^2.

Analysis of variance (ANOVA) was used to determine the effect of treatment, while treatment means were compared with least significance difference (LSD) at $P<0.05$ using SAS software (9.4 version, SAS Institute Inc., North Carolina 27513, USA).

RESULTS AND DISCUSSION

Nitrogen rates and plant densities significantly influenced the plant height, number of leaves, cob number and cob length (Table 1). N_3 (160 kg N/ha) produced the highest plant height, number of leaves, chlorophyll content, leaf area and cob length followed by N_4 (180 kg N/ha), while the lowest was observed in N_1 (120 kg N/ha). Higher plant growth attributes were observed in lower plant density (75 x 20 cm) compared to higher plant density (65 x 20 cm). In general, corn growth was highest with the application of 160 kg N/ha. It was due to enhanced N fertilizer by producing further protein. This helped to improve plant height and other parameters of growth. The lower plant density D_2 (75 x 20 cm) produced higher plant height and leaf area, but number of leaves, cob number and cob length were not significantly different between both the densities. The reduction of the leaf area in

Table 1. Effect of different nitrogen rates and plant densities on plant height, number of leaves, cob number and cob length

Treatments	Plant height (cm)	No. of Leaves	Cob number	Cob length (cm)
Nitrogen rates				
N_1	190.92b	11.63b	1.13a	18.67c
N_2	192.47b	11.76ab	1.16a	19.37b
N_3	196.93a	11.92a	1.21a	20.37a
N_4	193.78ab	11.73ab	1.18a	20.2b
Density				
D_1	192.32b	11.71a	1.16a	19.52a
D_2	194.78a	11.81a	1.18a	19.77a

Significant difference within columns with same letters at P≥0.05. N_1–120 kg N/ha, N_2–140 kg N/ha, N_3–160 kg N/ha, N_4–180 kg N/ha, D_1–65 x 20 cm, D_2–75 x 20 cm and WAS-Week after sowing.

the plant density might be due to the low availability of carbohydrates as the result of high competition among plants. The results conformed with Sher *et al.* (2018). The DM yield of leaves, stem, cob and total plants were significantly affected by nitrogen rates and plant densities (Table 2). The higher dry mater yield was observed at 65 x 20 cm planting density with the application of 160 kg N/ha, followed by 180 kg N/ha and 140 kg N/ha and the lowest was recorded in 120 kg N/ha. The management of N in corn production is an important consideration as it is the important and fundamental nutrient for the growth and development of plant. This could be attributed to the fact that the accumulation of DM was linked with the leaf area index which enhanced with a higher plant population (Fromme *et al.*, 2019).

Nitrogen rates significantly influenced the N, P and K content of corn plant, while it was not significantly different among both the densities (Table 3). N_3 (160 kg/ha N) produced the highest N, P and K content followed by N_2 and N_4, while N_1 (120 kg/ha N) recorded the lowest N content. This may be because of the sufficient availability of N which resulted in an enhancement of the nutrient in corn tissues. Singh *et al.* (2023) reported that the availability of adequate nutrients, especially N, in soil effectively improved the N content. A strong link between P and N contents was found in corn tissues, which indicated that an adequate N rate influenced the P concentration of corn. Galindo *et al.* (2016) reported that an increased amount of P was attributed to greater accumulation of N in corn production.

Table 3. Main effects of different nitrogen rates and plant density on nitrogen, phosphorus and potassium content (%)

Treatment	N(%)	P(%)	K(%)
Nitrogen rates			
N_1	2.05b	0.38c	2.25c
N_2	2.17ab	0.43b	2.31b
N_3	2.29a	0.46a	2.35a
N_4	2.19a	0.43b	2.32b
Density			
D_1	2.16a	0.42a	2.3a
D_2	2.19a	0.43a	2.31a

Significant difference within columns with same letters at P≥0.05. Treatment details are given in Table 1.

The increase of nitrogen fertilizer increased the weed species and population of the weed species (Table 4). The highest weed population was obtained when 180 kg N/ha was used. As N rates increased it enhanced the number of weed species. Higher soil nitrogen rates improved the growth of many weed species. The application of N fertilizer in crop systems might ultimately have the unintended effect of emerging growth and increasing the weeds' competitive ability more than crops (Berquer *et al.*, 2023). It was concluded from the results that corn production could be significantly

Table 2. Effect of different nitrogen rates and plant densities on leaf, stem, cob and plant dry matter yield (t/ha)

Treatment	Leaf DM yield (t/ha)	Stem DM yield (t/ha)	Cob DM yield (t/ha)	Total DM yield (t/ha)
Nitrogen rates				
N_1	3.22c	6.01c	15.03c	24.27c
N_2	3.5b	6.56b	15.38b	25.45b
N_3	3.75a	6.89a	16.16a	26.8a
N_4	3.54b	6.62b	15.43b	25.6d
Density				
D_1	3.54a	6.57a	15.56a	25.68a
D_2	2.47b	6.46b	15.44b	25.38b

Significant difference within columns with same letters at P≥0.05. Treatment details are given in Table 1.

Table 4. Main effects of different nitrogen rates and plant density on number of weed species and weed population

Treatment	No. of weed species	Weed population
Nitrogen rates		
N_1	14.12c	218.37b
N_2	15bc	227.75b
N_3	15.37b	243.5a
N_4	16.25a	247.25a
Density		
D_1	15.12b	231.93b
D_2	15.25a	236.5a

Significant difference within columns with same letters at P≥0.05. Treatment details are given in Table 1.

increased by adjusting population density (75 x 20 cm) with adequate N application rate (160 kg N/ha).

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