SINAI Journal of Applied Sciences 13 (3) 2024 327-342

Available online at www.sinjas.journals.ekb.eg

SCREENED BY iThenticate Professional Plagiarism Prevention

SINAI Journal of Applied Sciences

Print ISSN 2314-6079
Online ISSN 2682-3527

ARU-EGYPT SJAS Trust Science | It Creates

CANOLA (*Brassica napus* L.) YIELD AND QUALITY AS WELL AS WEED COVERLET AS AFFECTED BY NITROGEN FERTILIZER LEVELS. A COMPARATIVE STUDY UNDER SPRINKLER AND DRIP IRRIGATION SYSTEMS

Fares S.M. Gomaa* and E.H.M. Fayed

Agron. Dept. Fac. Agric., Zagazig Univ., Egypt.

ARTICLE INFO

Article history:
Received: 10/04/2024
Revised: 17/05/2024
Accepted: 27/05/2024

Keywords:
Canola, sprinkler irrigation, drip irrigation, nitrogen fertilizer, water consumption, oil yield.

ABSTRACT

In order to sustain canola production as an oil seed crop, two separated filed experiments were performed in the sandy experimental farm, faculty of Agriculture, Zagazig University, Egypt during the two successive winter seasons of 2022/23 and 2023/24. Four nitrogen fertilizer levels (30, 60, 90 and 120 kg N/fad) were experimented, once under sprinkler irrigation system and another under drip irrigation system using Randomized Complete Block Design (RCBD) in three replicates. The study aimed at optimizing the nitrogen dose for maximized yield and quality of canola crop, in addition to comparing between the behavior of canola plants under both the irrigation systems. Results showed significant differences in growth traits, yield components, seed and oil yields as well as weeds distribution due to varied nitrogen levels. 90 and 120 kg N/fad achieved the same level of significance maximizing all traits under study including the highest seed and oil yields, so it is recommended to fertilize canola by 90 kg N/fad. Additionally, drip irrigation showed superiority in all studied traits over sprinkler system recording 8% over seed yield and conserving 16.75% water in both seasons; in addition to the efficacy of drip irrigation in limiting weed coverlet. Thus, it is recommended to grow canola in sandy soil under drip irrigation fertilized by 90 kg N/fad.

Check for updates

INTRODUCTION

Canola (*Brassica napus*), a member of the Brassicaceae family of the double zero type, is an oil seed crop that has gained significant importance in global agriculture due to its high-quality oil and protein content. It is primarily cultivated for its seeds, which are processed to produce canola oil, staple cooking oil known for its health benefits, including low saturated fat content and a favorable omega-3 to omega-6 fatty acid ratio (**Bennouna *et al.*, 2021**). Canola's versatility extends beyond culinary uses; it serves as a vital feedstock for biofuels and contributes to sustainable agricultural practices through crop rotation and soil health improvement.

In Egypt, the demand for edible oils has surged in recent years, leading to an increasing reliance on imports to meet local consumption needs. The country faces a pressing challenge in oil production, with statistics indicating that Egypt imports approximately 60% of its edible oil requirements (**Wally, 2023**). This dependency not only strains the national economy but also highlights the urgent need for domestic production solutions. Given the vast arid regions of Egypt, particularly the Great Desert, there exists substantial potential for

*** Corresponding author: E-mail address:** fares_soliman2010@yahoo.com
https://doi.org/10.21608/sinjas.2024.319762.1290

cultivating crops like canola that can thrive under specific conditions.

Sandy soils, prevalent in many parts of Egypt, present unique challenges for agricultural productivity. Characterized by low nutrient retention and poor water-holding capacity, sandy soils often require careful management strategies to optimize crop yields. However, these soils also offer opportunities for cultivation when appropriate irrigation methods are employed. The implementation of suitable irrigation techniques is crucial for enhancing water efficiency and ensuring adequate moisture levels necessary for canola growth.

Al-Kaisi *et al.* (2017) highlighted that drip irrigation tends to outperform traditional surface irrigation methods by providing a more consistent moisture supply directly to the root zone, thus enhancing crop productivity. **Zhang *et al.* (2019)** emphasized the importance of sprinkler irrigation system which improved water use efficiency (WUE) compared to flood irrigation, leading to better growth parameters and higher seed yields in sandy soils. **Mkhabela *et al.* (2020)** examined how different irrigation strategies affect soil moisture dynamics in sandy soils planted with canola and indicated that regulated deficit irrigation (RDI) not only conserves water but also maintains adequate soil moisture levels necessary for optimal canola development during critical growth stages. **Karam *et al.* (2021)** reported that varying irrigation methods influence nutrient uptake in canola crops grown on sandy soil, and they observed that localized irrigation techniques facilitated better nutrient availability and uptake due to reduced leaching losses compared to conventional furrow or basin methods. **Liu *et al.* (2022)** reported that optimized irrigation schedules not only enhance yield but also improve oil quality parameters such as fatty acid composition and total oil content. A comprehensive economic analysis presented by **Hossain *et al.* (2023)** assesses the cost-effectiveness of various irrigation methods for canola cultivation in sandy regions and concluded that while initial investments may be higher for advanced systems like drip or sprinkler irrigation, long-term benefits include increased yields and reduced water usage costs. Lastly, **Smith and Jones (2023)** argued that adopting modern irrigation technologies helps mitigate risks associated with drought conditions, thereby securing food production.

The application of nitrogen (N) fertilizers is a critical agronomic practice that significantly influences the growth, yield, and quality of canola (*Brassica napus* L.), particularly when cultivated in sandy soils. Sandy soils are characterized by their low nutrient-holding capacity and rapid drainage, which can lead to nutrient leaching and reduced availability for crops.

Hocking *et al.* (1997) found that increasing nitrogen level to 150 kg N/ha dsignificantly enhanced seed yield and oil content up to a certain threshold, beyond which no further benefits were observed. **Kniuipytė *et al.* (2023)** highlighted that sandy soils often require higher nitrogen inputs due to their lower organic matter content and faster mineralization rates, which necessitate careful management of fertilizer applications to prevent leaching losses. **Smith *et al.* (2018)** recommend using precision agriculture techniques to optimize fertilizer use efficiency while maintaining high yields. **Gholamhoseini *et al.* (2019)** assured that continuous high-nitrogen inputs could lead to soil acidification and degradation over time, highlighting the need for integrated nutrient management practices. **Zhuo *et al.* (2024)** concluded that while higher nitrogen levels up to 200 kg/ha could lead to increased yields, they also resulted in diminishing returns at elevated rates, suggesting that farmers should adopt a more strategic approach based on soil testing and crop requirements. Additionally, **Zhuo *et al.* (2024)**focused on the physiological responses of canola plants to varying nitrogen levels under sandy soil conditions and illustrated that adequate nitrogen supply improved photosynthetic efficiency and biomass accumulation, leading to better overall plant health and resilience against environmental stresses. Finally, **Sitthaphanit *et al.* (2022)** advocated for split applications of fertilizers based on crop growth stages and recommended incorporating cover crops or organic amendments to enhance soil fertility sustainably.

The aim of this research paper is to investigate the effects of various nitrogen fertilizer levels on canola cultivation in sandy soil environments. As well, studying the response of canola plants to different irrigation methods and by exploring these relationships, this study seeks to provide insights into effective agricultural practices that could enhance local oil seed production while addressing sustainability concerns within Egypt's agricultural sector.

MATERIALS AND METHODS

Experimental Field Location

Two separated field experiments were carried out during the two successive winter seasons of 2022/23 and 2023/24 in the experimental farm of the Faculty of Agriculture, Zagazig University, Egypt, which is located in El-Khattara region, Sharqia Governorate, Egypt (30°39'54.2"N 31°53'05.2"E).

Study Treatments and Experimental Layout

The two experiments aimed at investigate the influence of four nitrogen fertilizer levels (30, 60, 90 and 120 kg N/fad) on growth, yield and quality of canola crop (*Brassica napus*) in addition to weed coverlet response to treatments. Each experiment was designed as a randomized complete block design (RCBD) with three replications and the experimental unit was 8 m^2 (2 ×4 m) containing 4 rows with 4 m long.

The first experiment

Utilized a sprinkler irrigation system, and irrigation schedule was based on the flowing rate per hour (37m^3/fad/hour) and soil moisture content before irrigation. Basing on the number of irrigations given to canola (40 and 42 in the 1st and 2nd season, respectively) staying 2 hours/ irrigation, hence, the total water consumptive use was amounted to 2960 m^3 and 3108 m^3 in the 1st and 2nd seasons, respectively.

The second experiment

Drip irrigation system was employed at a rate of one hour per irrigation. The dripper flow was 2.2 L/hour, upon the pressure of the irrigation machine in the farm, giving a total flow/faddan/ irrigation amounted to 61.6 m^3. While the total number of irrigations/season was 40 and 42 in the 1st and 2nd seasons, respectively; hence, the total consumptive use was amounted to 2464 m^3 and 2587.2 m^3 in the 1st and 2nd seasons, respectively (fig 1).

Soil Sampling and Analyses

During soil preparation, soil samples from the upper 30 cm depth were taken to assess both physical and chemical properties of the experimental site soil which were as follows: 88.2% sand, 4.4% silt, 7.4% clay, pH 7.4, 0.5 % organic matter, EC 0.7 ds/m, available N 25 ppm, available P 10.2 ppm and available K_2O 100 ppm. Soil parameters were valued as described by **Jackson (1958)** as well as **Lindsay and Norvell (1978)**.

Seeds Source and Sowing

Canola seeds (Serw 4 cv.) were obtained from the Agricultural Research Center (ARC), Giza, Egypt. The two experiments were sown on Nov. 15th in both seasons by hand drilling the small seeds of canola in longitudinal grooves represent the rows which were 50 cm apart. Seeding rate was 3 kg/fad (faddan, 2400 m^2) as recommended in the sandy soil achieving a plant density of 150.000 plant/fad.

Agricultural Practices

All agricultural practices for canola crop tillage were done as recommended in the same way under both experiment conditions. Weed control was performed trice by hand uprooting. Phosphorus fertilizer as mono calcium superphosphate (15.5% P_2O_5) was supplied at 100 kg fertilizer. Potassium fertilizer as potassium sulfate (48% K_2O) was added during soil preparation at a level of 48 kg/ fad., while nitrogenous fertilizer was fertigated as Urea (46%) in five equal doses according to nitrogen levels under study. Plants were manually harvested 165 DAS.

Data Sampling and Collection

At harvest, a sample of 10 plants was taken randomly from the inner rows of each plot from the two experiments to assess plant height (cm), biological yield (ton/ fad./), No. of racemes/ plant, No. of siliquae (pods, metaphorically)/plant, seeds weight/ plant as well as seed yield/fad. A sample of seeds was taken to evaluate seed index (1000 seed weight) and to analyze oil content as well as crude protein content as described in the methodology of **AOAC (1990)**. Moreover, an area of 1 m^2 was determined to count No. of weeds. The weeds collected were counted then air dried till a certain point before oven drying at 105°c and weighted to get weeds dry weight (g). Harvest index (%) was calculated as the seed yield (kg) divided into the biological yield (kg). Nitrogen uptake and agronomic nitrogen use efficiency (NUE) as the proportion of total nitrogen uptake and the total applied nitrogen (kg kg-1) were calculated according to **Fageria (1992).** Additionally, water use efficiency as kg seed/m^3 water consumed was evaluated.

Data Analyses

Data collected from each plot were subjected to the analysis of variance (ANOVA) of RCBD design according to **Gomez and Gomez (1984)** using COSTAT -Statistics Software 6.400 package as described by **Cardinali and Nason (2013)**, available at https://cran.r-project.org/ web/ packages /costat/citation.html. Means were compared using LSD **(Waller and Duncan, 1969)**.

RESULTS AND DISCUSSION

The First Experiment (Nitrogen Fertilizer Levels under Sprinkler Irrigation system)

Plant growth

Results presented in Table 1 show significant differences among canola plants due to N levels variation, in height and No. of racemes/plant in both seasons; however No. of days to 50% flowering were not affected significantly. 120 kg N/fad (N_4) resulted in the tallest plants (143.62 cm and 153.82 cm) in the 1st and the 2nd seasons, respectively, carrying the highest No. of racemes in the 1st and the 2nd seasons too (9.29 and 8.59). In the 2nd season, 90 kg N fad (N_3) reached the same level of significance as N_4 achieving plant height of 149.87 cm carrying 8.43 racemes/ plant. N_2 and N_3 (60 and 90 kg N/fad) ranked 2nd affecting plant height in both seasons and No. of racemes/plant in the 1st season. 30 kg N/fad (N_1) recorded the shortest plants in the 1st season, however in the 2nd season, N_1 and N_2 did not differ significantly. Results assure the important role of nitrogen as a growth stimulator leading to taller plants and a higher number of racemes formed/plant; and these results were in the same line with results reported by **Sible *et al.* (2021)**.

Yield components, seed and biological yields as well as Harvest index

Results displayed in Tables 2 and 3 indicate that there were significant differences among canola plants in all yield components (No. of siliquae/plant, seed index and seed weight/plant) as well as seed and biological yields/fad and consequently, harvest index due to varied nitrogen levels.

Table 1. Plant height, No. of racemes and days to 50% flowering of canola as affected by nitrogen fertilizer levels

	Plant height (cm)		No. of racemes/ plant		Days to 50% flowering	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad)	125.05 c	135.86 c	7.04 c	7.34 b	80.07	82.19
N_2 (60 kg N/fad)	135.35 b	147.59 b	7.96 b	7.55 b	80.07	80.91
N_3 (90 kg N/fad)	138.52 b	149.78 ab	8.26 b	8.34 a	81.68	83.44
N_4 (120 kg N/fad)	143.62 a	153.82 a	9.29 a	8.59 a	79.49	81.91
F. test	*	*	*	*	NS	NS

* Significant at 5% and NS indicate not significant. Alphabets express the order of significance.

Application whichever 90 and 120 kg N/fad., (N_3 and N_4) recorded at par and the highest value for each of No. of siliquae/ plant, seed index and seed weight/plant in both seasons, however N_2 (60 kg N/fad.) reached the same level of significance as N_3 and N_4 recording the highest No. of siliquae/plant as well as individual plant seed weight in the 2nd season. N_2 (60 kg N/fad) ranked 2nd in No. of siliquae/plant and seed weight/plant in the 1st season; and also ranked 2nd in seed index in both seasons. 30 Kg N/fad., (N_1) resulted in the lowest yield components in both seasons.

Seed yield (kg/fad.) was the highest while supplying 90 kg N/fad., (N_3) in both experimenting seasons, however N_4 (120 kg N/fad.) gave the same significant results in the 2nd season. 120 kg N/fad., (N_4) ranked 2nd producing 1418 kg seed yield/fad in the 1st season, while in the 2nd season, 60 kg N/fad., (N_2) ranked 2nd producing 1325 kg seeds/ fad.

Biological yield (ton/fad) was the most superior while adding 120 kg N/fad., (N_4) in the 1st and the 2nd seasons recording 5.18 and 5.69 ton, respectively; followed by lower levels of nitrogen in order (N_3, N_2 and N_1) *i.e.* 90, 60 and 30 kg/fad. The lowest level of nitrogen (30 kg N/fad, N_1) produced the lowest seed and biological yields in both seasons.

The values of harvest index (HI) as a physiological parameter expresses the efficiency of vegetative growth in contributing in the final yield, were the highest while applying 90 kg N/fad., (N_3) amounting to 30.53% and 27.09%, in the 1st and the 2nd seasons, orderly. In the 1st season, N_1 (30 kg N/fad.) and N_2 (60 kg N/fad) ranked 2nd with at par values of HI; while in the 2nd season, N_4 (120 kg N/fad) ranked 2nd achieving 25.23% HI followed by N_2 (60 kg N/fad) which achieved 24.63% HI. These results are align with what was reported by **Castiglione *et al*. (2021)**.

Seed oil content (%) and oil yield (kg/ fad.)

Results displayed in Table 4 indicate that canola seed oil content (%) was affected significantly by varied N levels in the 1st season, however in the 2nd season it didn't differ significantly. N_1, N_2 and N_3 recorded same significant higher seed oil content in the 1st season by 46.1, 45.9 and 45.7%, followed by N_4 which produced the lowest oil content (44.5%). In the 2nd season, oil content did not differ significantly due to N levels variation.

Table 2. No. of siliquas/plant, seed index and seed yield (g/plant) of canola as affected by nitrogen fertilizer levels

	No. of siliquae/plant (pods)		Seed index (1000 seed wt.)		Seed weight (g/plant)	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad)	141.05 c	167.16 b	2.99 c	3.16 c	8.46 c	10.03 b
N_2 (60 kg N/fad)	161.12 b	194.97 a	3.16 b	3.33 b	9.67 b	11.70 a
N_3 (90 kg N/fad)	190.42 a	193.52 a	3.41 a	3.57 a	11.43 a	11.61a
N_4 (120 kg N/fad)	186.77 a	204.51 a	3.50 a	3.68 a	11.21 a	12.27 a
F. test	*	*	*	*	*	*

* Significant at 5% and NS indicate not significant. Alphabets express the order of significance.

Table 3. Seed yield (kg/fad), biological yield (ton/fad) and harvest index (%) of canola as affected by nitrogen fertilizer levels

	Seed yield (kg/fad.)		Biological yield (ton/fad.)		Harvest index (%)	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad.)	1222 d	1199 c	4.25 d	4.79 c	28.73 b	25.02 b
N_2 (60 kg N/fad.)	1364 c	1325 b	4.77 c	5.38 b	28.61 b	24.63 c
N_3 (90 kg N/fad.)	1504 a	1487 a	4.93 b	5.49 b	30.53 a	27.09 a
N_4 (120 kg N/fad.)	1418 b	1436 a	5.18 a	5.69 a	27.37 c	25.23 b
F. test	*	*	*	*	*	*

* Significant at 5% and NS indicate not significant. Alphabets express the order of significance.

Table 4. Oil percentage (%) and oil yield (kg/fad) of canola as affected by nitrogen fertilizer levels

	Oil percentage		Oil yield (kg/fad.)	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad.)	46.1 a	44.9 a	563.34 c	538.35 d
N_2 (60 kg N/fad.)	45.9 a	44.7 a	626.08 b	592.28 c
N_3 (90 kg N/fad.)	45.7 a	44.5 ab	687.33 a	661.72 a
N_4 (120 kg N/fad.)	44.5 b	44.3 b	631.01 b	636.15 b
F. test	*	NS	*	*

* Significant at 5% and NS indicate not significant. Alphabets express the order of significance.

Oil yield in both seasons was significantly different due to N levels variation in favor of N_3 (90 kg N/fad.) which produced the highest oil yield in the 1st and the 2nd seasons (687.33 and 661.72 kg/fad., respectively). N_4 (120 kg N/fad.) ranked 2nd producing 631.01 and 636.15 kg oil/fad., in the 1st and 2nd seasons, respectively. In the 1st season, N_2 (60 kg N/fad.) was as significant as N_4 producing 626.08. The lowest oil yield was recorded due to supplying 30 kg N/fad. (N_1).

There is an inverse relationship between the percentage of oil in the seeds and the oil yield per acre. This is due to the seed yield taking an opposite direction to the percentage of oil due to the different nitrogen treatments (Table 3).

Protein content (%), nitrogen uptake (NU), nitrogen use efficiency (NUE) and water use efficiency (WUE)

Results presented in Table 5 indicate that the highest protein contents recorded in both seasons (24% and 24.3%) were in favor of supplying 120 kg N/fad., while 90 kg N/fad., ranked second recording 23.5% and 23.8% protein content in the 1st and the 2nd seasons, respectively. 60 kg N/fad., recorded the lowest protein contents in both seasons. These results affirm the fact that the more nitrogen supplied to canola plants, the more protein is assimilated due to the role of nitrogen in composing amino acids which are the building blocks of all proteins.

N uptake which refers to the ability of canola plants to assimilate nitrogen in produced seeds was found to be higher due to higher levels of nitrogen supplied. The highest significant N uptake value was found due to supplying whichever 90 or 120 kg N/fad., in both seasons. Supplying 60 kg N/fad., ranked second in both seasons, while 30 kg N/fad., achieved the lowest N uptake in both seasons. In the contrary, NUE values were found to be in negative correlation with N uptake, wherein the lowest level of nitrogen supplied (30 kg N/fad.) recorded the highest nitrogen use efficiency in the 1st and the 2nd seasons (0.873 and 0.810 kg kg^{-1}), while the lowest value of NUE recorded in the 1st and the 2nd seasons (0.379 and 0.389 kg kg^{-1}) due to supplying the highest level of nitrogen (120 kg N/fad.). These results refer to the higher utilization of nitrogen in the case of its scarcity, and *vice versa*. Moreover, these results indicate to the fact that the more nitrogen added the more losses with less use efficiency. The previous results go along with what was reported by **Svecnjak and Rengel (2006)**.

Table 5. Protein content (%), nitrogen uptake (NU), nitrogen use efficiency (NUE) and water use efficiency (WUE) as affected by nitrogen fertilizer levels

	Crude protein (%)		**N uptake (kg/fad)**		**NUE (kg kg^{-1})**		**WUE (Kg/m^3)**	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad.)	22.9 c	22.6 d	44.77 d	43.36 d	0.837 a	0.810 a	0.454 c	0.386 c
N_2 (60 kg N/fad.)	23.3 b	23.2 c	50.85 c	49.18 c	0.609 b	0.589 b	0.507 b	0.426 b
N_3 (90 kg N/fad.)	23.5 b	23.8 b	56.55 a	56.62 a	0.498 c	0.499 c	0.559 a	0.478 a
N_4 (120 kg N/fad.)	24.0 a	24.3 a	54.45 a	55.83 a	0.379 d	0.389 d	0.527 b	0.462 a
F. test	*	*	*	*	*	*	*	*

* Significant at 5%. Alphabets express the order of significance.

Water use efficiency (WUE) as the ratio of seed yield produced and the total seasonal consumptive water use was significantly different due to varied N levels. The highest WUE in both seasons were due to supply 90 kg N/fad., by 0.559 and 0.478 kg kg^{-1}, however 120 kg N/fad., reached the same level of significance as 120 kg N/fad., in the 2nd season recording 0.462 kg kg^{-1} in the time that it was in the 2nd ranking in the 1st season. These results are expected because it depend on the seed yield produced by different nitrogen levels (Table 3) propertied to the constant water consumptive use.

Weed coverlet (number and dry weight of weeds/m^2)

Results presented in Table 6 refer to the significant effect of added N levels on both weeds number and dry weight/m^2. The lesser level (30 kg N/fad., N_1) was accompanied by the lowest No. of weeds and its dry weight which amounted to 42.52 and 57.93 weeds/ m^2 with a dry weight of 87.59 g and 117.02 g in the 1st and 2nd seasons, respectively. In the 1st season, N_2 (60 kg N/fad) ranked 2nd affecting No. of weeds and its dry weight/ m^2, while N_3 and N_4 ranked 3rd. In the 2nd season, N_1, N_2 and N_3 achieved the same significance level recording the lowest number and dry weight of weeds/m^2. These results indicate that increasing N level exhibited weeds growth due to the abundance of nitrogen as a macro-element.

The Second Experiment (Nitrogen Fertilizer Levels under Drip Irrigation system)

Plant growth

Results in Table 7 display that plant height, No. of racemes/plant and days to 50% flowering were significantly affected by varied N fertilizer levels. 120 kg N/fad., (N_4) achieved the tallest plants in the 1st and the 2nd seasons, respectively (184.82 cm and 201.7c cm), and the maximum number of days to 50% flowering in the 1st and the 2nd seasons, respectively (93.94 and 92.11 days); however it ranked 2nd in producing No. of racemes/plant in the 1st and 2nd season by 13.74 and 15.40 racemes). N_3 (90 kg N/fad.) needed 93.43 days to 50% flowering in the 1st season, which was as significant as N^4 (120 kg N/fad).

Moreover, it is noted from the results presented in Table 7 that N_1, N_2 and N_3 had the same significant effect on plant height, No. of racemes/plant and days to 50% flowering. Previous results assure the significant role of nitrogen as a macronutrient in increasing canola canopy volume under both irrigation systems which highlight the importance of nitrogen fertilization in sandy soil. 90 kg N/fad., (N_3) besides N_4 (120 kg N/fad.) recorded the highest values of yield attributes which form the potentiality of canola plant to produce yield.

Yield components, seed and biological yields as well as Harvest index

Considering Table 8, it was showed that N_3 and N_4 (90 and 120 kg N/fad.) achieved the same level of significance recording the highest No. of siliquae/plant, seed index and seed weight/plant in both seasons. N2 (60 kg N/fad.) ranked 2nd and N_1 (30 kg N/fad.) ranked 3rd affecting previous mentioned components. N3 (90 kg N/fad.) produced 360.72 siliqua/plant in the 1st season and 340.93 ones in the 2nd season, as well as 3.58 g and 3.46 g as seed index in the 1st and the 2nd seasons, respectively, in addition to 21.64 g and 20.46 g/plant as seed weight of the individual plant in the 1st and the 2nd seasons, consequently. These results refer that 90 kg N/fad (N_3) is considered the recommended significant N level for maximizing yield components.

Regarding seed and biological yields (Table 9), the highest value for each of them was obtained through supplying 120 kg N/fad., (N_4) in both seasons; however N_3 (90 kg N/fad.) achieved the same significant seed yield as N_4 in the 1st season. In the 1st season, N_4 produced 1600 kg seeds/fad., and N_3 produced 1590 kg. N_2 (60 kg N/fad.) ranked 2nd and N_1 (30 kg N/fad.) ranked 3rd achieving the lowermost seed yield; meanwhile in the 2nd

Table 6. Weed number and dry weight (g) as affected by nitrogen fertilizer levels

	No. of weeds/m^2		Dry weight of weeds/m^2	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N1 (30 kg N/fad.)	42.52 a	57.93 a	87.59a	117.02 a
N2 (60 kg N/fad.)	48.67 b	63.79 a	101.72b	126.30 a
N3 (90 kg N/fad.)	59.26 c	64.89 a	117.93c	136.27 a
N4 (120 kg N/fad.)	61.81 c	75.18 b	126.09c	152.28 b
F. test	*	*	*	*

* Significant at 5% and NS indicate not significant. Alphabets express the order of significance.

Table 7. Plant height, No. of racemes and days to 50% flowering of canola as affected by nitrogen fertilizer levels

	Plant height (cm)		No. of racemes/plant		Days to 50% flowering	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad.)	171.46 b	193.09 b	13.43 b	15.25 b	89.15 c	89.79 b
N_2 (60 kg N/fad.)	174.63 b	195.54 b	13.64 b	15.61 b	90.51 b	89.86 b
N_3 (90 kg N/fad.)	175.64 b	196.24 b	15.24 a	16.36 a	93.43 a	90.52 b
N_4 (120 kg N/fad.)	184.82 a	201.7 a	13.74 b	15.40 b	93.64 a	92.11 a
F. test	*	*	*	*	*	*

* Significant at 5% and NS indicate not significant. Alphabets express the order of significance.

Table 8. No. of siliquae/plant, seed index and seed weight (g/plant) of canola as affected by nitrogen fertilizer levels

	No. of siliquae/plant (pods)		Seed index (1000 seed wt.)		Seed weight (g/plant)	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad.)	251.05 c	259.32 d	3.10 c	3.12 c	15.06 c	15.56 c
N_2 (60 kg N/fad.)	287.11 b	299.43 c	3.43 b	3.39 b	17.22b	17.97 b
N_3 (90 kg N/fad.)	360.72 a	340.93 a	3.58 a	3.56 a	21.64 a	20.46 a
N_4 (120 kg N/fad.)	361.20 a	368.09 a	3.65 a	3.71 a	21.67 a	22.09 a
F. test	*	*	*	*	*	*

* Significant at 5% and NS indicate not significant. Alphabets express the order of significance.

Table 9. Seed yield (kg/fad.), biological yield (ton/fad.) and harvest index (%) of canola as affected by nitrogen fertilizer levels

	Seed yield (kg/fad.)		Biological yield (ton/fad.)		Harvest index (%)	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad.)	1365 c	1304 d	4.86 b	5.72 b	28.10 c	22.78 d
N_2 (60 kg N/fad.)	1419 b	1428 c	4.99 b	5.82 b	28.47 c	24.53 c
N_3 (90 kg N/fad.)	1590 a	1518 b	5.03 b	5.85 b	31.64 a	25.95 b
N_4 (120 kg N/fad.)	1600 a	1612 a	5.39 a	6.07 a	29.67 b	27.03 a
F. test	*	*	*	*	*	*

* Significant at 5% and NS indicate not significant. Alphabets express the order of significance.

season, N_3 ranked 2nd and N_2 ranked 3rd, in the time that N_1 ranked 4th producing the lowest seed yield/fad. N_1, N_2 and N_3 produced the same significant biological yield in the 2nd rank after N_4, which could be an indicator to the high efficacy of using nitrogen under drip irrigation system.

Concerning the Harvest index (HI), in the 1st season, N_3 (90 kg N/fad.) recorded the highest value of HI (31.64), in the time that the seed yield was also the highest (1590 kg/fad), while the biological yield was ranking 2nd due to N_3. These results refer to the high efficiency of plants treated by 90 kg N/fad., (N_3) in accumulating dry matter under drip irrigation system. In the 2nd season, the highest value of HI (27.03%) was in favor of N_4 (120 kg N/fad.) and this result is expected because N_4 recorded the highest seed yield in the 2nd season.

These results highlight that canola yield components and the final seed yield were significantly affected by different nitrogen levels under both irrigation systems, however nitrogen use efficiency under drip irrigation was higher, thus 90 kg N/fad., (N_3) the optimum producing the highest value for each of yield components, and consequently, the highest seed and oil yields.

Seed oil content (%) and oil yield (kg/ fad.)

Results in Table 10 clarify that canola seed oil content (%) was affected significantly by varied N levels in both seasons in favor of the lowest N levels (N_1 and N_2) which produced the highest oil content. 90 kg N/fad., (N_3) ranked 2nd and 120 Kg N/fad., (N_4) ranked 3rd recording the lowest seed oil content in both seasons. There is a fact observed that the more nitrogen supplied the lesser oil content produced. In inverse, it is found from the results noted in Table 10 that the significant oil yield (kg/fad.) was in favor of the higher N levels supplied. These results are due to the high significant difference in seed yield of canola plants due to varied N levels which was in favor of the higher N levels (Table 9).

Protein content (%), nitrogen uptake (NU), nitrogen use efficiency (NUE) and water use efficiency (WUE)

Results presented in Table 11 indicate that the highest protein contents recorded in both seasons (24.5%) were in favor of supplying 120 kg N/fad., while 90 kg N/fad ranked second recording 23.9% and 23.8% protein content in the 1st and the 2nd seasons, respectively.

Table 10. Oil percentage (%) and oil yield (kg/fad) of canola as affected by nitrogen fertilizer levels

	Oil percentage		Oil yield (kg/fad.)	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad.)	45.8 a	45.9 a	625.17 c	598.54 d
N_2 (60 kg N/fad.)	45.8 a	46.2 a	649.90 b	659.74 c
N_3 (90 kg N/fad.)	45.1 b	45.5 b	717.09 a	690.69 b
N_4 (120 kg N/fad.)	44.3 c	44.5 c	708.80 a	717.34 a
F. test	*	*	*	*

* Significant at 5% and NS indicate not significant. Alphabets express the order of significance.

Table 11. Protein content (%), nitrogen uptake (NU), nitrogen use efficiency (NUE) and water use efficiency (WUE) as affected by nitrogen fertilizer levels

	Crude protein (%)		N uptake (kg/fad.)		NUE (kg kg^{-1})		WUE (Kg/m^3)	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad.)	23.1 c	23.0 d	50.45 d	47.99 d	0.943 a	0.897 a	0.554 c	0.504 d
N_2 (60 kg N/fad.)	23.3 c	23.3 c	52.90 c	53.24 c	0.633 b	0.637 b	0.576 b	0.552 c
N_3 (90 kg N/fad.)	23.9 b	23.8 b	60.80 b	57.81 b	0.536 c	0.509 c	0.645 a	0.587 b
N_4 (120 kg N/fad.)	24.5 a	24.5 a	62.72 a	63.19 a	0.437 d	0.440 d	0.649 a	0.623 a
F. test	*	*	*	*	*	*	*	*

* Significant at 5%. Alphabets express the order of significance.

60 kg N/fad., recorded the lowest protein contents in both seasons. These results confirm the fact that the more nitrogen supplied to canola plants, the more protein is assimilated due to the role of nitrogen in composing amino acids which are the building blocks of all proteins (**Lopez and Mohiuddin, 2024**).

N uptake was found to be higher due to higher levels of nitrogen supplied. The highest significant N uptake values were found due to supplying 120 kg N/fad., in the 1st and the 2nd seasons (62.72 and 63.19 kg/fad.). Supplying 90 kg N/fad., ranked second in both seasons achieving 69.80 and 57.81 kg, while 30 kg N/fad., outturn the lowest N uptake in the 1st and the 2nd seasons (50.45 and 47.99 kg). NUE values were found in negative correlation with N uptake, wherein the lowest level of nitrogen supplied (30 kg N/fad.) recorded the highest nitrogen use efficiency in the 1st and the 2nd seasons (0.943 and 0.897 kg kg^{-1}), while the lowest value of NUE recorded in the 1st and the 2nd seasons (0.437 and 0.440 kg kg^{-1}) was due to supplying the highest level of nitrogen (120 kg N/fad.). These results assure the fact that the more N supplied the more losses with less use efficiency.

Water use efficiency (WUE) was significantly different due to varied N levels, wherein the highest WUE in the 1st and the 2nd seasons were due to supply 120 kg N/fad., by 0.649 and 0.623 kg kg^{-1}, in the time that 90 kg N/ fad., reached the same level of significance as 120 kg N/fad., in the

2nd season recording 0.462 kg kg^{-1} in the time that it was in the 2nd ranking in the 1st season. These results are logically expected because they are based on the seed yield produced due to different nitrogen levels (Table 9) propertied to the constant water consumptive use under all nitrogen levels.

Weed coverlet (number and dry weight of weeds/m^2)

From results declared in Table 12, it is observed that the behavior of weed coverlet components (number and dry weight) followed the same trend as under sprinkler irrigation, where the lesser level of nitrogen were accompanied by less weeds number per unit area and thus lesser dry weight. A positive correlation between weed coverlet density and N levels could be observed. The highest No. of weeds/m^2 in the 1st and the 2nd seasons (42.41 and 50.85) was in favor of supplying 120 kg N/fad., and hence the total weeds dry weight/m^2 (83.55 and 103.73 g), in the 1st and the 2nd seasons, orderly. The abundance of nitrogen was a promoter for more weeds growth, and *vice versa*.

Water consumptive use

Fig. 1 shows the total amount of water consumed under both experiments (under sprinkler and drip irrigation systems). Canola crop consumed about 2960 m^3 and 3108 m^3 of water during the 1st and 2nd season, respectively, under sprinkler irrigation (the 1st experiment); while under drip irrigation (the 2nd experiment), canola consumed about 2464 m^3 and 2587.2 m^3 in both seasons, respectively.

Water saving under drip irrigation system reached to 496 m^3 in the 1st season and 520.8 m^3 in the 2nd season, amounting to total water save valued by 1016.8 m^3 in both seasons forming 16.75% of the total water consumption. This percentage of water conserved is considered a great benefit in favor of dripping irrigation, especially while considering irrigation process is one of the most costing productive factors in sandy soils. Taking into account the final economical seed yield due to nitrogen fertilization levels, which were higher under drip irrigation than under sprinkler irrigation, it is worthy recommended to cultivate canola crop under drip irrigation system for more productivity and more water save.

Conclusion

It is concluded from the study results that growing canola in sandy soil require drip irrigation system and 90 kg N/fad split in numerous doses for maximized yield components and obtaining higher seed and oil yields with more weeds controlled. Additionally, these recommendations contribute in conserving water use till 16.75%. These conclusions are serving to achieve sustainable development goals.

Table 12. Weeds number and dry weight (g) as affected by nitrogen fertilizer levels

	No. of weeds/m^2		Dry weight of weeds/m^2	
Nitrogen level	**2022/23**	**2023/24**	**2022/23**	**2023/24**
N_1 (30 kg N/fad.)	35.73 a	46.54 a	71.10 a	95.41 a
N_2 (60 kg N/fad.)	37.31 a	47.77 a	77.60 a	97.45 a
N_3 (90 kg N/fad.)	37.82 a	48.12 ab	74.13 a	93.35 ab
N_4 (120 kg N/fad.)	42.41 b	50.85 b	83.55 b	103.73 b
F. test	*	*	*	*

* Significant at 5% and NS indicate not significant. Alphabets express the order of significance.

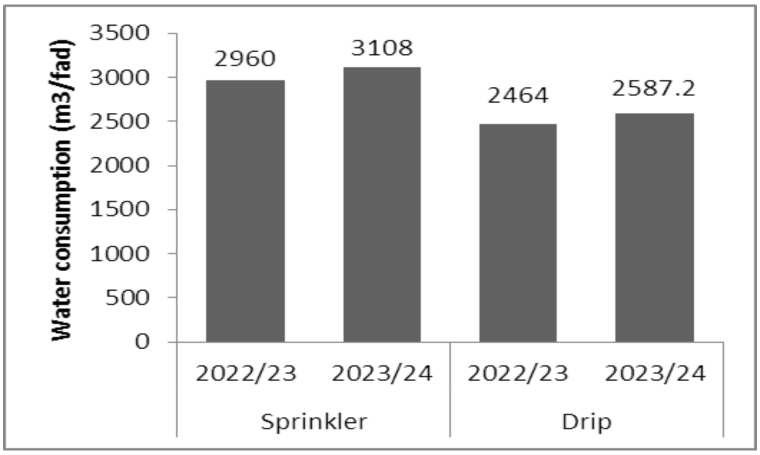

Fig. 1. Water consumptive use under both irrigation systems in both seasons

REFERENCES

Al-Kaisi, M.; Yin, X. and Barlow, J. (2017). Effects of irrigation method on canola yield in sandy soils: a comparative study. Agric. Water Manag., 180 (1): 123 - 130.

AOAC (1990) Official Methods of Analysis. 15th Ed., Association of Official Analytical Chemist, Washington DC.

Bennouna, D.; Tourniaire, F.; Durand, T.; Galano, J.M.; Fine, F.; Fraser, K.; Benatia, S.; Rosique, C.; Pau, C.; Couturier, C.; Pontet, C.; Vigor, C.; Landrier, J.F. and Martin, J.C. (2021). The *Brassica napus* (oilseed rape) seeds bioactive health effects are modulated by agronomical traits as assessed by a multi-scale omics approach in the metabolically impaired ob-mouse. Food Chemist. Molec. Sci., 2: 100011.

Cardinali, A. and Nason, G.P. (2013). Costationarity of locally stationary time series using costat. J. Stat. Software, 55 (1): 1–22.

Castiglione, A.M.; Mannino, G.; Contartese, V.; Bertea, C.M. and Ertani, A. (2021). Microbial biostimulants as response to modern agriculture needs: Composition, role and application of these innovative products. Plants, 10(8): 1533.

Fageria, N.K. (1992) Maximizing crop yields. Marcel Dekker, Inc., New York.

Gholamhoseini, M.; Aghaalikhani, M.; Dolatabadian, A. and Khodaei, J.A. and Zakikhani, H. (2019). Decreasing nitrogen leaching and increasing canola forage yield in a sandy soil by application of natural zeolite. Agron. J. (104) 9: 1467.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. 2nd Ed., John Wiley and Sons, New York, 680.

Hocking, P.J.; Randall, P.J. and DeMarco, D. (1997). The response of dryland canola to nitrogen fertilizer: partitioning and mobilization of dry matter and nitrogen, and nitrogen effects on yield components. Field Crops Res., 54 (2-3) 201-220.

Hossain, M.A.; Rahman, M.M. and Islam, M.S. (2023). Economic viability analysis of various irrigation methods for canola cultivation in sandy regions. Agric. Econ., 54 (1): 67-78.

Jackson, M.L. (1958) Soil Chemical Analysis. Prentice-Hall Inc., Englewood Cliffs, NJ, 498.

Karam, F.; Naderi-Beni, S. and Zare-Maivanani, M.H. (2021). Nutrient uptake response of canola to different irrigation methods on sandy soils: implications for fertilizer management strategies. J. Plant Nutr., 44(5): 754-765.

Kniuipytė, I.; Dikšaitytė, A.; Praspaliauskas, M.; Pedišius, N. and Žaltauskaitė, J. (2023). Oilseed rape (*Brassica napus* L.) potential to remediate Cd contaminated soil under different soil water content. J. Environ. Manag., 325(A): 116627.

Lindsay, W.L. and Norvell, W.A. (1978) Development of a Dtpa Soil Test for Zinc, Iron, Manganese, and Copper. Soil Sci. Soc. Ame. J., 42: 421-428.

Liu, H.; Chen, Y. and Xu, Z. (2022). Impact of irrigation practices on oil quality parameters of canola grown in sandy soil conditions. Indust. Crops and Prod., 178(3): 114-122.

Lopez, M.J. and Mohiuddin, S.S. (2024). Biochemistry, Essential Amino Acids. [Updated 2024 Apr 30]. In: StatPearls [Internet]. Treasure Island (FL): Stat Pearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/ books /NBK557845/

Mkhabela, M.; Tindall, J. and Reddy, K.R. (2020). Soil moisture dynamics under regulated deficit irrigation for canola production on sandy soils: a field study approach. Soil Sci. Soc. Ame. J., 84 (4): 1008-1016.

Sible, C.N.; Seebauer, J.R. and Below, F.E. (2021). Plant biostimulants: A categorical review, their implications for row crop production, and relation to soil health indicators. Agron. mdpi.com.

Sitthaphanit, S.; Limpinuntana, V.; Toomsan, B.; Panchaban, S. and Bell, R. (2022). Fertiliser strategies for improved nutrient use efficiency on sandy soils in high rainfall regimes. J. Nutr. Cycling in Agroecosys., 10 (85): 123 - 139.

Smith, J.A. and Jones, R.B. (2023). Climate resilience through efficient irrigation practices: a case study on canola farming in arid regions with sandy soils. Environ. Sci. Policy, 132 (2): 112-120.

Smith, P.; Jones, R.A. and Taylor, M.L. (2018). Environmental implications of agricultural N use: Balancing productivity with sustainability.

Svecnjak, Z. and Rengel, Z. (2006). Nitrogen utilization efficiency in canola cultivars at grain harvest. Plant and Soil, 283: 299-307.

Waller, R.A. and Duncan, D.B. (1969) A bayes rule for the symmetric multiple comparisons problems. J. Ame. Stat. Assoc., 64: 1484-1503.

Wally, A. (2023). oilseeds and products annual: oilseeds and products (Report No. EG2023-0005). United States Department of Agriculture. Available at: https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Oilseeds%20and%20Products%20Annual_Cairo_Egypt_EG2023-0005

Zhang, Y.; Wang, L. andLi, Q. (2019). Water use efficiency of canola under different irrigation techniques: implications for sustainable agriculture practices in sandy soils. Field Crops Res., 240 (2): 45- 53.

Zhuo, H.; Liu, X.; Luo, S.; Ou, X.; Rong, X.; Yang, L.; Li, Q. and Han, Y. (2024). Physiological changes underlying increased photosynthetic-nitrogen use efficiency in response to low-nitrogen conditions in *Brassica napus* L. J. Indust. Crops and Prod., (211): 118240.

الملخص العربي

محصول وجودة الكانولا (*Brassica napus* L.) وكذلك غطاء الحشائش متأثرين بمستويات السماد النيتروجينى تحت نظامى الري بالرش والتنقيط: دراسة مقارنة

فارس سليمان محمد جمعة – السيد حسن محمد فايد

قسم المحاصيل - كلية الزراعة - جامعة الزقازيق – مصر

أجريت تجربتان حلقيتان كلٌ على حدة خلال الموسمين الشتويين 23/2022 و24/2023 بالمزرعة التجريبية بالأرض الرمليه الخاصه بكلية الزراعة، جامعة الزقازيق، مصر بهدف دراسة تأثير أربعة مستويات من السماد النيتروجينى (30 و60 و90 و120 كجم نيتروجيى/فدان) تحت نظامي ري منفصلين (الري بالرش والتنقيط) باستخدام تصميم القطاعات الكاملة العشوائية (RCBD) في ثلاث مكررات. هدفت الدراسة إلى استدامة إنتاج الكانولا كمحصول زيت فى الأراضى الجديدة من خلال تحديد نظام الري الأمثل وجرعة النيتورجين المُثلى لتحقيق أعلى عائد من المحصول كماً وجودة. أظهرت النتائج اختلافات كبيرة في صفات النمو ومكونات المحصول ومحصولى البذور والزيت وكذلك مدى انتشار نباتات الحشائش بسبب مستويات السماد النيتروجينى المختلفه تحت كلا نظامي الري. حققت إضافة 90 و 120 كجم نيتروجين/فدان نفس مستوى المعنوية فى كل الصفات تحت الدراسة، وعليه أعلى محصول بذور وزيت/فدان. كما أظهر الري بالتنقيط تفوقاً في جميع الصفات المدروسة على الري بالرش حيث سجل زيادة فى محصول البذور قدرها 8% مع توفير مياه الرى اللازمه للفدان بنسبة 16.75% خلال كل موسم من مواسم الدراسه. كذلك أظهر نظام الرى بالتنقيط فعاليه فى الحد من انتشار نباتات الحشائش. تُوصى الدراسه باتباع طريقة الرى بالتنقيط عند زراعة الكانولا فى الأراضى الجديدة مع التسميد النيتروجينى بمعدل 90 كجم نيتروجين للفدان للحصول على أعلى محصول بذور وزيت.

الكلمات الاسترشادية: الكانولا، الري بالرش، الري بالتنقيط، التسميد بالنيتروجين، استهلاك المياه، محصول الكانولا.

REVIEWERS:
Dr. Wael A. Teilab | dr.waelteilab74@gmail.com
Dept. Oil Crops Research, Cairo Univ., Egypt.
Dr. Mohammed Saad Maghazi | abdelaty2009@yahoo.com
Dept. Crops, Wheat Breeding, Fac. Agric., Kafr Unive., Egypt.