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Productivity Improvement of Canola Genotypes Under Salinity Stress Conditions by Integration Between Mineral and Nano-Scale Forms of Nitrogen Fertilizer

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Abstract: Two field experiments were conducted during in 2019/20 and 2020/21 seasons to study the impact of integration among mineral and nano-particle nitrogen (N) fertilizer levels on yield traits and chemical characters of some canola genotypes grown under salt stress conditions. Four treatments of N fertilization (190 kg N/ha as recommended dose; 50% of the recommended, 95 kg N/ha+nano nitrogen (5 L/ha); 25 % of the recommended, 47.5 kg N/ha+nano-nitrogen (5 L/ha), and nano-nitrogen (rate of 5 L/ha). canola genotypes (Trabber, Agamax, and Serw4) performance were assessed under three levels of saline irrigation water (control, 2000, and 4000 mg L^{-1}). Results showed that increasing salinity levels up to 4000 mg L^{-1} led to decreasing in all studied yield parameters compared with those of control (tap water). Trabber genotype excelled significantly in most of the yield characteristics. Integration between nanoscale and mineral nitrogen fertilizer, i.e. 95 kg N/ha+5 nano N L/ha) showed superiority over all applied N treatments, recording the highest values. It could be concluded that since application of 95 kg N/ha+5 nano N L/ha exploiting the nano form of N saves about 50% of applied nitrogen in canola under saline conditions. Accordingly, nanoparticles help the environmental pollution to be reduced.

1 Introduction

Canola is considered one of the prime sources for consumable vegetable oil for human utilization due to its higher quality related with a lower level of saturated fat (40-45%) and protein (36-40%) within the seed. Canola oil has one of the best fatty acid profile of edible oil comparing other oilseed crops. It is characterized by less than 1 % Erucic acid and a higher percent of oleic which has been shown to reduce serum cholesterol level (Hossain et al 2019, Hozayn et al 2021, Russo et al 2021). As of now, it developed into a region of 107 million hectares yearly, with an addition up to the production of 219 million tons around the world (FAOSTAT 2018, 2019 and 2020). In Egypt, canola is still in its early stages of development and is not yet commercially farmed. However, many investigations conducted in Egypt demonstrated that canola (spring varieties) will succeed where this expansion in canola cultivation will occur in newly reclaimed lands which are suffering from abiotic stresses such as salinity, drought, and extreme chemical and temperature toxicity. Also, increased salinization of arable land is expected to have devastating global effects, resulting in a 30% land loss within the next 25 years and up to 50% by the year 2050 (Wang et al 2013, Rezaei et al 2017, Kanwal et al 2021).

Soil salinity is a significant limiting factor in agricultural output. Salt stress has been linked to stunted growth and development, as well as reduced photosynthesis and protein synthesis. Salt ion toxicity has a multitude of detrimental effects on plants (Abd El-Mageed et al 2022), as it increases the denaturation of cytosolic proteins and the formation of reactive oxygen species (ROS), which can injure membranes and proteins. (Javeed et al 2021). Sabagh et al (2019) noted how the efficiency of the canola plant tends to diminish beneath diverse abiotic stresses due to their unfavorable impact on morphological, physiological, and biochemical processes, counting lowered or decreased leaf zone, leaf relative water substance, soundness of cell films, photosynthetic capacity, stomatal conductance, harm to chlorophyll and the production of responsive oxygen species as a result of osmotic stretch, ion toxicity, and diminished water and mineral accessibility and causes oxidative stress, which is a major component of most abiotic stresses. Reactive oxygen species (ROS) are a type of signaling molecule that is produced as a consequence of plant cellular metabolism. Limitations in photosynthetic electron transport and partial stomatal closure may be to blame for the decrease in photosynthetic activity typically observed during salt stress (Javeed et al 2021, Kainat et al 2021, Makhlouf et al 2022). During abiotic and biotic stressors, the generation of reactive oxygen species (ROS) in cells increases, as does the level of ROS-induced damage. In salt-affected areas, canola has a lot of potentials to develop. Some antioxidant enzymes, such as SOD, CAT, and POD, discovered to be major determinants of salt tolerance in many crops (Analin et al 2020, Jiang et al 2020). Despite substantial research into the effects of salt stress on photosynthesis, the causes of saline stress-induced photosynthesis inhibition remain unexplained. Ahmadi and Ardekani (2006) reported that seed yield was not influenced by saltiness until EC=5 dS/m but decreased significantly at higher saltiness levels. ACSN1 and Shirali cultivars did not vary essentially in seed yield production but varied in seed oil substance. Canola is tolerant to moderate to extraordinary natural conditions and can be successfully grown beneath bone-dry land conditions (Qaderi et al 2012). To enhance this environment push plants, require a few bolsters from outside sources that may be reasonable planting date, which favors plant to convenient total its life cycle or supplements alteration for better development and execution (Singh et al 2021).

Nitrogen (N) plays an important component in crop production since it increases crop yield. Protein is also an essential component of plant metabolism all major mechanisms in plants are dependent on it, where N is an essential component (Wang et al 2021). Optimizing the application of nitrogen fertilization rates leads to improved characteristics of the canola crop, wherein there is positively correlated with soil N level and canola traits i.e. plant height(cm), number of branches/plant, number of pods/plant, seed yield and oil yield (Ganya et al 2018). Yield traits are positively affected directly by N as a result of increased stem length, a higher number of flowering branches, total plant weight tone/ha, seeds/ pod, number and weight of pods and seeds/pod (Béreš et al 2019).

Furthermore, continuous application of chemical fertilizers creates soil contamination and consumes great energy and cost during the chemical industry process are some of the mechanisms that cause N loss in the atmosphere. There is a mistake in applying this N fertilization to the crop, in reality, applying these to the pre-plants on a continual basis will not result in optimal use of the total amount added. Because the nutrients in the soil are taken away when the plants are harvested, it is vital to replace them with a readily available fertilizer to ensure that the nutrients are always available to the plants. Nitrogen (N), which is required in huge quantities, is vital for plant growth and animal nutrition and is the nutrient that all plants take up the most.

The most important factor nitrogen is required in large quantities, and its uptake generates a large number of problems for plants. A variety of fertilizers for different crop interests are discussed. Due to its ability to increase crop production (Saudy et al 2022), improve soil fertility and reduce pollution, nano-fertilizers, the most important field in agriculture, have attracted the attention of soil scientists as well as ecologists. The rate of nutrient release from laboratory-made nano-fertilization was compared, as well as its effect on crop yield, it was found that the use of nitrogen as nanoparticles has a positive effect on the yield and quality (Qureshi et al 2018). Increase the nutrients present in plants when harvested (Hessini et al 2019). The use of nitrogen as nanoparticles has been shown to have a positive effect on the production and quality of canola oil. In addition, it was also found that by treating plants containing 40 kg of nitrogen + 20% Nano. N/Acre has given the best quality and quantity in canola production (Alwakel et al 2021). This investigation aims to study the impact of integration among mineral and nanoparticle nitrogen fertilizer levels on yield and yield attributes as well as chemical characters of some canola genotypes grown under salt stress conditions.

2 Materials and Methods

2.1 Experimental site

Two field experiments were carried out at the Agricultural Production and Research Station of National Research Center, Nobaryia region, Behaira Governorate, Egypt, (30°29′53.4″N, 30°19′13.9″E). During two successive winter seasons 2019/2020 and 2020/2021 to study the impact of integration among mineral and nanoparticle nitrogen fertilizer levels on yield and yield attributes as well as chemical characters of some canola genotypes grown under salt stress conditions. Mechanical and chemical characters of the soil experimental site were analysis before sowing and the data are presented in **(Table 1)**. Climatic conditions of the experimental site were obtained from a station close to the experimental site (wind speed, relative humidity, maximum and minimum temperatures, precipitation rate) in 2019/20 and 2020/21 seasons are illustrated in **(Table 2)** (as obtained from the Central Laboratory of Meteorology, Ministry of Agriculture and Land Reclamation). The soil was Burr before planting in the first season and the previous crop in the second season was maize.

2.2 Experimental design

The experimental design was a strip–plot in completely randomized block design using four replicates applying the model of Casella (2008). The vertical main plots consisted of three salinity levels Tap water (control), 2000 mg L^{-1} and 4000 mg L^{-1} of irrigation water); four treatments of nitrogen fertilization were combination between mineral nitrogen (soil application) and nanoscale nitrogen (foliar application) as follows: soil application recommended dose of N fertilizer as control (190 kg N/ha), 50 % of recommended dose mineral nitrogen fertilizer (95 kg N/ha) + nanoscale nitrogen at the rate of 5 litter/ha (500 mg L^{-1} nano-nitrogen), 25% of recommended dose mineral nitrogen fertilizer (47.5 kg N/ha) + nano nitrogen at the rate of 5 litter/ha (500 mg L^{-1} nano-nitrogen) and nano nitrogen at the rate of 5 litter/ha (500 mg L^{-1} nano-nitrogen). Fertilization treatments were started applied after 30 days from sowing, the rate just every two weeks. The foliar application of nano-nitrogen fertilizers was applied using a knapsack sprayer had one nozzle with 480 L water ha^{-1} as a solvent/carrier. Transmission electron microscopy (TEM) images of nanoscale nitrogen crystals is depicted in **Fig 1**.

Four treatments of nitrogen fertilization were occupied the sub plots, while the three canola genotypes (Agamax, Trabber and Serw 4) were assigned in horizontal ones. The plot involved 6 ridges with area of $14.7m^2$ (3.5m× 0.7m), whereas, sowing was on one ridge side, 10 cm between hill and two plants per hill. Soil ploughed and ridged with application of super phosphate (15.5% P_2O_5), Canola seeds sown on 21 November and 23 November in 2019 and 2020 seasons, respectively. The irrigation process was done every 5 days by using drip irrigation system. The harvest of canola plants was done on April 30 and 11 May in the first and second seasons, respectively. The used canola genotypes (Agamax, Trabber and Serw4) saved through the Egyptian – German project No. 23134 (National Research Centre (NRC), Egypt and Julius Kuhn-Institute (JKI), Germany) where the project saved two German genotypes (Agamax and Traber) and the Egyptian cultivar Serw 4 was got from Field Crops Institute, Agricultural Research Center (ARC), Egypt.

2.3 Preparing of nanoscale nitrogen fertilizer

Ammonium hydroxide (NH4OH) and hydrate (FeCl2.4H2O) were bought from Merck. All of the acids were of the highest purity and came from Merck. Merck's PK ions are obtained from inorganic sources of potassium and phosphorous. An aliphatic di-amine group was used as the source of nitrogen in this article. By using the co-precipitation approach, iron oxide magnetic NPs with the proper surface chemistry are created. In a nutshell, chemical preparation techniques can be used to create iron NPs. techniques allow for the management of the size, composition, and even the shape of the NPs and are straightforward, tractable, and effective. By adding a base to the co-precipitation of Fe2+ and Fe3+, iron oxides can be created. The type of salt employed, the ratio of Fe2+ and Fe3+, the pH, and the ionic strength all affect the size, shape, and composition of iron nanoparticles (NPs) produced chemically. The main reasons chemical-based synthesis methods are used are their high yield and low manufacturing costs. Typically, magnetites are created by mixing an aqueous solution of Fe2+ and Fe3+ chloride at a 1:2 molar ratio with a base, producing a black hue according to Laurent et al (2008), Wu et al (2011), Hasany et al (2012), Abdulhady and El-Shazly (2018).

Table 1. Mechanical and chemical analysis of the experimental site soil

Mechanical Analysis	**Sand (%)**	**Silt (%)**	**Clay (%)**			**Texture class**			
	72.5	10	17.3			Sand			
Chemical Analysis	**pH**	**EC ds/m**	**Soluble anions (meq/l)**			**Soluble cations (meq/l)**			
			Cl^-	**HCO_3^-**	**$SO_4^=$**	**K^+**	**Mg^{++}**	**Ca^{++}**	**Na^+**
	8.58	0.68	1.8	3.7	1.1	0.24	0.92	1.9	3.5

Table 2. Climatic conditions of the study site (wind speed, relative humidity, maximum the temperature, minimum the temperature, precipitation rate) of the area in 2019/20 and 2020/21 seasons

2019/20	**WS2M**	**WS10M**	**RH2M**	**TEMP 2M**		**Precipitation (mm)**
Month				**MIN**	**MAX**	
NOV	2.5	3.57	57.73	15.95	27.88	0
DEC	3.31	4.7	65.5	11.69	21.02	0.82
JAN	3.3	4.71	70.03	9.27	17.67	1.58
FEB	2.75	4.02	68.58	9.37	19.61	0.86
MAR	3.23	4.62	62.35	10.46	23.12	2.21
APR	2.81	3.92	59.83	12.65	25.61	3.19
MAY	3.17	4.34	54.06	15.88	31.05	0
2020/21	WS2M	WS10M	RH2M	T2M_MIN	T2M_MAX	Precipitation (mm)
Month						
NOV	2.55	3.6	65.02	15.79	24.18	1.22
DEC	2.4	3.51	64.56	11.97	22.3	0.06
JAN	2.86	4.17	65.55	10.25	21.01	0.34
FEB	2.53	3.75	64.41	9.83	21.23	1.3
MAR	3.02	4.27	61.09	11.555	24.365	2.7
APR	2.99	4.13	56.945	14.265	28.33	2.5
MAY	3.1	3.99	54.52	30	31.05	0

T2M_ MIN, MAX (Maximum and minimum temperature at 2 meters high)
RH2M (Relative humidity at 2 meters high)
WS2M (Wind speed at 2 meters high), WS10M (Wind speed at 10 meters high)
Precipitation mm (Precipitation rate mm/month)

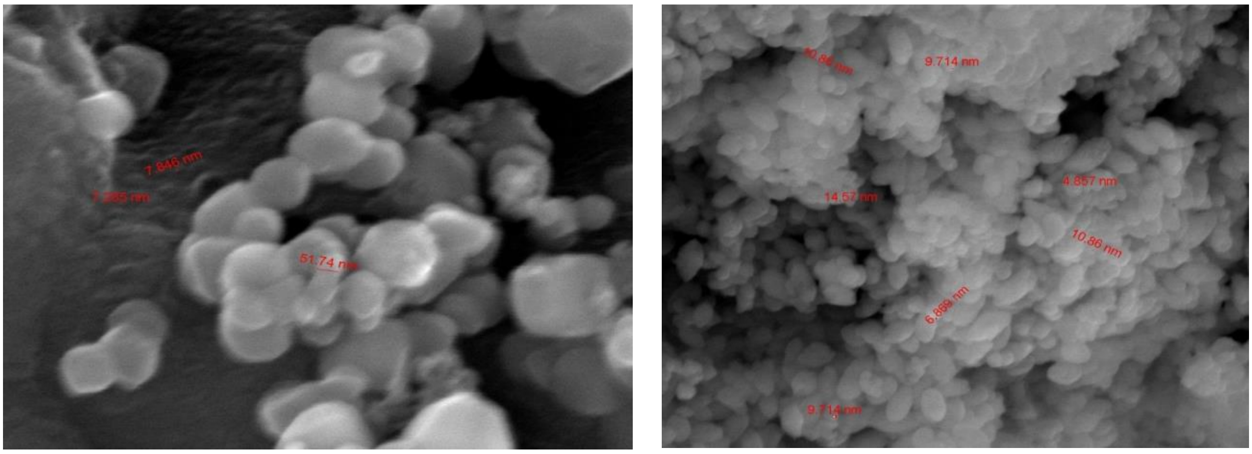

Fig 1. Transmission electron microscopy (TEM) images of nanoscale nitrogen crystals

2.4 Yield and yield attributes

At harvest, samples of 10 plants were chosen randomly from each plot to estimate yield attributes characters i.e. plant height (cm), number of branches/plants, number of pods/plant, seeds weight/plant, and 1000 –seed weight of (g). Whole plants of the experimental unit harvested to estimate seed yield (ton/ha), straw yield (ton/ha) and biological yield (ton/ha).

2.5 Seed chemical composition

Total nitrogen was determined using the modified micro Kjeldahl method according to AOAC (2012) Hence, crude protein content was calculated by multiplying the total nitrogen by 5.7.

Seed oil content (%) was measured using Soxhlet Apparatus with hexane as an organic solvent according to AOAC (2012).

2.6 Statistical analysis

The obtained data were subjected to homogeneity test and the Anderson–Darling normality test (Scholz and Stephens 1987). prior to performing an analysis of variance (ANOVA). The results showed that the data homogeneity and normality were met, allowing for further ANOVA. As a result, each season's data was subjected to ANOVA in accordance with to Casella (2008), using COSTAT software program, Version 6.303 (2004). Using, Duncan’s multiple range test, means separation was done only when the F-test indicated significant ($P < 0.05$) differences among the treatments.

3 Results

3.1 The main effects of salinity, canola genotypes and companied between mineral and nano-nitrogen fertilizers

Based on the analysis of variance, data of yield and its attributes characters (**Table 3)** indicated that plant height, number of branches/plant, number of pods/plant, seed weight ,1000-seed weight, seed yield, straw yield, biological yield, oil % and protein % showed significant differences due to different salinity levels. Data in **(Table 3)** showed that increasing salinity concentration of irrigation water up to 4000 mg L^{-1}, led to decrease in the number of branches/plant by 19.85%, number of pods/plant by 27.24%, seed weight by 32.26%, 1000 seed weight by 5.09%, seed yield by 30.09%, straw yield by 17.86%, biological yield by 19.95% and oil % by 10.77% compared with control (tap water). While, the highest protein % were optioned when plants irrigated with salinity concentration 4000 mg L^{-1} in irrigation water. Concerning the response of canola genotypes, data cleared that Traber genotype excelled significantly in most of the yield characteristics and its components such as, number of branches/plant, number of pods/plant, seed weight, 1000 seed weight, seed yield, biological yield, straw yield, oil % and protein %. While Serw4 genotype was the superior in plant height.

Table 3. Effect of salinity levels, canola genotypes and nanoscale-nitrogen fertilizer levels on yield and yield characters (Combined data for both 2019/20 and 2020/21 seasons)

Studied factor	Plant height (cm)	Number of branches/plant	Number of pods/plant	Seeds weight/plant(g)	Seed yield (ton/ha)	Biological yield (ton/ha)	Straw yield (ton/ha)	1000 seed weight (g)	Oil%	Protein%
Salinity (S)										
S0(tap water)	138.06±2.29a	18.69±1.22a	350±32.51a	48.29±2.36a	2.26±0.05a	13.23±0.2a	10.97±0.23a	6.88±0.0a	40.46±0.7a	28.37±0.97b
S1(2000 mg L^{-1})	137.38±1.59b	16.55±1.17b	299.26±28.6b	44.95±2.25b	1.94±0.05b	11.68±0.2b	9.74±0.24b	6.64±0.0b	39.27±0.8b	31.37±0.93a
S2(4000 mg L^{-1})	137.11±1.92b	14.98±0.86c	254.65±24.25c	32.71±1.29c	1.58±0.09c	10.59±0.45c	9.01±0.38c	6.53±0.06c	36.28±0.67c	32.23±0.81a
Genotypes(G)										
Serw4	148.55±1.56a	12.28±0.45c	195.19±14.76b	36.45±1.33b	1.85±0.06b	11.77±0.36b	9.92±0.31b	6.75±0.07a	39.24±0.70b	32.24±0.84b
Agamax	129.15±1.16b	13.56±0.71b	203.73±19.27b	36.67±2.27b	1.78±0.09b	10.59±0.35c	8.82±0.28c	6.54±0.05b	36.20±0.59c	26.32±0.69c
Trabber	130.84±1.21b	24.37±0.75a	504.99±15.13a	52.82±2.05a	2.15±0.07a	13.14±0.33a	10.98±0.27a	6.76±0.06a	40.56±0.87a	33.42±0.83a
Fertilizer (F)										
F0(190kgN/ha)	136.44±2.17b	17.33±1.08b	333.67±36.82b	45.34±2.43b	2.04±0.09b	12.41±0.32b	10.38±0.25b	6.80±0.06b	43.17±0.91a	4.56±0.09a
F1(95kgN/ha+5lnanoN/ha)	141.27±2.58a	19.94±1.38a	366.84±29.33a	48.83±2.47a	2.25±0.09a	13.74±0.32a	11.49±0.24a	6.88±0.07a	40.26±0.50b	33.99±0.74a
F2(47.5kgN/ha+5lnanoN/ha)	135.49±2.04b	15.52±1.30c	290.31±32.84c	39.13±2.76c	1.77±0.08c	11.59±0.3c	9.82±0.25c	6.65±0.06c	37.22±0.36c	29.14±0.81b
F3 (5lnanoN/ha)	131.53±1.98c	14.16±1.16d	214.39±29.44d	34.63±2.19d	1.66±0.07d	9.59±0.41d	7.93±0.35d	6.39±0.06d	34.03±0.61d	24.93±0.68c

Different small letters within columns indicate that there are significant differences by Duncan's Multiple Range Test at $p \leq 0.05$

Application of N Fertilizers affected significantly all yield and its attributes traits as presented in **(Table 3)**, whereas, application of integration between 95 kg N/ha (50% of the recommended dose) plus foliar application with nanoscale-nitrogen (5L/ha) showed superiority over all tested application treatments, giving the highest values of plant height, number of branches/plant, number of pods/plant, seed weight, 1000- seed weight, seed yield, straw yield and biological yield. On the other hand, canola plants treated with recommended dose exhibited the highest oil and protein %.

3.2 The interaction between salinity levels and canola genotypes

Data illustrated in **Table 4** showed a significant interaction effect of genotypes and salinity concentration of irrigation water on yield and its component characters. Generally, Trabber genotype irrigated by tap water was the efficient interaction treatment for enhancing number of branches/plant, number of pods/plant, seed yield, biological yield, straw yield, seed weight and oil %. While, the highest value of protein % was obtained when Trabber genotype irrigated with 2000 mg L^{-1} salinity concentration as well as the same genotype with the tap water. Moreover, Serw4 genotype was more efficient to produce higher values of plant height and 1000- seed weight under irrigation with tap water than irrigated by salinity water.

3.3 The interaction between salinity levels and companied between mineral and nano-nitrogen fertilizers

Table 5 shows the averages of interaction between salinity levels and mineral and nano-nitrogen fertilizer levels of yield and yield component characters. (F1) 95 kg N/ha and foliar application with 5 l nano-N /ha and irrigation by (S0) tap water exhibited the highest values of plant height, number of branches/plants, number of pods/plant, seed weight, 1000- seed weight, seed yield), straw yield, biological yield. While the highest oil % was obtained when plants fertilized with recommended dose of nitrogen (control) and irrigated with 2000 mg L^{-1} salinity concentration. On the other hand, fertilizering with the recommended dose of nitrogen (control) and irrigating with 4000 mg L^{-1} salinity concentration gave the highest value of protein %.

3.4 The interaction between canola genotypes and companied between mineral and nano-nitrogen fertilizers

Interaction between canola genotypes and nanoscale-nitrogen fertilizer levels showed significant effects on number of pods/plants, seed weight/plant, 1000- seed weight, seed yield, straw yield, biological yield, oil% and protein %except plant height and number of branches/plant (**Table 6**). Seed weight/plant, seed, straw and biological yield were increase when Trabber genotype fertilized with (F1) 95 kg N/ha and foliar application with 5l nano-N /ha by 9.82%, 6.72%, 8.14% and 7.97%, receptively compared with Trabber genotype under recommended dose of nitrogen (F0). Meanwhile, Trabber genotype exhibited the highest values of number of pods/plants, oil % and protein % when fertilized with 190 kg N/ha. On the other hand, Serw 4 gave the highest 1000- seed weight when fertilized with 95 kg N/ha and foliar application with 5l nano-N/ha.

3.5 The interaction among salinity levels, canola genotypes and companied between mineral and nano-nitrogen fertilizers

Interaction among salinity levels, canola genotypes and nanoscale-nitrogen fertilizer levels showed significant differences among means of plant height (cm), number of branches/plants, number of pods/plant, seed weight/plant, 1000- seed weight, seed yield, straw yield, biological yield, oil% and protein % (**Table** 7). The maximum values of number of branches/plants, seed weight plant and seed yield, straw yield and biological yield were achieved for Trabber genotype irrigated by tap water (control) when fertilized with 95 kg N/ha and foliar application with 5l nano-N /ha. While the interaction among tape water (control), recommended dose of nitrogen (190 kg N/ha.) with Trabber genotype achieved the highest values of number of pods/plant and oil %. On the other hand, Serw 4 irrigated with tap water (control) and received recommended dose of nitrogen (190 kg N/ha) achieved maximum 1000- seed weight. While, when fertilized with 95 kg N/ha + foliar application with 5l nano-N /ha gave the highest plant height, whereas, when fertilized with recommended dose of nitrogen (190 kg N/ha) achieved the highest protein %.

Table 4. Effect of interaction between salinity levels and canola genotypes on yield and yield characters (Combined data for both 2019/20 and 2020/21 seasons)

Studied factor		Plant height (cm)	Number of branches/plant	Number of Pods/Plant	Seeds weight/plant (g)	Seed yield (ton/ha)	Biological crop (ton/ha)	Straw weight (ton/ha)	1000 seed weight (g)	Oil %	Protein %
Interaction											
S0 (tap water)	Serw 4	153.67±2.80a	12.73±0.92ef	188.35±29.77f	39.43±3.1c	2.16±0.09b	12.91±0.41b	10.76±0.3b	7.10±0.10a	41.06±0.9b	30.64±1.33c
	Agamax	129.08±2.50c	15.85±1.24d	306.04±43.5d	47.35±4.6b	2.16±0.05b	12.16±0.26c	10.00±0.22d	6.71±0.05c	36.93±0.5d	23.45±1.09e
	Trabber	131.42±1.50c	27.48±0.93a	555.60±30.20a	58.08±2.3a	2.46±0.09a	14.62±0.43a	12.17±0.3a	6.82±0.06b	43.39±1.3a	31.02±1.63bc
S1 (2000 mg L^{-1})	Serw4	148.69±2.80b	11.38±0.65f	205.65±30.80e	36.83±1.8c	1.70±0.07e	11.45±0.53d	9.75±0.47d	6.78±0.09c	39.42±1.1c	33.09±1.39ab
	Agamax	128.77±1.63c	13.44±1.26e	175.15±8.20 f	36.46±1.6c	2.08±0.05c	11.16±0.49e	9.08±0.45e	6.48±0.11d	37.22±1.4d	26.5±0.86d
	Trabber	133.88±2.35c	24.83±1.20b	516.98±18.03b	61.55±2.2a	2.05±0.07c	12.44±0.3c	10.39±0.2c	6.66±0.13c	41.18±1.4b	34.52±1.05a
S2 (4000 mg L^{-1})	Serw 4	143.29±1.6b	12.75±0.73ef	191.56±15.10f	33.10±1.10c	1.70±0.10e	10.95±0.77e	9.25±0.71e	6.37±0.09d	37.25±1.2d	32.98±1.63ab
	Agamax	129.60±1.90c	11.4±0.89f	130.00±7.74g	26.20±2.11d	1.08±0.04f	8.46±0.41f	7.38±0.39f	6.42±0.05d	34.46±0.8e	29±1.11c
	Trabber	127.23±1.90c	20.79±0.99c	442.38±18.63c	38.84±1.64c	1.95±0.16d	12.35±0.7c	10.40±0.5c	6.80±0.12c	37.12±1.2d	34.71±0.94a

Different small letters within columns indicate that there are significant differences by Duncan's Multiple Range Test at $p \leq 0.05$

Table 5. Effect of interaction between salinity levels and nano-nitrogen fertilizer levels yield and yield characters (Combined data for both 2019/20 and 2020/21seasons)

Studied factor		Plant height (cm)	Number of branches/ plant	Number of Pods/ Plant	Seed weight/ plant (g)	Seed yield (ton/ha))	Biological crop (ton/ha)	Straw weight (ton/ha)	1000 seed weight (g)	Oil %	Protein %
Interaction											
F0 (190kgN/ha)	S0 (tap water)	140.22±3.95abc	17±2.26bc	392.22±75.71 b	50.91±4.95b	2.38±0.06b	13.68±0.45b	11.30±0.40b	7.01±0.14ab	44.75±1.67a	31.99±1.85c
	S1 (2000 mg L^{-1})	136.92±4.06bcd	18.19±2.09bc	317.94±63.16cde	47.63±4.05bc	1.98±0.06e	12.06±0.15d	10.08±0.11d	6.77±0.06 c	45.26±0.91a	35.24±1.54ab
	S2 (4000 mg L^{-1})	132.17±3.12de	15.64±1.13cd	290.83±53.00e	37.47±2.14d	1.75±0.19g	11.51±0.69e	9.76±0.51e	6.63±0.08d	39.50±1.36c	36.44±0.09a
F1 (95kgN/ha+51-nanoN/ha)	S0 (tap water)	144.64±5.33 a	22.92±2.36a	454.61±40.46a	60.60±2.40a	2.57±0.07a	14.88±0.42a	12.31±0.35a	7.09±0.05a	41.47±1.16b	32.23±1.13c
	S1(2000 mg L^{-1})	142.03±4.62 ab	19.33±2.76b	359.00±53.32bc	48.68±4.09bc	2.21±0.07c	13.75±0.19b	11.54±0.21b	6.95±0.08 b	41.01±0.58b	34.57±1.52b
	S2 (4000 mg L^{-1})	137.14±3.42bcd	17.58±1.86bc	286.92±46.26e	37.20±1.59d	1.96±0.19e	12.59±0.67c	10.63±0.48c	6.60±0.17de	38.30±0.25c	35.17±1.07ab
F2 (47.5kgN/ha+51 -nanoN/ha)	S0 (tap water)	135.81±4.31 cd	17.83±2.41bc	335.94±61.44cd	42.81±4.47cd	2.10±0.05d	12.69±0.41c	10.59±0.39c	6.77±0.05 c	38.73±0.51c	26.81±1.48e
	S1 (2000 mg L^{-1})	135.39±3.80 cd	14.28±2.44de	296.39±58.70de	45.89±5.50bc	1.85±0.08f	11±0.24f	9.15±0.21f	6.70±0.08cd	36.81±0.54d	30.17±1.41d
	S2 (4000 mg L^{-1})	135.28±2.71 cd	14.44±1.90de	238.58±51.92f	28.68±1.66e	1.35±0.11h	11.08±0.66f	9.73±0.56e	6.49±0.14ef	36.13±0.51d	30.44±1.01d
F3 (51-nanoN/ha)	S0 (tap water)	131.56±4.20de	15.83±2.50cd	217.22±59.47f	38.83±3.56d	1.99±0.08e	11.68±0.23e	9.70±0.20e	6.64±0.04cd	36.89±0.71d	22.43±1.13f
	S1 (2000 mg L^{-1})	134.11±2.86 e	14.39±1.83de	223.69±53.90 f	37.58±2.14d	1.73±0.07g	9.91±0.39g	8.19±0.41g	6.14±0.12g	34.01±0.72e	25.51±0.91e
	S2 (4000 mg L^{-1})	128.92±3.52 de	12.25±1.62e	202.25±44.45 f	27.49±2.90e	1.25±0.07i	7.17±0.33h	5.92±0.33h	6.40±0.08f	31.17±0.79f	26.87±1.05e

Different small letters within columns indicate that there are significant differences by Duncan's Multiple Range Test at $p \leq 0.05$

Table 6. Effect of interaction between canola Genotypes and nano-nitrogen fertilizer levels on yield and yield characters (Combined data for both 2019/20 and 2020/21 seasons)

Studied factor		Plant height (cm)	Number of branches/ plant	Number of Pods/ plant	Seed weight/ plant (g)	Seed yield (ton/ha)	Biological crop (ton/ha)	Straw weight (ton/ha)	1000 seeds weight (g)	Oil%	Protein%
Interaction											
F0 (190kgN/ha)	Serw 4	149.83±1.80b	12.72±0.42f	224.14±12.18g	40.69±1.60c	1.91±0.11d	12.39±0.28e	10.48±0.19e	7.01±0.10b	44.45±0.6b	36.81±0.63ab
	Agamax	130.19±1.54df	15.17±0.85e	197.94±27.17g	42.21±5.91bc	1.82±0.17 e	11.06±0.54g	9.24±0.37g	6.77±0.06c	38.64±1.35e	29.09±1.23d
	Trabber	129.28±2.52def	24.11±1.18b	578.92±31.80a	53.11±2.97a	2.38±0.08b	13.80±0.42c	11.42±0.35c	6.63±0.08d	46.42±1.29a	37.77±0.61a
F1 (95kgN/ha+5l-nanoN/ha)	Serw 4	156.28±3.48a	14.94±0.83e	311.67±17.22e	44.15±2.74c	2.25±0.09 c	14.15±0.19b	11.90±0.16b	7.09±0.05 a	40.21±0.64d	35.62±0.61b
	Agamax	133.50±2.26de	16.92±1.64d	250.61±39.99f	43.99±3.96c	1.95±0.19d	12.18±0.57e	10.23±0.38e	6.95±0.08b	38.46±0.4e	29.52±0.75d
	Trabber	134.03±2.39 d	27.97±1.67a	538.25±27.40b	58.33±4.38a	2.54±0.07 a	14.90±0.38a	12.35±0.31a	6.60±0.10e	42.11±1.0c	36.82±0.74ab
F2 (47.5kgN/ha+5l-nanoN/ha)	Serw 4	145.22±2.93bc	12.14±0.67f	142.36±8.99 h	31.50±0.91d	1.66±0.08g	11.36±0.31f	9.70±0.27f	6.77±0.05 c	37.60±0.2e	31.24±0.96c
	Agamax	128.17±2.56ef	10.53±1.04g	247.64±51.22f	32.91±2.69d	1.69±0.19fg	10.34±0.44i	8.65±0.27h	6.70±0.08cd	35.54±0.41f	24.28±0.84f
	Trabber	133.08±2.45de	23.89±1.24b	480.92±17.52c	52.97±5.47a	1.96±0.09d	13.07±0.35d	11.11±0.33d	6.49±0.14ef	38.53±0.6e	31.9±0.57c
F3 (5l-nanoN/ha)	Serw 4	142.86±2.37c	9.33±0.43g	102.58±8.00 h	29.45±1.21 d	1.59±0.07 g	9.19±0.65j	7.6±0.61i	6.64±0.04cd	34.71±1.10f	25.27±0.61f
	Agamax	124.75±2.18 f	11.64±1.00g	118.72±10.73h	27.57±3.09d	1.64±0.15fg	8.80±0.73k	7.16±0.60i	6.14±0.12g	32.17±0.71g	22.37±0.94g
	Trabber	126.97±1.83f	21.5±1.18c	421.86±13.48d	46.88±2.71b	1.74±0.14ef	10.78±0.62h	9.05±0.49g	6.40±0.08f	35.20±1.15f	27.17±1.34e

Different small letters within columns indicate that there are significant differences by Duncan's Multiple Range Test at $p \leq 0.05$

Table 7. Effect of interaction between salinity levels, canola genotypes and mineral and nano-nitrogen fertilizers (Combined data for both 2019/20 and 2020/21 seasons).

Studied factor			Plant height (cm)	Number of branches/ plant	Number of Pods/ plant	Seeds weight/ plant (g)	Seed yield (ton/ha)	Biological crop (ton/ha)	Straw weight (ton/ha)	1000 seed weight (g)	Oil %	Protein %
S 0	G1	F0	154.17±3.03bc	13.00±0.95hijkm	186.33±1.17klmn	45.50±1.51efgh	2.33±0.05cdef	13.44±0.12f	11.12±0.07gh	7.50±0.10a	45.52±1.00bc	34.61±0.35bcd
		F1	164.08±5.28a	16.00±2.25fghi	347.5±12.39hi	53.34±1.81cdef	2.54±0.04bc	14.76±0.11c	12.23±0.14c	7.24±0.08b	42.46±0.48def	33.83±1.09cde
		F2	151.25±3.68bcd	12.50±1.04ijklm	119.08±20.35nop	30.58±1.23klmn	1.96±0.02hijk	12.29±0.36gh	10.33±0.36ijkl	6.89±0.12cdef	38.5±0.23hij	28.77±2.28ijkl
		F3	145.17±5.55cdef	9.42±0.79klmn	100.5±3.00op	28.29±2.21mn	1.81±0.07jkl	11.15±0.11ki	9.35±0.18o	6.76±0.01defgh	37.75±0.27ijk	25.33±1.92nop
	G2	F0	131.08±3.04ghij	14.50±0.14ghij	304.17±14.88ij	55.57±16.11bcde	2.22±0.05defg	12.25± 0.00gh	10.03±0.05jklm	6.57±0.02hijkl	38.99±0.35hij	24.93±0.52nop
		F1	139.52±2.71efg	22.17±2.37cde	408.08±19.39fgh	59.22±1.29abcd	2.34±0.06cdef	13.5±0.14ef	11.17±0.10fgh	7.01±0.05bd	37.4±0.36ijk	28.23±1.22jklm
		F2	131.83±3.38ghij	14.08±0.36ghijk	415.17±89.95efgh	38.00±2.50hijklm	2.12±0.08fghi	11.58±0.11ijk	9.46±0.14no	6.68±0.03fghij	37.12±0.24jkl	21.67±0.16q
		F3	125.58±4.35ijk	12.67±0.67ijklm	96.75±3.13op	36.62±2.06hijklm	1.97±0.05ghijk	11.31±0.09ki	9.34±0.13o	6.6±0.02ghijk	34.22±0.54m	18.94±0.22r
	G3	F0	135.42±4.24fghi	27.00±1.01ab	686.17±16.92a	51.67±2.44defg	2.59±0.06b	15.33±0.21b	12.74±0.27b	6.96±0.03cde	49.73±1.75a	36.43±1.56abc
		F1	130.25±0.87ghij	30.58±1.54a	608.25±22.13b	69.25±1.23a	2.83±0.03a	16.38±0.12a	13.55±0.11b	7.03±0.02bc	44.54±1.52cd	34.63±0.59bcd
		F2	129.17±4.37hij	26.92±2.46ab	473.58±25.91def	59.84±0.42abcd	2.22±0.08defg	14.19±0.15d	11.97±0.17a	6.74±0.09efghi	40.57±0.11fgh	30±0.87ghijk
		F3	130.83±2.32ghij	25.42±1.54bc	454.42±14.84defg	51.58±1.87defg	2.19±0.16efgh	12.59±0.09gh	10.40±0.17cd	6.55±0.06hijkl	38.7±0.33hij	23±1.04pq
S 1	G1	F0	151.58±1.66bcd	11.67±0.51ijklmn	251.58±24.64jk	39.67±2.60hijklm	1.74±0.01klmn	11.60±0.16ijk	9.86±0.15lmn	6.85±0.01cdefg	45.39±1.06bc	37.33±0.09ab
		F1	157.17±4.92ab	13.17±0.68hijkl	341.92±7.52hi	43.00±3.23fghij	2.02±0.10ghij	14.2±0.09d	12.19±0.12c	7.21±0.06 b	39.82±0.15ghi	36.20±0.72abc
		F2	142.33±5.17def	12.17±1.39ijklm	152.5±11.14mnop	33.42±2.05ijklmn	1.55±0.05mno	10.32±0.18mn	8.78±0.21p	6.44±0.01jklm	37.15±0.07jkl	33.13±0.73def
		F3	143.75±0.88def	8.50±0.80lmn	130.67±4.09nop	31.24±3.14klmn	1.5±0.07 no	9.67±0.15o	8.17±0.21q	6.62±0.04ghijk	35.31±0.22klm	25.7±0.38mnop
	G2	F0	130.33±4.24ghij	17.67±1.82efgh	142.08±5.42mnop	40.06±1.69hijkl	2.11±0.04fghi	12.03±0.13hi	9.93±0.09jklmn	6.61±0.02ghijk	42.77±1.70def	29.33±1.17hijkl
		F1	129.08±3.60hij	14.67±0.82ghij	185.75±4.18klmn	38.88±2.16hijklm	2.29±0.1def	13.07±0.14f	10.79±0.06hi	6.73±0.09efghi	39.96±0.17ghi	28.83±0.73ijkl
		F2	125.67±3.92ijk	8.25±0.72mn	211.75±6.11klm	37.90±1.11hijklm	2.01±0.08ghij	10.77±0.11im	8.76±0.18p	6.71±0.02efghi	34.82±0.10 lm	24.67±0.6op
		F3	130.00±2.31ghij	14.00±1.44ghijk	161±4.77imno	29.00±3.21lmn	1.92±0.01ijk	8.76±0.36p	6.84±0.36r	5.86±0.06 p	31.34±0.90 n	23.17±0.44pq
	G3	F0	128.83±3.93hij	25.25±1.64bc	560.17±15.17bc	63.17±2.47abc	2.1±0.04fghi	12.55±0.04g	10.45±0.05ijkl	6.85±0.14cdefg	47.62±0.28 ab	37.83±0.17a
		F1	139.83±4.32efg	30.17±1.37a	549.33±27.79bc	64.17±1.41ab	2.33±0.03cdef	13.98±0.16de	11.65±0.19def	6.91±0.08cdef	43.27±0.41cde	38.67±0.6a
		F2	138.42±5.13efgh	23.25±1.61bcd	524.92±33.85 cd	66.36±6.23 a	2±0.09ghij	11.9±0.02hij	9.9±0.1klmn	6.95±0.07cde	38.45±0.42hij	32.7±0.35defg
		F3	128.42±2.32hij	20.67±0.65de	433.5±5.97efg	52.50±1.81cdef	1.77±0.08ghi	11.31±0.06ki	9.55±0.06mno	5.95±0.04op	35.39±0.11klm	27.67±2.13klmn
S 2	G1	F0	143.92±3.86def	13.50±0.29hijk	234.5±5.27jkl	36.92±1.50hijklm	1.67±0.12lmno	12.11±0.04gh	10.44±0.1ijkl	6.43±0.11cdef	42.42±0.64def	38.5±0.76a
		F1	147.58±4.93cde	15.67±0.58fghi	245.58±7.98jk	36.13±1.73hijklm	2.19±0.13efgh	13.48±0.06ef	11.3±0.1fgh	6.32±0.19 b	38.36±0.55hij	36.83±0.44ab
		F2	142.08±7.59def	11.75±1.52jklmn	155.50±4.85mnop	30.50±1.21 no	1.47±0.04op	11.47±0.11jk	10.00±0.11jklm	6.03±0.17cde	37.15±0.07jkl	31.83±0.44defgh
		F3	139.50±3.61efg	10.08±0.58jklmn	76.58±2.70 p	28.84±0.58 o	1.46±0.09op	6.74±0.11q	5.27±0.19s	6.68±0.09 no	31.07±1.72n	24.77±0.62op
	G2	F0	129.17±0.67hij	13.33±0.58hijk	147.58±11.81mnop	31.00±1.52klmn	1.14±0.01qr	8.9±0.10p	7.76±0.11q	6.57±0.01jklm	34.17±0.40m	33±0.29def
		F1	131.83±6.54ghij	13.92±2.24ghijk	158.00±3.25imno	33.88±1.19ijklmn	1.23±0.11q	9.96±0.27no	8.73±0.17p	6.28±0.15lmn	38.03±0.36hij	31.5±1.32efghi
		F2	127.00±3.13ijk	10.08±0.85jklmn	116.00±3.84nop	22.83±1.74klmn	0.93±0.05r	8.66±0.18p	7.73±0.2q	6.48±0.07 op	34.68±0.26im	26.5±1.44lmno
		F3	118.67±0.30k	7.42±0.94n	98.42±2.96op	17.08±1.83lmn	1.04±0.06qr	6.34±0.11q	5.30±0.15s	6.37±0.01fghij	30.96±1.30n	25±0.87nop
	G3	F0	123.58±2.71jk	20.08±0.36def	490.42±42.11cde	44.50±2.18fghi	2.43±0.11bcde	13.51±0.15ef	11.08±0.13gh	6.88±0.09hijkl	41.89±0.63efg	39.05±0.53a
		F1	132.00±4.78ghij	23.17±3.44bcd	457.17±44.17def	41.58±3.18ghijk	2.47±0.03bcd	14.32±0.08cd	11.85±0.06cde	7.2±0.03mn	38.52±0.52hij	37.17±1.3ab
		F2	131.67±1.92ghij	21.5±1.52cde	444.25±14.15efg	32.72±1.37jklmn	1.65±0.04lmno	13.11±0.32f	11.46±0.34efg	6.95±0.02ijklm	36.57±1.15jklm	33±0.58def
		F3	121.67±2.60jk	18.42±1.08efg	377.67±18.69ghi	36.56±1.12hijklm	1.26±0.03pq	8.45±0.19p	7.19±0.21r	6.16±0.03klmn	31.50±1.65n	30.83±0.6fghij

S0 Control, S1 (2000 ppm), S2(4000 ppm)- G1: (Serw4) – G2: (Agamax) – G3: (Trabber)- F0(190kg N/ha) – F1(95kg N/ha+5lNano N/ha)- F2(47.5kg N/ha+5lNano N/ha)- F3(5lNano N/ha). Different small letters within columns indicate that there are significant differences by Duncan's Multiple Range Test at *$p \leq 0.05$*

3.6 Principal component analysis biplot

Principal component analysis was employed to study the relationship among the assessed treatments and traits as displayed in **Fig 2**. The first two PCAs exhibited 72.77% of the variability. The PCA1 accounted for 53.94% of the variation and was associated with the level of assessed treatments of nitrogen fertilization on canola under salinity stress conditions in different levels from the nanoscale nitrogen only under salinity stress conditions on the extreme left. The integrated between mineral and nanoscale nitrogen under salinity stress conditions on canola the extreme right. The high levels of treatments (F0 and F1) of canola under all treatments of salinity stress conditions had slight multi-dimensional space as it is exhibited by small distances of plots along PCA1compared to the F2 and F3 of canola under all treatments of salinity stress conditions. The evaluated plant height, number of branches /plant, number of pods /plant, seeds weight /plant, 1000 – seed weight, seed yield, straw yield and biological yield and quality traits were positively associated with the F0 and F1 of canola under all treatments of salinity stress on the PCA1, as projected from the aforementioned displayed results.

4 Discussion

Newly reclaimed sandy soils suffer from a lack of nitrogen and many natural stresses. Therefore, it is necessary to develop the varieties and needed treatments to increase the tolerance of the plants and increase their growth and yield under these poor conditions. Findings of the current research clarified the differential response of canola varieties for yield, yield components and quality traits (**Tables 3, 4, 5, 6 and 7)**. This indicates the diverse potential among canola varieties to tolerate salinity stress and respond to the complementarity between mineral nitrogen fertilization and nano-nitrogen foliar application due to their different genetic background. Where the genotype Trabber irrigated by tap water (control) when fertilized with 95 kg N/ha + foliar application with 5l nano-N /ha achieved the highest values of number of branches/plants, seed weight/plant and seed yield. Moreover, yield rates in three assortments diminished within the presence of NaCl concentrations (Abili and Zare 2014). Moravveji et al (2017) observed that salinity had a significant detrimental impact on of parameters with high salt levels, including seed number, number of pods per secondary branch, number of pods per main branches, weight per pod, pod length, dry matter, days to physiologic maturity, and seed yield. Seed yield substantially correlated with the number of branches, number of pods per main and secondary branches, dry matter, date to physiologic maturity at various salinity levels. Number and length of secondary pods the quantity of major pods had the most direct positive effect on seed yield. Rameeh (2012) showed that evaluation of canola under salinity levels of irrigation water 0, 4, 6, 8 and 12 dsm^{-1}. The studied characteristics were plant height, number of pods per plant, pod length, 1000-seed weight and seed yield. As salinity levels increased, decreased other all traits with high salinity levels. There is no significant difference between the first and second levels of salinity for all study characteristics. Akhtar et al (2002) indicated that at salinity levels of 4.75 and 6.0 dSm^{-1}, *B. napus* seed had the highest seed oil content, followed by *B. carinata,* and *B. compestris*. However, at salinity level of 3.0 dSm^{-1}, *B. carinata* seed had the highest oil content, while *B. napus* had the highest oil content at level of 9.5 dsm^{-1}, and this rise in oil content was 15.4 % higher than *B. carinata*, *B. juncea*, and *B. compestris*, respectively.

Many researchers reported significant differences in growth and yield traits among canola varieties in response to N rates. Nitrogen is a basic supplement for plant development and may be a key limiting factor in agro-ecosystems. Nitrogen could be a constituent of amino acids, which are required to synthesize proteins and other related compounds. It plays a part in nearly all plant metabolic forms (Mekki 2013). Increasing N fertilizer rates significantly increased yield and its components (Zangani 2021). N enhance metabolites synthesized by plant which lead to more transformation of photosynthesis to reproductive parts and induce different physiological mechanisms to access the nutrient (Ahanger et al 2017). Canola yield and its components, the number of pods, flowers per plant, total plant weight and harvest index in some varieties of canola have been found to increase with increasing rates of nitrogen (Ganya et al 2018). The maximum rates of fertilizer application were found to give significantly higher total dry matter than the minimum rate of fertilizer application (Yahbi et al 2022).

Nano fertilizers are crucial instruments in agriculture to increase nutrient usage efficiency, lower fertilizer waste, and lower cultivation costs while also enhancing crop growth, yield, and quality traits. With the ability to match the crop growth stage for nutrients and perhaps give nutrients throughout the crop growth

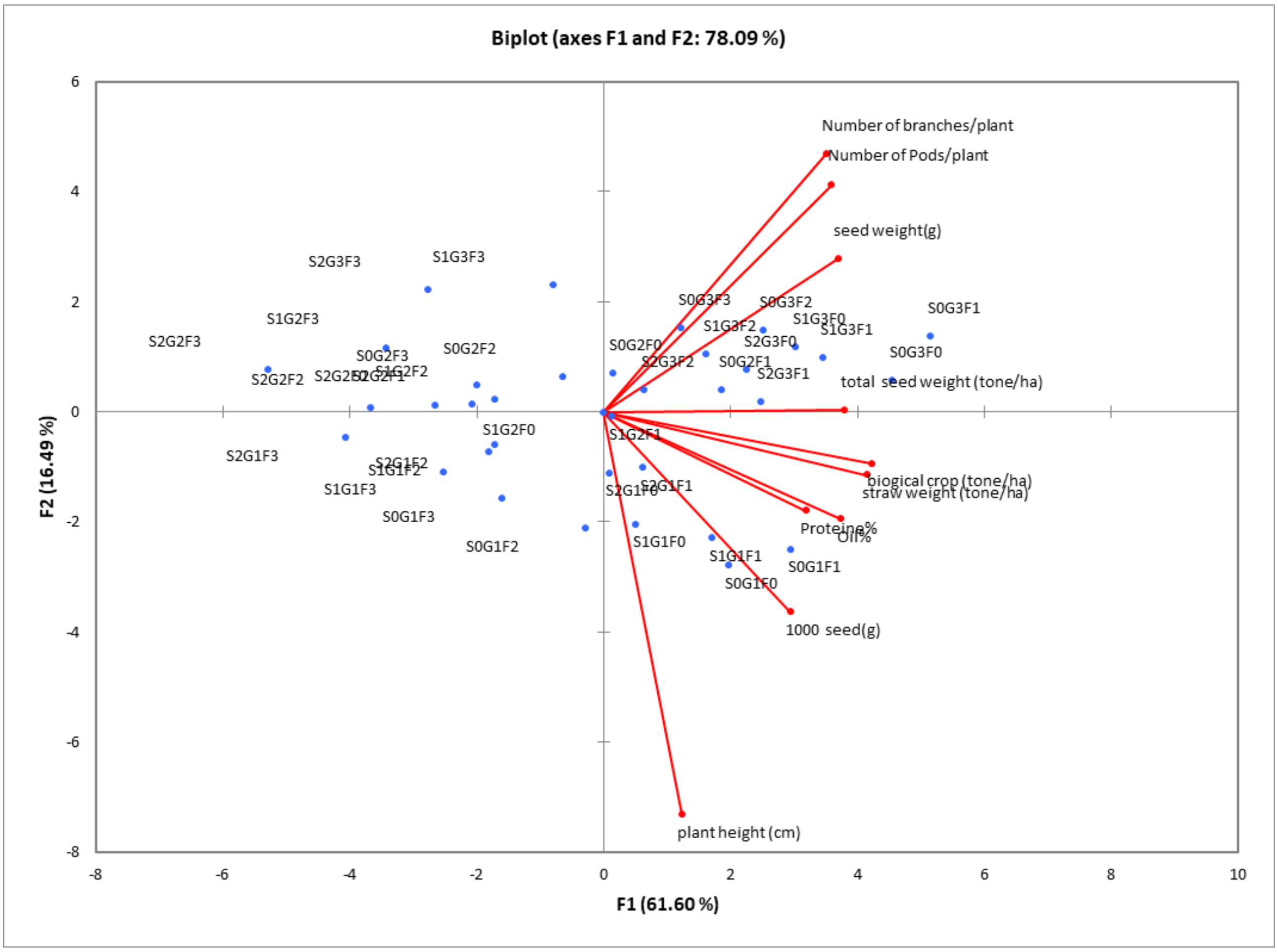

Fig 2. Principal component analysis (PCA) biplot for the assessed treatments of nitrogen fertilization on canola under salinity stress conditions in different levels and the evaluated traits over the two growing seasons

period, nano-fertilizers are particularly useful for accurate nutrient management in precision agriculture. Nano-fertilizers provide the plant's various metabolic processes additional surface area, which speeds up photosynthesis and increases the amount of dry matter and crop output. Additionally, it protects the plant from many biotic and abiotic stresses. Discharge of nitrogen in the nanohybrid composite created utilizing solvent aided grinding procedures, the rate of N release was noticeably slower. Studies with Oryza sativa (rice) showed that the plant nano N nutrition significantly increased yield. Application of nano fertilizers greatly increases crop output over control or without. The use of nano fertilizers increase of plant components in addition to metabolic processes like photosynthesis increases the amount of photosynthets accumulated. Relocation to the areas of the economy plant. Nanoparticles applied topically as fertilizer dramatically boosts crop yields crop (Qureshi et al 2018). Valojai et al (2021) deduced that NPK nano fertilizers significant increases of yield and its attributes. Alwakel et al (2021) obtained that application nitrogen fertilizer with rate (40 kg N +20% nano. N/ fed) gave the highest seed yield and 1000 seed weight.

5 Conclusions

In the current study, compared to Serw 4, Agamax and Traber genotypes and integrated between mineral and nano-nitrogen under salinity stress conditions. Where, Traber genotype showed higher yield components, yield, and quality under normal and salinity stress conditions. Therefore, Traber genotype must be taken into account for its high productivity under normal and salinity stress conditions. Application of integration between 190 kg N/ha (50% of the recommended dose) + foliar application with nanoscale nitrogen 5 L/ha showed superiority over all application treatments studied under normal and salinity stress conditions.

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