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Effect of different rates of nitrogen fertilizer on growth, seed yield, yield components and quality of canola (*Brassica napus* L.) under arid environment of Saudi Arabia

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Abstract

Canola (*Brassica napus* L.) was planted for two consecutive seasons (2004-05 and 2005-06) in the Arid Land Agricultural Research Station, King Abdul Aziz University at Hada Al-Sham to determine the effect of different rates of nitrogen fertilizer (0, 60, 120 and 180 kg N/ha) on crop growth, seed yield, yield components and seed quality. Nitrogen was applied in three equal splits, 2 weeks, 4 weeks and 8 weeks after planting during each crop season. Randomized complete block design, with four replications was used. Statistical analysis of the obtained data presented that nitrogen at a rate of 180 kg N/ha dominated other N rates of 120, 60, 0 kg N/ha for plant growth, yield and quality parameters except seed oil content that were higher at 120 Kg N/ha level. An overall improvement of 59% in plant height, 112% in number of branches, 111% in number of fruits/plant, 87% in 1000 seed weights and 19% in crude protein content were documented for 180 Kg N/ha. On contrary a reduction of 5% in oil content was recorded by moving from 120 Kg N/ha to 180 Kg N/ha. Current results suggested that N at a rate of 180 Kg/ha can be adopted as best level of nitrogen fertilizer for canola cultivation under arid land conditions of Saudi Arabia.

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Introduction

Plant have to interact with moisture deficit stress under rain fed cropping systems. Arid land conditions are mostly associated with other abiotic stresses i.e. heat, light and salinity along with low soil nutritional and biological capacity. Water crises under arid land conditions is the prime limiting factor for crop production in Saudi Arabia (Al-Suhaibani, 2009). Canola (*Brassica napus* L.) belongs to crucifer group of oil seed crops and considered one of the prime source for edible vegetable oil for human consumption due to its higher quality associated with lower level of saturated fat (40-45%) and protein (36-40%) in the seed (Alberta Agriculture, 1984). Currently it cultivated on an area of 36 million hectares annually with total production of 72 million tons worldwide (FAOSTAT, 2014). Europe, China and Canada are leading producers of rapeseed with higher area under cultivations and production (Commodity Research Bureau, 2005). Other than human consumption, canola is used by different ways depending upon its potential and availability, i.e. potential for biodiesel market (Economic Research Service, 1996).

Leaves and stems of canola at green and dry form are good source of high quality forage due to its low fiber and high protein contents for animals and can be milled into animal feed (Wiedenhoeft & Bharton, 1994). Its seed is enriched with 40% oil content and meal have 35-40% crude protein (Raymer, 2002). Currently canola oil is considered as acceptable alternative to soya bean oil (Muhammad, *et al.,* 2007).

Canola is tolerant to moderate to extreme environmental conditions and can be successfully grown under arid land conditions (Qaderi *et al.,* 2012). Anyhow growth and final dry matter accumulation of canola is significantly affected under dry rain fed cropping systems. To ameliorate this environment stress plant need some support from external sources that may be suitable planting date which favor plant to timely complete its life cycle or nutrients adjustment for better growth and performance (Khaliq *et al.,* 2013).

Nitrogen is one of the most important nutrient elements for crop growth and protein synthesis, cell size, protoplasm, and photosynthetic activity (Yasari & Patwardhan, 2006). When compared to cereals, canola is classified as nutrient exhaustive crop with clearly higher critical nitrogen demand and under arid conditions this demand may enhance depending upon the interaction of severe abiotic and biotic stresses (Rathke *et al.,* 2005). So, choice of fertilizer become critical depending upon its source, rate of application, method of application, time of application and crop growth stage of application. Choosing the correct rate and timing of nitrogen fertilizer application is one of the most important aspects of successful canola growth and yield production in arid systems.

Nitrogen plays essential role in its healthy growth and is one of the main precursors of protein which absorbs in the form of mineral, ammonium or nitrate by canola plant (Hopkins & Hunter, 2004). Jackson (2000) found that canola yield and nutrient uptake are highly dependent on nitrogen fertility and high grain yields occur with 120 to 180 kg N/ha. Canola yield and yield components, the number of pods and flowers per plant, the total plant weight and harvest index in some varieties of canola have been found to improve with higher rates of nitrogen (White *et al.,* 2015). Excess nitrogen rate, higher than optimum/luxurious growth to toxicity however, can reduce grain yield and quality of canola significantly (Öztürk, 2010). Uncontrolled growth along with plant lodging has been noticed repeatedly, when a high rates of nitrogen applications were applied. The highest rates of fertilizer application were found to give significantly higher total dry matter than the lowest rate of fertilizer application (Kumar *et al.,* 1997). Some studies also resulted in lower oil content under higher nitrogen applied rates but an increment in crude protein was attained with increasing levels of nitrogen fertilizers (Rathke *et al.,* 2005), some studies also reported that no significant difference was recorded for oil content under increasing levels of nitrogen fertilizer Brennan *et al.* (2000). El-Nakhlawy and El-Fawal (1991) in Saudi Arabia investigated that canola oil content decreased significantly as nitrogen fertilizer rates increased after the 131 kg N/ha, While in Egypt El-Nakhlawy (1996) found a significant increase as nitrogen rate increased up to 90 kg N/ha. An adequate application of nitrogen fertilizer can enable the plant to produce rapid leaf growth which can significantly contribute in grain filling (Al- Barrak, 2006).

Keeping in view the importance of nitrogen in affecting yield and quality parameters of canola, the present study was conducted to study the effects of nitrogen levels and methods of N application on yield and quality parameters of canola under Arid Environment conditions of Saudi Arabia.

Materials and methods

Experimental site and Treatments

A field experiment was carried out during the two consecutive seasons of 2004-2005 at the Agricultural experimental Research Station of King Abdulaziz University (KAU) located at Hada Al-Sham village, 100 km north east of Jeddah (21^o 48′ 3″ N, 39 ^{o} 43′ 25″ E). The climatic conditions data were collected from the meteorological station located at the experimental site (Table 1). This experiment was carried out in order to investigate effect of different rates of nitrogen fertilizer (0.00, 60, 120 and 180 kg N/ha) on growth, seed yield, yield components and seed quality of canola crop the source of nitrogen was urea fertilizer. The experimental design was randomized completely block design with four replications (Steel and Torrie, 2000). The four nitrogen levels were added in three equal doses; 2 weeks, 4 weeks and 8 weeks after planting. There were 16 plots (3m x 3m), each with 7 rows and spaced 40 cm apart having distances between plant to plant of 20 cm. Seed rate was 5 kg/ha. The experiments were cultivated in soil characterized with 8.03 pH, 1.15 dSm^{-1}, 0.50% organic matter and 0.18% N. Super phosphate and potassium were added to the soil before planting with the rates of 217 kg P_2O_5/ha and 100 kg K_2O/ha, respectively.

Planting time

Planting dates were January 25 and 30 in the two 2004 and 2005, respectively. The characteristics of the soil site at depths of 0-15 and 15-30 cm were 9.7 and 8.03 for the 8.03 pH, 1.15 dSm^{-1} for the electrical conductivity (EC)· 0.501% organic matter and 0.18% N. Sprinkler irrigation system was used in this study. All Other recommended cultural practices were applied to treated and non-treated plots without any distinction.

Statistical analysis

At maturity 4 plants were selected randomly from the central 2 lines from each plot. Then, length of plant, number branches / plant, number of fruit / plant, weight of 1000 seeds, seeds yield / ha, seed oil and protein contents were determined. Oil and protein contents of canola seeds (%) were determined using Soxhlet and Kjeldahl instruments, respectively. A combined statistical analysis (Using SAS 8.1) of variance was conducted for the obtained data of the two seasons after applying the assumptions of analysis of variance.

Without parenthesis: For crop season 2004 ~2005; with parenthesis: for crop season 2005~2006. *T*min: Minimal temperature; *T*max: Maximal temperature; *T*ave: Average temperature. *H*min: Minimal humidity; *H*max: Maximal humidity; *H*ave: Average humidity.

Results and discussion

It is well known that nitrogen fertilizer rate influence canola seed yield and quality (Malhi *et al.,* 2007). This study demonstrates that as nitrogen fertilizer rate increased, yield and its components increased significantly (Elewa *et al.,* 2014). The effects of the four nitrogen fertilizer rates on plant parameters are presented in Table 2. The maximum rate of fertilizer application 180 kg N/ha produced a significantly higher plant height than all other rates. Similar results were reported by Allen and Morgan (1975) in the UK, Kumar *et al.* (1997) in India. This trend was also observed on number of branches per plant.

The highest rates of fertilizer application also gave significantly higher number of fruits/plant than the lowest rate of fertilizer application (Elewa *et al.,* 2014). The previous results could be largely due to the positive effect of nitrogen on the growth development of stem and leaf area, which was reflected into taller plants (Cheema *et al.*, 2001). Consistent with previous reports (Javaheri *et al.,* 2014), the present study indicates that 1000-seed weight was significantly increased with increasing levels of nitrogen fertilizer application. Under 180 kg N/ha, 1000-seed weight mean was the highest value 3.74 g, while the lowest value was 2.00 g which produced under the 0.00 kg N/ha.

Table 1. Average air temperature and humidity at the experimental site during the crop growing season 2004~2005 and 2005~2006.

Month	T_{min} (°C)	T_{max} (°C)	T_{ave} (°C)	H_{min} (%)	H_{max} (%)	H_{ave} (%)
January	10.2 (11.0)	35.9 (34.0)	23.8 (22.5)	28 (22)	98 (99)	59 (60.5)
February	6.3 (10.2)	38.4 (35.1)	22.2 (22.6)	23 (22)	95 (99)	54 (60.5)
March	12.7 (8.1)	39.5 (38.2)	27.0 (23.1)	22(20)	97 (99)	58 (59.5)
April	13.8 (15.2)	42.5 (43.1)	29.8 (29.1)	24 (23)	93 (99)	55 (61.0)
May	18.0 (15.1)	46.2 (48.0)	33.2 (31.5)	29 (24)	86 (99)	55 (61.5)
June	18.0 (20.2)	48.8 (48.0)	33.9 (34.1)	25 (21)	86 (99)	51 (60.0)
July	19.2 (20.3)	48.3 (45.2)	33.6 (32.7)	21 (27)	92 (97)	44 (62.0)
August	19.2 (19.1)	48.3 (47.1)	33.4 (33.1)	21 (30)	92 (99)	49 (64.5)
September	19.2 (20.0	48.3 (47.3)	33.0 (33.6)	21 (25)	100 (99)	61 (62.0)
October	16.7 (19.0)	42.0 (42.1)	29.9 (30.5)	23 (21)	99 (99)	62 (60.0)
November	14.2 (16.1)	26.5 (39.0)	29.2 (27.5)	27 (30)	99 (99)	67 (64.5)
December	15.3 (11.1)	27.0 (35.2)	25.3 (23.1)	22 (27)	99 (98)	64 (62.5)

For seed yield of canola, this study found that increasing in seed yield as result of the higher nitrogen fertilizer application, with maximum yields (2.21 t/ha) being attained under the highest N rate (180 kg N/ha), as shown in Table (2). Similar findings were reported by other authors (Hocking *et al.*, 1997). An adequate application of N fertilizer can enable the crop to produce rapid leaf growth which can positively contribute in grain filling. This is reflected in efficient partitioning of assimilate into economic seed yield. The higher seed yield for the fourth treatment (180 kg N/ha) than for any of the other rates of fertilizer application was largely result from the greater number of fruits per plant (432.80) and seed yield (2.21 t/ha) (Table 2). This trend is supported by the results of previous studies (Al-Barrak, 2006).

Table 2. Means of plant height (cm), no. of branches/plant, no. of fruits/plant, 1000-seed weight (g) and seed yield (t/ha) under the effect of four nitrogen fertilizer rates as average of the 2004 and 2005 seasons.

Nitrogen Rate (kg N/ha)	Means				
	Plant height (cm)	No. of branches / plant	No. of fruits / plant	1000-seed weight (g)	Seed yield (t/ha)
0.00	80.37 d*	3.70 d	204.77 d	2.00 d	0.94 d
60.00	106.28 c	5.38 c	312.12 c	2.84 c	1.41 c
120.00	122.67 b	6.64 b	381.84 b	3.34 b	1.93 b
180.00	127.62 a	7.87 a	432.80 a	3.74 a	2.21 a

*Means followed by the same letter(s) are not significantly different according to LSD at $P < 0.05$.

This study would suggest that protein content under the effects of nitrogen fertilizer rates showed significant increase as nitrogen levels increased (Table 3). The nitrogen rate of 180 kg N/ha produced seeds which had the highest protein content (31.77 %) followed by 120 kg N/ha (28.19%), then 60 kg N/ha (28.24 %) and the lowest protein content was produced under no nitrogen fertilizer (26.52 %). The increase in protein content with the increase in N level confirmed the results of Dubey *et al.* (1994) and Kutcher *et al.* (2005) who reported that protein contents of canola increased with the increasing N levels. The increase in seed protein content of canola with the application of N might be due to the negative correlation between protein content and oil content (Hao *et al.*, 2004) as oil content declined with increase in N rate in this study. Another reason for the negative correlation could be that the carbohydrate content of oils is higher than of protein (Lambers and Poorter, 1992); increased N supply can intensify the synthesis of protein at the expense of fatty acid synthesis, therefore reducing the oil content of the seed (Rathke *et al.*, 2005).

Table 3. Means of oil content (%) and protein content (%) of the studied canola variety as average of the 2004 and 2005 seasons.

Nitrogen rate (Kg N/ha)	Means	
	Oil content (%)	Protein content (%)
0.00	28.97 a*	26.52 c
60.00	31.59 a	28.24 bc
120.00	31.52 a	29.36 ab
180.00	30.04 a	31.77 a

* Means followed by the same letter(s) are not significantly different according to LSD at $P < 0.05$.

For oil content (%), fertilizer application of N did not significantly affect the seed oil content, but light decrease in seed oil content was associated with the highest rate of N. This study revealed that under 60 kg nitrogen rate, oil content was the highest, then significantly decreased under the higher nitrogen rates (Table 3). Similar findings were reported by others (Cheema *et al.,* 2001; Ahmad *et al.,* 2007). However, Brennan *et al.* (2000) found that the oil concentration of canola seed unaffected by N fertilizer rates. This reduction in seed oil percentage with the increase of N fertilizer levels may be due to the dilution effect of increased seed yield with increased N fertilization and the inverse relationship of protein and oil content (Kutcher *et al.,* 2005). Brennan *et al.* (2000) stated that reduction in seed oil might be due to the disturbance of carbohydrates translocation mechanism.

Conclusion

Canola responded positively with increasing levels of nitrogen fertilizer. Crop growth and yield significantly affected by higher amounts of applied fertilizers. Seed quality aspects i.e. crude protein content and oil content represented variable response to each increment in nitrogen fertilizer. At highest applied levels 180 kg/ha seed protein content were highest while a reduction in oil content was apparent. Depending upon the consumer demand it's highly recommended that use 180 Kg/ha N fertilizer for protein consumption otherwise lower rate of N fertilizer are suitable for canola production for oil content, under arid land conditions.

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