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RESEARCH PAPER

Influence of Combination Between Fertilizer Treatments and Nipping on Growth, Yield and Quality of Sesame (*Sesamum indicum L.)*

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A B S T R A C T:

A field experiment was undertaken during the summer growing season of 2021 at two locations (Grdmala with GPS reading of latitude 36. 01061N, longitude 44. 05854E and elevation of 413.8 meters above sea level and Grdarasha with GPS reading of Latitude 36.10116 N, Longitude 44.00925 E, and elevation of 415 meters above sea level) - Erbil Governorate to study the influence of five fertilizer treatments [Control, recommended fertilizer (NPK), Nano-NPK, Humic acid and Nano-NPK+ Humic acid] and two nipping practice [without Nipping and with Nipping] on some growth, yield and quality parameters of sesame crop (Somar genotype), using factorial RCBD with three replicates.The results indicated a significant effect of the studied factors and their combination on the studied characteristics. The maximum seed yield (3.23 and 2.45) t ha^{-1} was recorded from sprayed with Nano-NPK+ Humic acid and Nano-NPK, while the lowest values (2.41 and 1.43) t ha^{-1} was recorded from control in both locations respectively. While the highest seed yield value (3.09 and 2.13) t ha^{-1} were obtained from nipping practice. On the other hand, the combination treatment of (Nano-NPK+ Humic acid * Nipping) and (Nano-NPK * Nipping) were recorded the highest seed yield which were (3.77 and 2.61) t ha^{-1} respectively. The highest oil values (57.71 and 59.49) % was observed from Nano-NPK+humic acid and treatment combination of (Nano-NPK+ Humic acid* Nipping) respectively. Furthermore, the results shows that Grdmala surpassed Grdarasha in most of the studied parameters.

KEY WORDS: Sesame; Fertilizer treatments; Nipping; Growth; Yield; Quality of sesame oil.
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1. INTRODUCTION:

Sesame (*Sesamum indicum* L.) is an important oilseed crop adapted to the tropics and subtropics zone belongs to Pedaliaceae family, its oil well known as "Queen of oilseed crops" because of its excellent quality. It is the oldest indigenous oil plant with longest history of cultivation. Sesame is an edible oilseed crop grown all over the world for its importance in food, medicine and industries (Islam, 2010). Sesame contains a very high oil (32.8 – 62.7) %, and contains important and predominant fatty acids (37–47) % linoleic, (35–43) % oleic acid, and low saturated fatty acid palmitic (8–11%) and stearic acid (5–10) %, the seeds contain also (14.1–29.5) % proteins, (4.3–20.5) % carbohydrates, (4.2– 6.9) % ash, and (2.7– 6.7) % fiber, along with vitamin E, minerals, lignans (sesamolin and sesamin), and tocopherols (Couch et al., 2017).

Nagendra Prasad et al. (2012) informed that both seeds and oil had a valuable worth in medical field and pharmaceutical science that's why both are used in many health cure inventions. Nanotechnology is emerging out as the greatest imperative tools in recent agriculture and predictable to become a driving economic force in the near future. At the same time nanotechnology employs different chemical agents and novel delivery systems to implement crop productivity and potentials to decrease use of bulk agrochemicals, nanotechnology may afford keener solutions for the current problems in the field of agriculture. Nanotechnology improves the nutrient

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use efficiency and reduces costs of environmental protection (Abobatta, 2018). Furthermore, humic acid (HA) is one of the main organic fertilizers, it is an important component which produced by the chemical and biological decomposition of organic material. It has an important role as a vital component of soil organic matter which improves the growth of many plant species due to enhances of soil fertility and improves soil physical and chemical characteristics (Tan, 2003). Humic acid is an organically charged bio-stimulant that significantly affects plant growth and development and increases crop yield (Hivare et al., 2019). Nipping or clipping of terminal bud removing which activates the dormant lateral buds to produce more branches, it is an important operation for increasing the sesame yield. This could be attributed to overall improvement in plant vigor leading to initiation of larger number of branches and ultimately better manifestation of yield attributes in sesame (Kithan and Singh, 2017). Nipping of the terminal bud at 30 days after sowing significantly increased the sesame seed yield (Korhale et al., 2012). Kokilavani et al. (2007) demonstrated that nipping practice done at different intervals of growing phases, nipping showed its supremacy over no nipping treatment for the yield and uptake of nutrient. The nipping practice of sesame necessitated the increased uptake of nutrients from the soil and this might be the cause for the increased uptake of NPK. Meanwhile considering the importance of Nano NPK, humic acids and nipping practices and their combination as growth-limiting factors and plant production are few or there were no studies about the role of the mentioned factors, so the current research was suggested to study influence of Nano NPK, humic acids nipping and their combination in improving growth, yield and quality of sesame (*Sesamum indicum* L.) at two different locations.

2. MATERIALS AND METHODS

The experiment implies that each combination treatment was represented by the combination of levels of two factor:

Factorial experiment based on Randomized Complete Block Design (RCBD) with three replications was conducted to study the influence of two factors and their combination on growth traits, yield and its component and quality of sesame (*Sesamum indicum* L.). The studied factors are:

1-Fertilization factor is foliar application of 5 fertilization treatments that were control, recommended NPK, Nano-NPK, Humic acid and Nano-NPK plus Humic acid.

2- Nipping factor which included control (non-nipping) and nipping.

First factor includes fertilizer placement methodology which include:

a. Control

b. Recommended fertilizer: NPK (18:44: 0) at rate of 240 kg ha^{-1} which applied twice, first at pre-reproductive stage during 50% open flowers and second at reproductive stage during mid bloom stage in which branches and minor plants stop flowering (Langham, 2008).

c. Humic acid at rate of (3.5 kg ha^{-1}) were applied two times, first at reproductive stage in 5 node pairs of capsules during early bloom stage and second time at reproductive stage in branches and minor plants stop flowering during mid bloom stage.

d. Nano – NPK 20.20.20 (Foliar application) at rate of (1kg ha^{-1})

e. Combination between Humic acid + Nano – NPK (Humic acid 3.5 kg ha^{-1} + 1kg ha^{-1} Nano - NPK) were applied two times same as humic acid and Nano NPK

Second factor: Nipping processes which include two levels:

a. Control (Without Nipping)

b. Nipping: were done 38 days after planting.

The number of combination treatment were 5*2= 10 and total number of experimental units = 5*2*3=30 for each location. The field was subjected to evaporation the soil was plowed by mold board plow and rotivator to soften the soil, table (1) exhibits some selected physical and chemical properties of the soil of the experimental site. The field was divided to 3 replicates, the dimensions of each experimental unit were (1*2) m, and each unit contained five rows, with row spacing of (50 cm) and distance between plants were (20 cm). On 21th and 22th May, 2021, the seeds were sown manually at (1-2) cm depth in both locations respectively. Then simultaneously irrigated using drip irrigation system, meteorological data taken for both locations as presented in (table 2), hand weeding practiced done as needed, all other cultural practices were followed according to standard recommendations for the locality. The plants were harvested on 28th

and 29th September ,2021 by hand in both locations.

Table 1. Some physical and chemical properties of the studied field before planting.

Soil properties		Units		Grdmala	Grdarasha
Particle Size Distribution	Sand	(g kg^{-1})		118	100.54
	Silt			432	480
	Clay			450	419.46
Textural Name				Silty clay loam	Silty clay loam
Soil pH				7.86	7.65
ECe		dSm^{-1}		0.50	1.23
Organic matter content		(g kg^{-1} soil)		9.76	11.77
Calcium carbonate				250	312.00
Total nitrogen		(mg g^{-1}soil)		0.80	2.35
Available Phosphorous		(µg g^{-1} soil)		9.3	3.42
Soluble ions		Ca^{2+}	Mmolc L^{-1}	2.50	1.99
		Mg^{2+}		1.55	1.88
		Na^{+}		0.95	0.72
		K^{+}		1.14	0.09
		HCO_3^{-}		3.50	3.22
		CO_3^{2-}		0	0
		Cl^{-}		2.3	1.07

***The soil properties tests were conducted at the Directorate of Agriculture Research Center/Erbil**

Table 2. Meteorological data for Grdmala and Grdarasha fields during growing season of 2021.

Grdmala location				Grdarasha location			
Month	Max Tepm.	Min Temp.	RH	Month	Max Tepm.	Min Temp.	RH
May	36	21.8	17.3	May	43.00	18.1	17.3
Jun	39.4	23.9	13.3	Jun	46.7	20.1	13.5
July	42.8	28.6	13.4	July	47.8	25.1	14.2
Aug	42.4	28.2	13.7	Aug	46.2	23.9	14.3
Sep	36.4	21.5	18.9	Sep	44.7	16.3	19.4

2.1: Sesame traits determination

Representative samples of 10 plants were taken from the inner rows for each experimental unit during physiological maturity stages to study the following characters:

2.1.1 Plant height (cm)

The plant height was determined from the soil surface to the top of the plant then average was calculated.

2.1.2 Height of first capsule (cm)

The height of first capsule was measured from soil surface to the first capsule.

2.1.3 Number of primary branches (branches plant^{-1})

2.1.4 Number of secondary branches (branches plant^{-1})

2.1.5 Chlorophyll content index (SPAD)

SPAD (Soil Plant Analysis Development) used with model Atleaf (CHL STD) as a hand-held device has been used for recording chlorophyll concentration in leaves before blooming (Thakur et al., 2013). For this purpose, measurements were done on three leaves (lower, middle, and upper) from five labeled plants at two different times. The total number of readings were 30 per experimental unit.

2.2 Sesame measurement at maturity stages included yield component

2.2.1 Number of capsules plant^{-1}

Total number of capsules of the ten labeled plants were separated by hand and calculated, then their average number was determined.

2.2.2 Number of seeds capsule^{-1}

Number of seeds were separated from 50 randomly capsules from the ten selected plants, then their mean number was calculated.

2.2.3 Seed index (weight of 1000 seeds) (g)

Thousand seeds were selected randomly from each experimental unit, then weighted and expressed in grams.

2.3 Yield measurements

2.3.1 Biological yield (t ha^{-1})

From each experimental unit all plants were weighted, then converted to (t ha^{-1}) to determine biological yield.

2.3.2 Seed yield (t ha^{-1})

The seeds for the all plants of each experimental unit were threshed, sieved and impurities were removed and weighed, then converted to t ha^{-1}.

2.4 Quality measurement

2.4.1 Oil content %

Determination done using the Soxhlet apparatus for oil extraction as mentioned by the Association of Official Analytical Chemists (A.O.A.C, 1980).

2.4.2 Protein content %

The total nitrogen content was determined by the micro-Kjeldahl digestion method.

Protein percent was determined according to the equation described by (Elsahookie and Waheeb, 1990) as follow: Protein % = N % x 6.25

2.5 Statistical analysis:

The data were statistically analyzed according to the technique of analysis of variance (ANOVA) for randomized complete block design (RCBD) using SPSS program version 26, the difference among means of treatments were tested using Duncan's multiple range test at level of significant 5%. The charts were drawn using Excel software package, simple correlation coefficient was calculated among all the studied traits (AL-Rawi and Khalaf-allah, 1980).

3. RESULTS

3.1 Effect of fertilizer treatments, nipping and their combination on some morphological parameters

3.1.1 Plant height

According to the data presented in table 3 there was a significant increase in plant height due to fertilizer treatments in both locations, the maximum plant height was noticed from the application of recommended fertilizer for Grdmala and Nano NPK+humic acid for Grdarasha (140.45 and 130.18 cm) whilst, the minimum plant height (128.30 and 116.28 cm) was recorded for control treatments at Grdmala and Grdarasha respectively. Like type of fertilizers, the nipping practice significantly affected on plant height. The maximum mean value of plant height (135.05 and 125.65 cm) was recorded for no nipping treatment and minimum value for nipping treatment (133.50 and 122.70 cm) at both locations respectively. The statistical analysis of the data revealed that the combination between fertilizers and nipping showed that the highest values (140.60 and 131.75) cm were recorded from combination treatment of (recommended fertilizer *no nipping) and (Nano NPK+humic acid fertilizer* no nipping) for both locations respectively. On the other hand, the lowest values (128.05 and 113.75cm) were noted from combination treatment (control * no nipping) and (control *nipping) for both locations respectively.

Table 3. Plant height (cm) response to fertilizer treatments, nipping and their combination.

Fertilizer treatments	Locations					
	Grdmala L_1			Grdarasha L_2		
	Non-nipping	Nipping	Mean of Fertilizers	Non-nipping	Nipping	Means of Fertilizers
Control (F_1)	128.05^{c}	128.55^{bc}	128.30^{c}	118.80^{cd}	113.75^{d}	116.28^{c}
Recommended NPK (F_2)	140.60^{a}	140.30^{a}	140.45^{a}	125.40^{abc}	121.45^{bc}	123.43^{b}
Humic acid (F_3)	140.20^{a}	130.90^{bc}	135.55^{ab}	123.10^{bc}	125.10^{abc}	124.10^{b}
Nano NPK (F_4)	135.85^{ab}	131.80^{bc}	133.83^{b}	129.20^{ab}	124.60^{abc}	126.90^{ab}
Nano NPK + Humic acid (F_5)	130.55^{bc}	135.95^{ab}	133.25^{bc}	131.75^{a}	128.60^{ab}	130.18^{a}
Means of Nipping	135.05^{a}	133.50^{b}		125.65^{a}	122.70^{b}	

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range Test.

3.1.2 Height of first capsule

Height of first capsule was significantly affected by application of fertilizers, nipping and their combination. According to the data presented in table 4, control treatment, no nipping and the combination treatment control*no nipping recorded lowest height of first capsule with values (20.25,20.70 and 18.00) cm and (20.25,20.59 and 19.20) cm at both locations respectively. Additionally, table 4 indicated that the recommended fertilizer treatment, nipping and the combination treatment humic acid* nipping recorded highest height (23.28,23.85 and 25.90) cm in Grdmala location. Whilst in Grdarasha location Nano NPK+humic acid treatment, nipping and the combination treatment humic acid *nipping recorded the highest with values (21.38,21.50 and 22.20) cm respectively.

Table 4. Height of first capsule (cm) response to fertilizer treatments, nipping and their combination.

Fertilizer treatments	Locations					
	Grdmala L_1			Grdarasha L_2		
	Non-nipping	Nipping	Mean of Fertilizers	Non-nipping	Nipping	Means of Fertilizers
Control (F_1)	18.00^{c}	22.50^{ab}	20.25^{b}	19.20^{d}	21.30^{abc}	20.25^{b}
Recommended NPK (F_2)	21.00^{bc}	25.55^{a}	23.28^{a}	20.77^{bc}	21.70^{ab}	21.23^{a}
Humic acid (F_3)	20.05^{bc}	25.90^{a}	22.98^{ab}	20.20^{cd}	22.20^{a}	21.20^{a}
Nano NPK (F_4)	23.85^{ab}	21.57^{abc}	22.71^{ab}	20.80^{bc}	21.48^{abc}	21.14^{a}
Nano NPK + Humic acid (F_5)	20.60^{bc}	23.75^{ab}	22.18^{ab}	21.97^{ab}	20.80^{bc}	21.38^{a}
Means of Nipping	20.70^{b}	23.85^{a}		20.59^{b}	21.50^{a}	

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range test.

3.1.3 Number of primary branches plant^{-1}

The number of primary branches plant^{-1} were significantly affected by the application of

fertilizers. The maximum mean value was (4.23) branches plant^{-1} which obtained from recommended fertilizer as compared with control treatment which was (3.63) branches plant^{-1} for Grdmala location. While at Grdarasha the maximum mean value (4.28) branches plant^{-1}

which obtained from application of humic acid as compared with control (2.98) branches plant^{-1}. It is evident from table 5 that nipping attributed the increase in number of primary branches in both locations, the maximum value (4.49 and 3.96) branches plant^{-1} obtained from nipping treatment meanwhile the minimum values were (3.51 and 3.37) obtained from no nipping treatment respectively. In the same table it is clear that, the maximum value (4.95 and 4.55) branches plant^{-1} was documented from combination treatment of (Nano NPK * nipping) and (Nano NPK+humic acid* nipping) at both locations respectively, no fertilizer application with no nipping resulted in lowest number in primary branches with values (3.25and 2.95) branches plant^{-1} for both locations respectively.

Table 5. Number of primary branches plant^{-1} response to fertilizer treatments, nipping and their combination.

Fertilizer treatments	Locations					
	Grdmala L_1			Grdarasha L_2		
	Non-nipping	Nipping	Mean of Fertilizers	Non-nipping	Nipping	Means of Fertilizers
Control (F_1)	3.25^{e}	4.00^{bc}	3.63^{a}	2.95^{b}	3.00^{b}	2.98^{d}
Recommended NPK (F_2)	3.60^{de}	4.85^{a}	4.23^{a}	3.27^{b}	3.37^{b}	3.32^{c}
Humic acid (F_3)	3.70^{cd}	4.35^{b}	4.03^{ab}	4.10^{a}	4.45^{a}	4.28^{a}
Nano NPK (F_4)	3.45^{de}	4.95^{a}	4.20^{a}	3.35^{b}	4.45^{a}	3.90^{b}
Nano NPK + Humic acid(F_5)	3.55^{de}	4.30^{b}	3.93^{b}	3.20^{b}	4.55^{a}	3.88^{b}
Means of Nipping	3.51^{b}	4.49^{a}		3.37^{b}	3.96^{a}	

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range test.

3.1.4 Number of secondary branches plant^{-1}

The presented data in table 6 reveled that fertilizer treatments affected significantly on number of secondary branches plant^{-1}. The highest and lowest values (3.21and 2.20) branches plant^{-1} was recorded from the recommended fertilizer and control treatment at Grdmala location. Whereas at Grdarasha location the maximum mean value (3.64 branches plant^{-1}) obtained from Nano NPK application compared to the control treatment which was (2.68 branches plant^{-1}). Also, significant difference was observed on secondary branches plant^{-1} due to nipping practice, the maximum values were (3.37 and 3.53) branches plant^{-1} noted for nipping practice whilst, the lowest values were (2.20 and 3.01) branches plant^{-1} for no nipping at Grdmala and Grdarasha location respectively. Additionally, the combination among the fertilizer and nipping on number of secondary branch plants^{-1} shown in table 6. Result noted that the maximum value for Grdmala was (3.85) recorded from the combination treatment (recommended fertilizer* nipping) for Grdarasha was (4.10) which recorded for (Nano NPK* nipping) and the minimum value (1.95and 2.40) for (control* no nipping) in both locations respectively.

Table6.Number of secondary branches plant^{-1} response to fertilizer treatments, nipping and their combination.

Fertilizer treatments	Locations					
	Grdmala L_1			Grdarasha L_2		
	Non-nipping	Nipping	Mean of Fertilizers	Non-nipping	Nipping	Means of Fertilizers
Control (F_1)	1.95^{d}	2.45^{cd}	2.20^{d}	2.40^{c}	2.95^{bc}	2.68^{b}
Recommended NPK (F_2)	2.57^{c}	3.85^{a}	3.21^{a}	3.00^{bc}	3.65^{ab}	3.33^{ab}
Humic acid (F_3)	2.20^{cd}	3.10^{b}	2.65^{c}	3.50^{ab}	3.75^{ab}	3.63^{a}
Nano NPK (F_4)	2.30^{cd}	3.80^{a}	3.05^{ab}	3.17^{abc}	4.10^{a}	3.64^{a}
Nano NPK + Humic acid (F_5)	1.97^{d}	3.65^{a}	2.81^{bc}	3.00^{bc}	3.20^{abc}	3.10^{ab}
Means of Nipping	2.20^{b}	3.37^{a}		3.01^{b}	3.53^{a}	

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range test.

3.1.5 Chlorophyll content (Soil Plant Analysis Development (SPAD) reading)

The data in fig.1 portrays the SPAD value as an index of chlorophyll content as influenced by fertilizer treatments, each value represents mean value of SPAD. As per the findings, a substantial difference was found among the fertilizer treatments for producing SPAD values. It ranged between (52.46 and 58.15) and (55.42and 61.28) for first and second reading, being the lowest with un treated plot and the highest with application of recommended fertilizer at Grdmala location. While at Grdarasha the SPAD reading ranged between (48.18 to 52.37) and (63.57 and 66.88), resulted from humic acid and recommended fertilizer in first and second readings obtained at Grdarasha. As per finding nipping practice significantly affected the chlorophyll content of leaves. It ranged between (56.82 and 54.46) and (59.41 and 58.15) respectively for first and second reading at Grdmala location. Whereas at Grdarasha it ranged between (51.09 and 50.53) and (66.12 and 64.91) for first and second reading, that being the heights with no nipping treatment and the lowest with nipping treatment at both locations. The combination among the fertilizer and nipping on the chlorophyll content in leaf as shown in fig.1 The results noted that the maximum was (58.23and 62.29) which was recorded from the combination treatment of (recommended fertilizer* nipping) and minimum value for control (50.04 and 52.89) for (Control* nipping) at Grdmala for first and second reading. Conversely, at Grdarasha highest value (53.10 and 67.25) was recorded from the combination between (humic acid *no nipping) and (recommended fertilizer*no nipping) in first and second reading as compare to combination treatment of (Control* no nipping) and (control* nipping) which were (48.07 and 62.81).

3.2 Effect of fertilizer treatments, nipping and their combination on sesame yield component at maturity

3.2.1 Number of capsules plant^{-1}

Table 7 clarified that fertilizer affected significantly on number of capsules plant^{-1} at both locations. The highest and lowest values for both locations were (312.35 and 304.35) and (206.93 and 225.00) capsules plant^{-1} respectively. Close examination of table 7 revealed that the number of capsule plant^{-1} was improved significantly due nipping practice, the highest values were (301.48 and 287.83 capsules plant^{-1}) for both Grdmala and Grdarasha locations respectively, while no nipping treatment recorded the lowest values which were (260.56 and 261.12) capsules plant-^{1} respectively. The two-factor combination (fertilizer treatments and nipping) were also found to be significant on the studied traits, the highest and lowest values were (330.65 and 165.65) and (328.70 and

220.35) capsules plant^{-1} were recorded for (Nano NPK+humic acid* nipping), (control* no nipping) and (control * nipping) at both locations respectively.

Table 7. Number of capsules plant^{-1} response to fertilizer treatments, nipping and their combination.

Fertilizer treatments	Locations					
	Grdmala L_1			Grdarasha L_2		
	Non-nipping	Nipping	Mean of Fertilizers	Non-nipping	Nipping	Means of Fertilizers
Control (F_1)	165.65^{c}	248.20^{b}	206.93^{b}	229.65^{cd}	220.35^{d}	225.00^{c}
Recommended NPK (F_2)	280.80^{ab}	297.50^{a}	289.15^{a}	236.50^{cd}	280.15^{b}	258.33^{b}
Humic acid (F_3)	308.65^{a}	314.45^{a}	311.55^{a}	303.40^{ab}	305.30^{ab}	304.35^{a}
Nano NPK (F_4)	306.30^{a}	318.40^{a}	312.35^{a}	265.10^{bc}	304.65^{ab}	284.88^{a}
Nano NPK + Humic acid (F_5)	241.40^{b}	330.65^{a}	286.03^{a}	270.95^{bc}	328.70^{a}	299.83^{a}
Means of Nipping	260.56^{b}	301.84^{a}		261.12^{b}	287.83^{a}	

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range test.

3.2.2 Number of seeds capsule^{-1}

According to the data presented in table 8 number of seeds capsule^{-1} significantly affected by application of different fertilizer treatments. The highest number of seeds (71.03 and 70.30 seeds capsule^{-1}) was recorded from application of humic acid and Nano NPK+ Humic acid fertilizers for both locations respectively. While the lowest values were (66.28 and 67.02) respectively obtained from control treatment. It appears from the previous results in table 8, nipping practice affected significantly on number of seeds plant^{-1} the maximum values were (69.53 and 69.07 seeds capsule^{-1}) were recorded for nipping treatment at both locations respectively. Moreover, lowest values (68.11 and 68.64) were observed for no nipping respectively. Significant difference was observed on number of seeds capsule^{-1} due to the combination between fertilizer treatments and nipping, according to the data represents in table 8 shows the highest and lowest mean value (71.77 and 64.77 seeds capsule^{-1}) which recorded form the combination treatment (humic acid *nipping) and (control *no nipping) at Grdmala location. On the other hand, the highest and lowest value for Grdarasha location were (70.39 and 66.21 seeds cpsule^{-1}) recorded from combination treatment of (Nano NPK+ humic acid *no nipping) and (control *no nipping).

Table 8. Number of seeds capsule^{-1} response to fertilizer treatments, nipping and their combination.

Fertilizer treatments	Locations					
	Grdmala L_1			Grdarasha L_2		
	Non-nipping	Nipping	Mean of Fertilizer	Non-nipping	Nipping	Mean of Fertilizers
Control (F_1)	64.77^{d}	67.80^{c}	66.28^{c}	66.21^{d}	67.83^{cd}	67.02^{c}
Recommended NPK (F_2)	70.31^{ab}	68.46^{bc}	69.39^{b}	68.37^{a-d}	69.53^{abc}	68.95^{ab}
Humic acid (F_3)	70.28^{ab}	71.77^{a}	71.03^{a}	69.25^{abc}	69.79^{abc}	69.52^{ab}

Nano NPK (F_4)	**66.97^{c}**	**70.82^{a}**	**68.90^{b}**	**68.97^{abc}**	**68.00^{bcd}**	**68.48^{bc}**
Nano NPK + Humic acid (F_5)	**68.23^{c}**	**68.80^{bc}**	**68.51^{b}**	**70.39^{a}**	**70.21^{ab}**	**70.30^{a}**
Means of Nipping	**68.11^{b}**	**69.53^{a}**		**68.64^{b}**	**69.07^{a}**	

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range test.

3.2.3 Seed index (weight of 1000 seeds g)

It is evident from table 9 that the application of fertilizers affected significantly on seed index. The highest mean value (3.70 and 3.67 g) obtained from application of Nano NPK fertilizer as compared to the lowest value (3.40 and 3.40 g) respectively observed from control treatment at both locations. In contrast, it was noticed that nipping had a significant effect on 1000- seed weight. The 1000 seed weight of nipping treatment was superior to that of no nipping treatment (9.50 and 4.60) % in both locations. Seed index were affected significantly by the combination between fertilizer and nipping. The maximum mean values were (3.81 and 3.74) respectively founded at Grdmala and Grdarasha locations from the combination treatment of (Nano NPK * nipping). In contrary, the lowest values were (3.20 and 3.27 g) was obtained from combination treatment of (control *no nipping) respectively at both locations.

Table 9. Seed index (g) response to fertilizer treatments, nipping and their combination.

Fertilizer treatments	Locations					
	Grdmala L_1			Grdarasha L_2		
	Non-nipping	Nipping	Mean of Fertilizers	Non-nipping	Nipping	Means of Fertilizers
Control (F_1)	**3.20^{c}**	**3.60^{ab}**	**3.40^{c}**	**3.27^{b}**	**3.53^{ab}**	**3.40^{b}**
Recommended NPK (F_2)	**3.40^{bc}**	**3.80^{a}**	**3.60^{ab}**	**3.47^{ab}**	**3.67^{a}**	**3.57^{ab}**
Humic acid (F_3)	**3.27^{c}**	**3.60^{ab}**	**3.43^{c}**	**3.53^{ab}**	**3.54^{ab}**	**3.54^{ab}**
Nano NPK (F_4)	**3.60^{ab}**	**3.81^{a}**	**3.70^{a}**	**3.60^{a}**	**3.74^{a}**	**3.67^{a}**
Nano NPK + Humic acid (F_5)	**3.40^{bc}**	**3.67^{a}**	**3.53^{bc}**	**3.53^{ab}**	**3.73^{a}**	**3.63^{a}**
Means of Nipping	**3.37^{b}**	**3.69^{a}**		**3.48^{b}**	**3.64^{a}**	

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range Test.

3.3 Effect of fertilizer treatments, nipping and their combination on sesame yield at maturity

3.3.1 Biological yield (t ha^{-1})

As with type of fertilizers, the value of this trait was affected significantly. Table 10 showed that the highest values of biological yield (16.75 and 14.94) t ha^{-1} for Grdmala and Grdarasha locations were obtained from application of recommended fertilizer and Nano-NPK+ humic acid fertilizers respectively such increases were particularly significant at ($P \leq 0.05$). While the lowest values were (12.63 and 11.75) t ha^{-1} were obtained from control treatment in both locations respectively. The nipping treatment recorded the highest biological yield were (15.40 and 13.95) t ha^{-1} for both locations respectively, while the lowest values were (12.93 and 13.23) t ha^{-1} which were recorded from no nipping treatment at both locations respectively. The combination treatment of (recommended fertilizer* nipping) and (Nano NPK *no nipping) were recorded the highest biological yield which were (18.50 and 15.13) t

ha^{-1}, while the lowest values (12 and 11.63) t ha^{-1} were observed from combination treatment (control *no nipping) for both locations respectively.

Table 10. Biological yield t ha^{-1} response to fertilizer treatments, nipping and their combination.

Fertilizer treatments	Locations					
	Grdmala L_1			Grdarasha L_2		
	Non-nipping	Nipping	Mean of Fertilizers	Non-nipping	Nipping	Means of Fertilizers
Control (F_1)	12.00^{d}	13.25^{bcd}	12.63^{b}	11.63^{b}	11.88^{b}	11.75^{c}
Recommended NPK (F_2)	15.00^{bc}	18.50^{a}	16.75^{a}	12.63^{b}	13.88^{a}	13.25^{b}
Humic acid (F_3)	12.50cd	16.00^{ab}	14.25^{b}	11.75^{b}	14.50^{a}	13.13^{b}
Nano NPK (F_4)	12.88^{cd}	16.00^{ab}	14.44^{b}	15.13^{a}	14.63^{a}	14.88^{a}
Nano NPK + Humic acid (F_5)	12.25^{cd}	13.25^{bcd}	12.75^{b}	15.00^{a}	14.88^{a}	14.94^{a}
Means of Nipping	12.93^{b}	15.40^{a}		13.23^{b}	13.95^{a}	

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range test.

3.3.2 Seed yield (t ha^{-1})

Figure 2 indicates the significant effect of fertilizer treatments, on seed yield (t ha^{-1}) of sesame at both locations. The highest seed yield for Grdmala and Grdarasha locations were (3.23 and 2.45) t ha^{-1}, which were recorded from application of Nano NPK+ humic acid and Nano NPK for both locations respectively. Increase of (34.02 and 71.32) % compared to control treatment at both locations. The nipping practice significantly affected on seed yield, the nipping treatment recorded (9.57and 13.30) % increase comparing with no nipping at Grdmala and Grdarasha location respectively. The combination treatment of (Nano NPK+ humic acid *nipping) and (Nano NPK*nipping) recorded the highest seed yield which were (3.77 and 2.61) t ha^{-1}, while the lowest values (2.38 and 1.42) t ha^{-1} were obtained from combination treatment of (control * nipping) for both locations respectively.

3.4 Effect of fertilizer treatments, nipping and their combination on sesame quality

3.4.1 Oil content %

It is evident from fig.3 the significant influence of the studied factors and their combination on oil percentage. The highest oil percentage was recorded from application of Nano NPK+humic acid the value of (57.71 and 59.49) % for both locations respectively. While the lowest values (42.31 and 45.14) % were recorded from control treatment. The oil % also affected significantly by nipping practice at both locations, the highest values (51.70 and 55.14) % were recorded for nipping treatment and the lowest values (47.56 and 49.26) % were recorded for no nipping treatment at both locations respectively. The combination treatment also had significant influence on seed oil%, the highest values (59.14 and 63.23) % were recorded from combination treatment (Nano NPK + humic acid *nipping) for both locations respectively whilst control* no nipping obtained the lowest value.

3.4.2 Protein content %

Figure 4 revealed that application of fertilizer treatments had significant effect on the protein content in sesame seeds of whole plant. The highest mean value of protein content was (17.81 and 18.83 %) were founded from the application of Nano NPK+ humic acid fertilizer which surprised (13.03 and 13.89) % control treatment for both locations respectively. The studied nipping practice affected significantly on the protein % at Grdmala location fig 4. The maximum mean value (15.50) % was recorded for

no nipping treatment and the lowest value (15.24) % was obtained from nipping practice. While at Grdarasha location the maximum mean value (16.97) % was recorded for nipping treatment and the lowest value (15.93) % was obtained from no nipping practice fig 4. Explained that there was a significant effect of combination treatment protein content %. The maximum mean value (17.91 and 19.47 %) was observed from combination treatment of (Nano NPK+humic acid *no nipping) and (Nano NPK+humic acid * nipping) for both locations respectively, and the lowest value (12.88 and 13.34 %) was obtained from combination treatment of (Control *nipping) and (control *no nipping) for both locations respectively.

3.5 Correlation study

Simple correlation coefficient done denoted by r value, which is a measure of straight –line between seed yield and the studied characteristics of growth, yield component and sesame quality as shown in table (11) and (12) for both locations respectively.

Correlation analysis shows that the seed yield (t ha^{-1}) had significantly positive correlation with No. capsule plant $^{-1}$ only, table (11) at Grdmala with (r = 0.65*), in the same table it noticed that significant correlation between seed index with primary branch, secondary branch and first capsule height (cm) with r value (0.86**,0.86** and 0.77**).

While at Grdarasha (table 12) there were significant positive correlation between seed yield (t ha^{-1}) and plant height (cm), p. branch, s. branch, no. capsule plant $^{-1}$, seed index (g), biological yield (t ha^{-1}), oil % and protein % with r value = (0.70*,0.75*,0.69*, 0.83**, 0.81**, 0.86**,0.83**and 0.83**).Furthermore, oil content correlate positively with no. capsule plant^{-1}, seed index (g) and biological yield (t ha^{-1}) r= 0.68*, 0.86** and 0.80** while protein content correlate with plant height(cm), seed capsule^{-1}, seed index (g), biological yield (t ha^{-1}) and oil content (r= 0.75* ,0.69* ,0.80** ,0.87**and 0.96**) respectively.

Table 11. Correlation analysis among the studied characters of sesame genotype at Grdmala.

Characteristics	Seed yield	Chlorophyll SPAD	Plant height	P. branch	S. branch	First Capsule height	No capsule	Seed Per capsule	Seed index	Biological yield	Oil content
Chlorophyll SPAD	0.07										
Plant height	0.34	**0.70***									
P. branch	0.47	-0.11	0.12								
S. branch	0.62	0.03	0.27	**0.94****							
First capsule height	0.11	0.20	0.22	0.61	**0.64***						
No. capsule	**0.65***	0.24	0.55	0.59	**0.65***	**0.67***					
Seed per capsule	0.57	0.18	0.34	0.54	0.46	0.39	**0.73***				
Seed index	0.38	-0.18	0.83	**0.86****	**0.86****	**0.77****	0.63	0.34			
Biological yield	0.22	0.25	0.35	**0.81****	**0.79****	**0.65***	0.45	0.50	**0.70***		
Oil content	0.60	0.10	0.12	0.47	0.56	0.44	0.55	0.26	**0.63***	0.22	
Protein content	0.55	0.29	0.26	0.12	0.25	0.16	0.43	0.11	0.32	-0.04	**0.90****

Table 12. Correlation analysis among the studied characters of sesame genotype at Grdarasha.

Characteristics	Seed yield	Chlorophyll SPAD	Plant height	P. branch	S. branch	First Capsule height	No capsule	Seed Per capsule	Seed index	Biological yield	Oil content
Chlorophyll SPAD	0.43										
Plant height	**0.70***	**0.68***									
P. branch	**0.75***	0.22	0.34								
S. branch	**0.69***	0.40	0.19	**0.73***							
First capsule height	0.44	0.21	0.28	0.27	0.60						
No. capsule	**0.83****	0.40	0.53	**0.92****	**0.70***	0.32					
Seed per capsule	0.56	0.54	**0.67***	0.44	0.42	**0.65***	**0.66***				
Seed index	**0.81****	0.32	0.35	0.62	**0.75***	0.57	**0.69***	0.58			
Biological yield	**0.86****	0.36	**0.78****	0.42	0.45	0.62	0.57	**0.65***	**0.67***		
Oil content	**0.83****	0.31	0.58	0.57	0.50	0.52	**0.68***	0.61	**0.86****	**0.80****	
Protein content	**0.83****	0.47	**0.75***	0.46	0.42	0.51	0.62	**0.69***	**0.80****	**0.87****	**0.96****

4. DESSCUSION

As explained in table (3 and 4) fertilizer treatments significantly influenced on plant height and height of first capsule these results concluded that the plant height at Grdmala location superior to plant height at Grdarasha location, this may be due to applied fertilizers and soil properties table 1. As mentioned by El Mahdi (2008) who concluded that application of different levels of nitrogen and phosphorus significantly increased the plant height and height of first capsule over control treatment. The increase in plant height may be because of nitrogen is the constitutional component of protein. On the other hand, its application accelerates cell division and meristematic activity in the crop (Hussein and Zedan, 2008). Furthermore, Shehu et al. (2010) reported that supply of phosphorus is usually associated with increased root density and proliferation, which aid in extensive exploration and supply of nutrients and water to the growing plant parts, resulting in increased growth traits. Additionally, this matter is because of the beneficial role of phosphorus fertilizers in fertility of soil and improvement of plant root as well as plant growth (Daniya et al., 2013).

According to the data in table 3 nipping treatment significantly influenced on the plant height. This result agreement with finding of Kavivel et al. (2021) which reported that nipping of the terminal bud resulted in reduction of plant height in sesame plant compared to other treatment. The similar result also reported by Obasi and Msaakpa (2005) in cotton plant. Likewise, Kithan and Singh (2017) clarified that as in terminal nipping practice, the apical bud is nipped and so the utilization of the photosynthates by the crop for lateral branches could be higher and this might be the reason for decreased plant height with nipping treatments, which was also reported by (Singh et al., 2013).

According to the data in table 5 and 6 the effect of different fertilizers and nipping on number of branches plant^{-1} was significant. This increase in number of branches plant^{-1} explain that response of sesame plant to N and P application. Addition of N and P through fertilizers enhances root development which improve the supply of other nutrient and water to the growing part of the plant and response of sesame plant to N and P application through fertilizers. As mentioned by Ali (2021) in the Iraqi Kurdistan Region, sesame crop is cultivated and usually fertilized with nitrogen and phosphorus fertilizers. Asl (2017) stated that seemingly, bio-fertilizer strengths plant growth through increasing free phosphorus of soil so that more photosynthetic materials are produced in plant, the growth of vegetative buds is promoted and the number of branches in plant is increased. Nitrogen could promote vegetative growth of plant through increasing soil fertility so that the number of branches increased. These results are similar to those reported by (Okpara et al., 2007). According to Abou EL-Leel et al. (2019) humic acid is a natural biological organic fertilizer derived from organic waste, which shows a highly promoting effect on plant growth and development. The results are in good accordance with those of Bakry et al. (2013) who reported that humic acid is complex substances derived from organic matter decomposition. Humic acid increases the permeability of plant membranes and enhance the uptake of nutrients, this may be the reason for increasing of number of branches plant $^{-1}$ as shown in table 5. Under nipping treatment, the utilization of photosynthates by the crop for the production of lateral branches would be higher and this might be the reason for increased number of branches plant^{-1} (Islam, 2010). Kithan and Singh (2017) showed that nipping practice 25 days after sowing might have efficiently altered the crop architecture by activating the dormant lateral branches which ultimately increased the lateral branches these results are going with those reported by (Duary and Ghosh, 2009). Similar results have been reported by (Vasanthan et al., 2019).

Figure 1 showed that fertilizer treatments and nipping significantly affected the chlorophyll content. This may be due to humic acid which amplified permeability of cell membrane. On the other hand, increasing energy inside the cells would lead to chlorophyll production and photosynthesis rate increase. Then, the growth process is accelerated, nitrogen absorption into the cells is intensified, nitrate production is diminished, and finally the production is improved SPAD readings this may be due to dilution effect as increasing in primary and secondary growth table 5 and 6.

It is evident from the data presented in table 7 that number of capsules plant $^{-1}$ was significantly

affected by Nano NPK and humic acids in both locations. The results indicated to the role of nutrients especially phosphorus and role of humic acid in nutrients availability in plant for capsule and seed formation which is available in each Nano-NPK and humic acid fertilizers. This may be due to the role of humic acid in increasing the biomass production and the secondary branches by increasing the nitrogen content and survival rate of leaves that resulted in enhancing the number of capsules plant^{-1}. These results are in agreement with (Omer and Mahmood, 2021; Suleiman and Mahmood, 2021). Moreover, nipping treatment has significant effect on number of capsules plant^{-1}. This may be because of in this technique the top portion of the plants are excised to enhance lateral branch formation so increasing number of secondary branches then of capsules plant^{-1} table 6 and 7. Bharathi et al. (2014) demonstrated that nipping treatments gave the highest value of number of capsules plant $^{-1}$. These results are in line with (Kithan and Singh, 2017).

Table 8 revealed that application of humic acid and Nano-NPK caused significant effects on number of seeds capsule^{-1}. This result may be due to that increase in the number of seeds capsule^{-1} as affected by humic acid applications is resulted from improving plant growth conditions and increasing the nutrients. Similarly, Nano fertilizer have high potential to increase yield of plants due to its role in increasing efficiency of nutrient uses these results were consistent with (Suleiman and Mahmood, 2021). Furthermore, nipping significantly affected number of seed capsule^{-1}. According to the data nipping treatment significantly influenced the number of seeds capsule^{-1}. These results are in accordance with those have been reported by (Sanjay et al., 2020).

The effect of Nano-NPK fertilizer was significant on seed index of sesame at both locations as disclosed in table 9. This result was in agreement with Zafar et al. (2020) when investigated that the seed index of linseed was affected significantly with different rates of NPK application. Moreover, nipping treatment significantly affected the seed index of sesame. These results are in accordance with those have been reported by (Vasanthan et al., 2019).

Biological yield significantly responded to fertilizer treatments as presented in table 10. Recommended fertilizer has significant effect at Grdmala location this result may be due to that sesame is very responsive to nitrogen and phosphorus fertilizers. Likewise, Nano-NPK and humic acid has significant effect at Grdarasha location, due to their high calcium carbonate content (table, 1), and application of Nano-NPK may cause nutrient balance then increase in biological yield. Additionally, role of humic acid in increasing nutrients availability for plant then increase in growth. According to the data in table 10 biological yield significantly affected by nipping treatment. Similar result was founded by (Shinde and Shihare, 2015).

Figure 2 showed that the seed yield of sesame was also influenced significantly by Nano-NPK and humic acid fertilizer this may be due to the role of Nano-NPK and humic acid in increasing number of capsules plant $^{-1}$ and number of seeds capsule^{-1} (table 7 and 8). Also, Humic acid is good to enhance the biological activity of the soil, and nutrients are absorbed better and faster due to humic acid application. These results agree with (Omer and Mahmood, 2021; Safaei et al., 2014). Effect of nipping treatment on seed yield of sesame was found significant. Similar result was recorded by (Jahan, 2015).

Figure 3 displayed the significant effect of Nano-NPK and humic acid on oil percentages this may be due to the role of phosphorus in oil formation similar result is in line with (Omer and Mahmood, 2021). Similarly humic acid essentially helps the movement of micronutrients from soil to plant, similar result was found by Kandil, (2015) who stated that oil content in sesame seeds was significantly affected by application of humic acid fertilizer. Effect of nipping treatment on oil percentage of sesame was found significant.

Data regarding protein content are shown in fig. 4 which indicated to the significant effect of Nano-NPK and humic acid fertilization and nipping treatment on this trait due to their role in nitrogen absorption and availability.

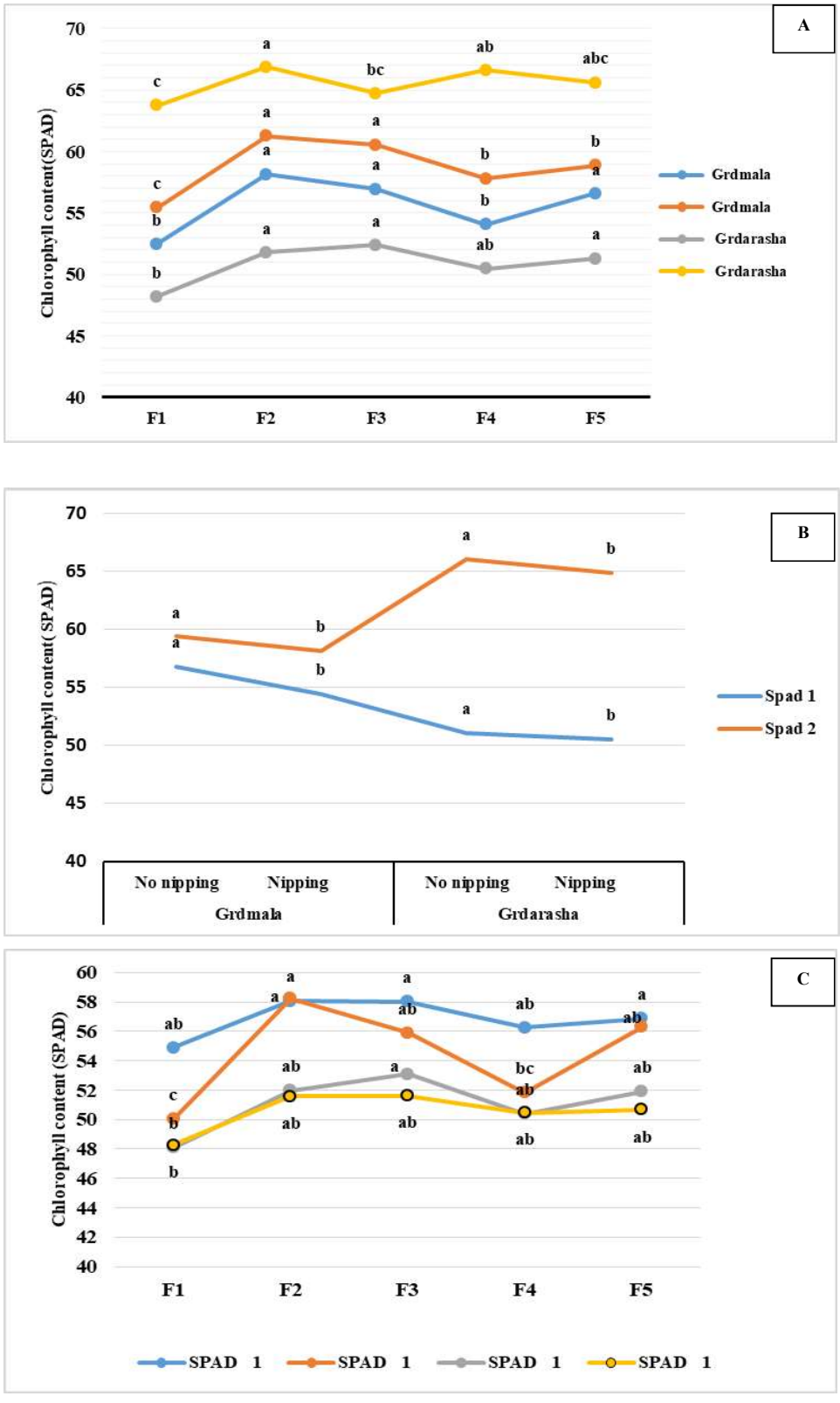


Fig 1. SPAD reading as affected by fertilizer treatments (A), nipping (B) and the combination between them (C).

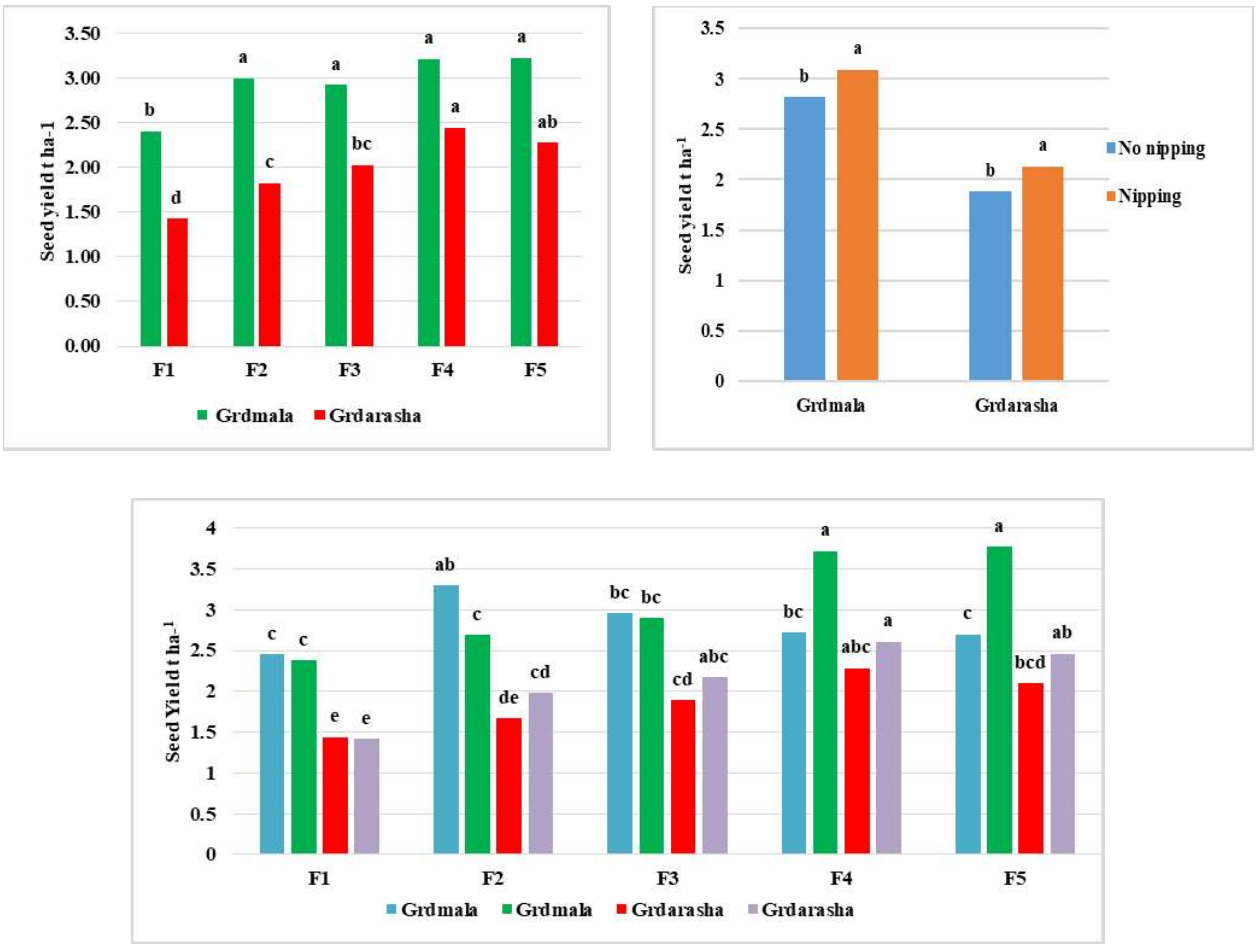
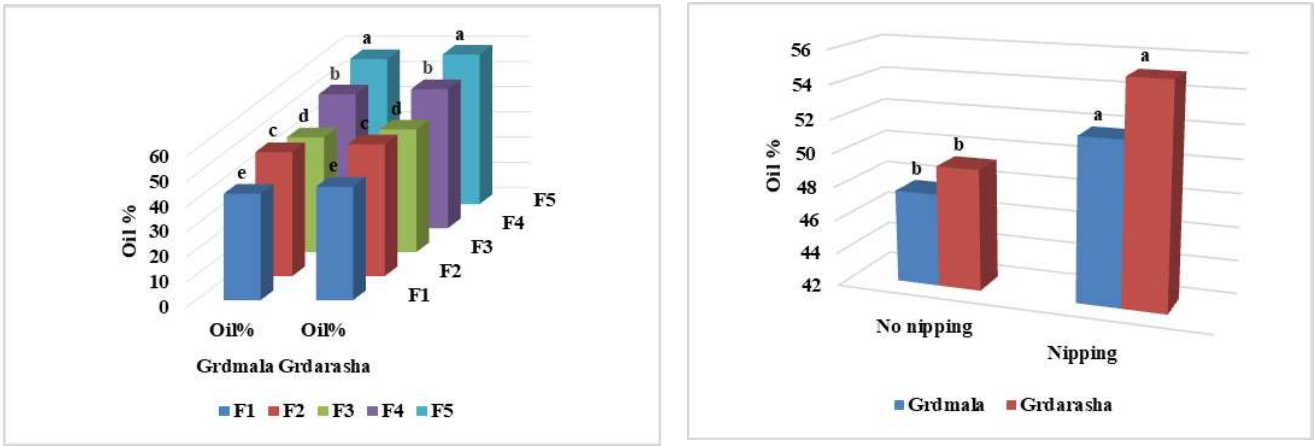


Fig 2. Seed yield t ha^{-1} as affected by studied factors and possible combination between them.



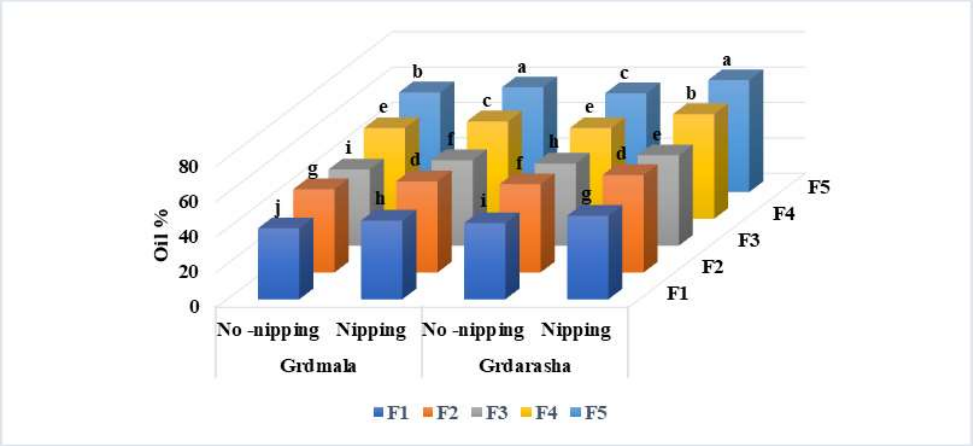
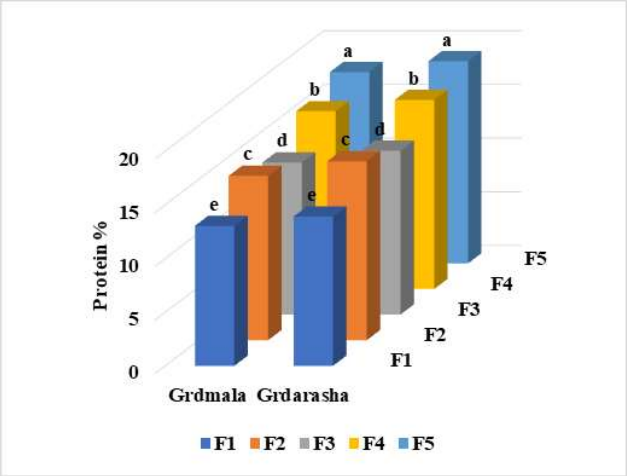
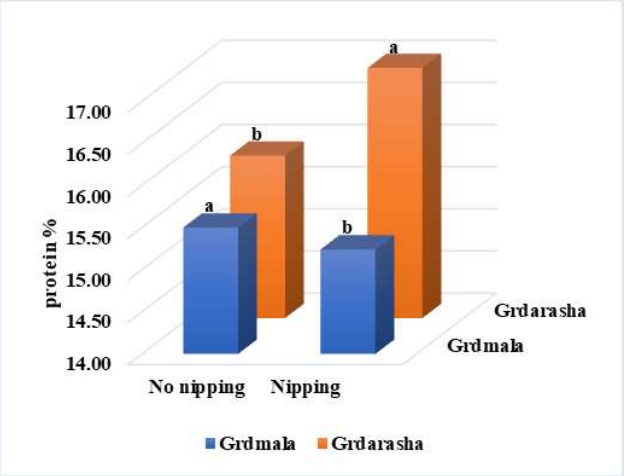


Fig 3. Oil content % as affected by studied factors and possible combination between them.





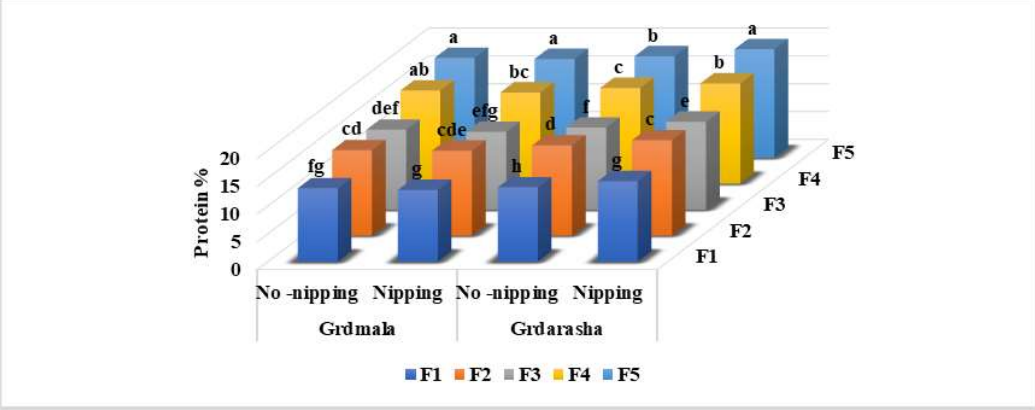


Fig 4. Protein content % as affected by studied factors and possible combination between them.

5.CONCLUSION

The sesame growth, yield and quality affected by fertilizer, nipping practice and their combination. It is worth mentioning that Nano-NPK and humic acid fertilizer played significant role in increasing yield and quality of sesame. The higher values for the most studied sesame characters were recorded at Grdmala location in comparing with Grdarasha location due to lower calcium carbonate at Grdmala location and higher phosphorous concentration which is responsible for seed formation and less calcium carbonate led to high availability of macro and micro elements then the higher productivity of the crop.

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